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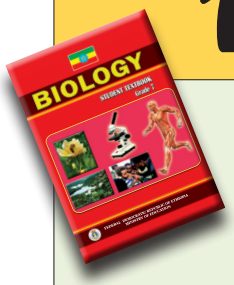

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BIOLOGY

STUDENT TEXTBOOK

GRADE 7

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FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF EDUCATION

Published E.C. 2004 by the Federal Democratic Republic of Ethiopia, Ministry of Education, under the General Education Quality Improvement Project (GEQIP) supported by IDA Credit No. 4535-ET, the Fast Track Initiative Catalytic Fund and the Governments of Finland, Italy, Netherlands and the United Kingdom.

The Ministry of Education wishes to thank the many individuals, groups and other bodies involved – directly and indirectly – in publishing this textbook and the accompanying teacher guide.

Developed and Printed by

STAR EDUCATIONAL BOOKS DISTRIBUTORS Pvt. Ltd.

24/4800, Bharat Ram Road, Daryaganj,

New Delhi – 110002, INDIA

and

ASTER NEGA PUBLISHING ENTERPRISE

P.O. Box 21073

ADDIS ABABA, ETHIOPIA

Under GEQIP Contract No. ET-MoE/GEQIP/IDA/ICB/G07/09-F.

ISBN 978-99944-2-261-6

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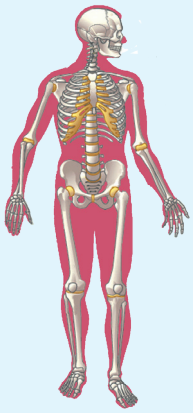

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Unit 1

Biology and Technology

Unit Outcomes

By the end of this unit, you will be able to:

- *define biology as the study of life;*
- *list the branches of biology;*
- *state what each of these branches of biology studies about;*
- *indicate that all natural sciences are interrelated;*
- *describe how biological knowledge is utilized in the fields of agriculture, medicine and food science;*
- *explain the relevance of biology to the society;*
- *give examples of technological innovations derived from biological knowledge;*
- *identify values developed in learning science to maintain a more proactive and environmentally conscious population.*

Main Contents

1.1 What is biology?
1.2 Industries that Utilize Biological Knowledge
1.3 Relevance of Biology to Society
1.4 Biology and Technological Innovations
1.5 Values in Biology Education
Unit Review

Introduction

In your earlier grades you have studied science, which dealt with all living and non-living things in nature in an integrated form.

Science is a systematic method of gaining knowledge about the natural world and the social aspect of human society. Generally, it is divided as social and natural sciences as shown in Figure 1.1. The study of natural science is divided into three major subject areas as *Biology*, *Chemistry* and *Physics*.

Which of your Grade 5 and 6 topics were about living things?

The survival and well-being of humans largely depend upon knowledge of living things, and their interactions among themselves and with their environment.

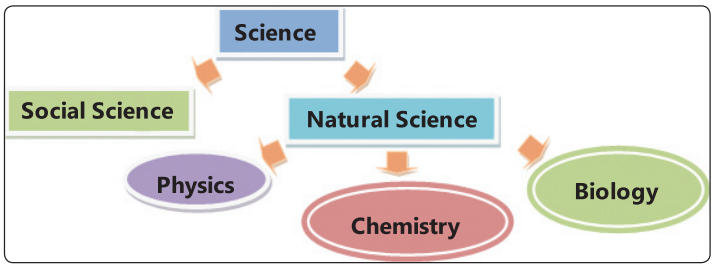


Figure 1.1: Classification of science

DID YOU KNOW?

Social science deals with how people think, behave and act; whereas natural science studies about natural things.

Do biology and technology interrelate?

Biology is a branch of science by which living things are studied. On the other hand, technology is the science or technique that develops machines, hardware or instruments used by humans.

Biology helps the society in many different aspects, like in medicine, agriculture, environment and population control. For biology to effectively serve the society it requires materials and instruments from technological innovations.

Key Terms

- **Science:** a systematic way of getting knowledge through observation and experimentation so as to understand nature.
- **Living things:** are organisms which show the properties of life.
- **Life:** is the characteristics of organisms that make them alive; it includes characteristics like growing, reproducing, sensitivity to stimuli, metabolizing, and moving by their own.

As biology requires the knowledge of technological innovations; so does technology; that is, technology needs the understanding of living systems for its further improvement and progress of techniques to better serve the society.

In this unit, you will start studying one branch of natural science known as *Biology*. You will describe biology as a part of science. You will also identify branches of biology, its relationship with other sciences, its application and relevance to society.

1.1 What is biology?

By the end of this section, you will be able to:

- define biology as the study of life;
- list the branches of biology;
- state what each of these branches of biology studies about; and
- indicate that all natural sciences are interrelated.

Did You Know?

* Living organisms range from the smallest bacteria to the biggest whale.
* The smallest bacteria which is the smallest organism is less than 1 micron (one-millionth of a meter) in diameter.

Can you define biology?

Biology is the study of living things. Biologists are people who study biology or about living things. Living things range from tiny organisms like bacteria to very large organisms, such as whales, elephants and big trees.

Word Roots and Origins

Biology: came from two Greek words 'bios' meaning life, and 'logos' meaning study.

Branches of Biology

Can you list down branches of biology?

Biology is the science that studies about various living organisms. A living organism could be a one-celled *bacteria* or a several-celled *organism* such as animal or plant. Although there are many branches of biology, each focused on different aspects of living things. The three main branches, are shown in Figure 1.2: *Zoology* (*animals*), *Botany* (*plants*), and *Microbiology* (*microorganisms*). See Table 1.1 for some of the major sub-branches of biology and their definitions.

Key Terms

☑ **Biologists:** are people who study living things.

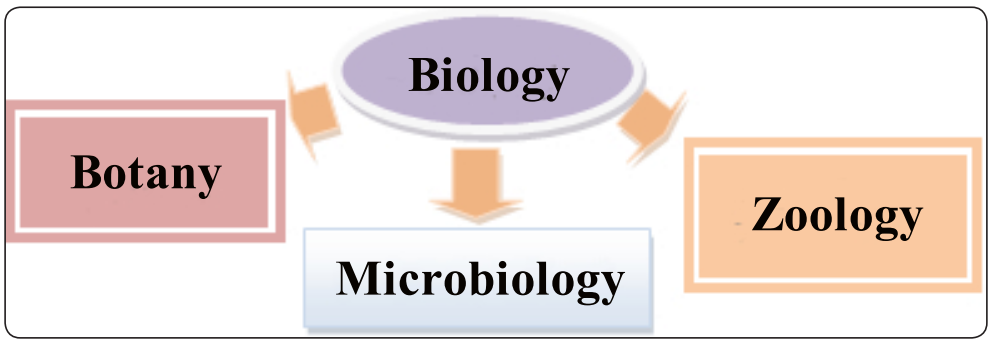


Figure 1.2 Classification of Biology based on major groups of organisms it studies

Table 1.1: Sub-disciplines in biological sciences

Sub discipline	Description
Botany	The scientific study of plants.
Cytology	The study of cells.
Ecology	The study of relationships between organisms, and their environment.
Evolution	The study of the origin and gradual change of organisms in time.
Genetics	The study of heredity and identity.
Microbiology	The study of microscopic organisms (micro-organisms).
Physiology	The biological study of the functions of living organisms and their parts.
Taxonomy	The science of identification, classification and naming of organisms.
Zoology	The study of animals.

Activity 1.1

Searching for other branches of biology

- ☑ Go to your school library.
- ☑ Find out other branches of biology

Present your findings: what do the branches study?

The Relationship of Biology with Other Sciences

Is biology related to other fields of science?

Biology requires knowledge from other fields of science to understand about processes in living things. These overlaps in the study areas of biology and other sciences resulted in interdisciplinary studies. The body of living things is composed of chemical substances. Understanding reactions in living organisms and their physical activities needs knowledge of chemistry and physics (Figure 1.3). The overlap of biology with chemistry, for example, forms biochemistry.

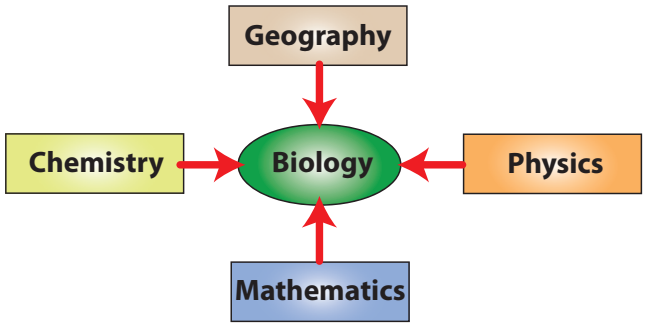


Figure 1.3: Overlap of biology with other fields

Exercise 1.1

Choose the best answer for each of the following.

1 The word biology is derived from

A Two Latin words – bios and logos

B Two English words – bio and logos

C Two Greek words – bios and logos

D Two Greek words – bio and logy

2 Which one of the following is not true about biology: It studies

A about all living things

B about life

C the interaction between organisms

D about non-living things

3 The branch of biology that studies about plants is

A Zoology C Ecology

B Botany D Taxonomy

4 One of the following field of biology examines organisms not seen by unaided eyes?

A Taxonomy C Genetics

B Microbiology D Ecology

5 The branch of biology which studies animals is known as

A Botany C Zoology

B Cytology D Micro biology

1.2 Industries that Utilize Biological Knowledge

By the end of this section, you will be able to:

- describe how biological knowledge is utilized in the fields of agriculture, medicine and food science.

Knowledge from all branches of biology are utilized directly or indirectly in different areas of human activities. These include agriculture, medicine, and the food industry. In general, the application of biological knowledge and techniques are necessary to the improvements in the quality of life as well as the economic benefits they generate.

Agriculture

How is biological knowledge utilized in agriculture?

Agriculture is one of the human activities to which biological knowledge and skills are very essential. Agricultural practices include cultivation of soil, growing and harvesting crops, breeding and raising livestock, forestry, etc. (see Figure 1.4a–d) for the illustration of some of the *terminologies used here*.

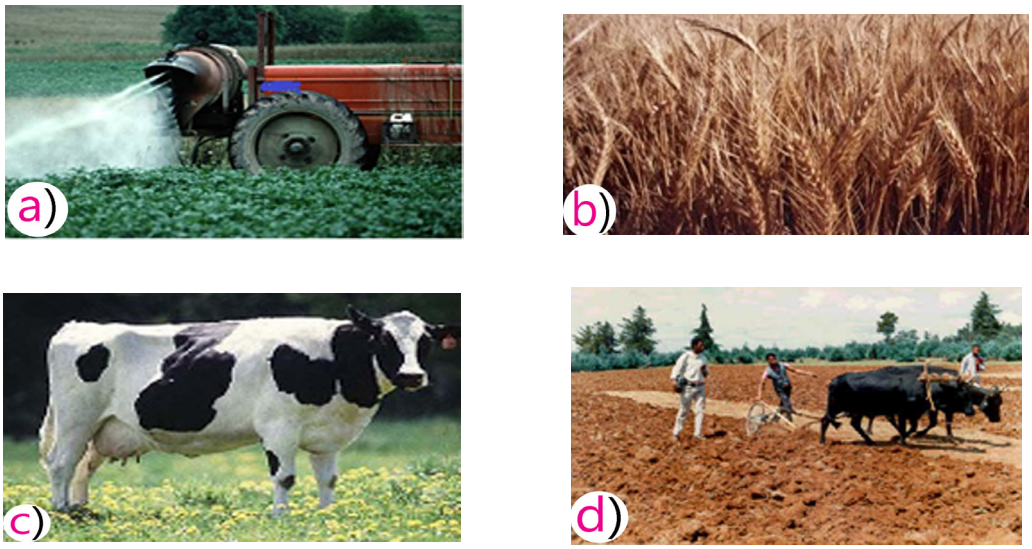


Figure 1.4 Different agricultural activities. a) *spraying pesticide to crop plantation*, b) *crop plantation*, c) *dairy cow* and d) *plowing with oxen*.

Is biological knowledge important to study plant nutrients?

Plants require different factors for their growth. These include temperature, inorganic nutrients, water, light, and air. Plants obtain substances such as inorganic nutrients and water from the soil. Therefore, biological knowledge is essential to understand the role of nutrients in plant growth.

Is biological knowledge necessary to study soil composition?

Soil plays a major role in determining the kinds of plants that grow on it. Biologists study growth requirement of crops, analyze soil composition and design ways of increasing productivity.

Did You Know?

- Plants use essential nutrients which are available in the soil.
- Primary nutrients include nitrogen, potassium and phosphorous.
- Soil is a non-renewable natural resource which is composed of minerals, water, organic matter and living organisms including microorganisms and worms.
- The top soil that contains much of the organic matter is the fertile layer of a soil.
- Different soil conservation practices (vegetation covering, avoiding overgrazing, exercising good farming practice, etc.) protect the top soil from being easily eroded out.
- Inorganic nutrients include major soil nutrients like nitrogen, phosphorus, calcium, potassium, magnesium and sulfur.

Is biological knowledge necessary to study agro-chemicals ?

Biological knowledge is used to increase productivity of crops in many ways. Agricultural industries use agro-chemicals like fertilizers, herbicides (*weed-killers*), and pesticides to increase productivity. See different types of agro-chemicals in Figure 1.5. Biological knowledge is utilized for the preparation and use of the right quantities and qualities of agrochemicals.

Figure 1.5: Agrochemicals used by large farms in Ethiopia: a) *atrazine (herbicide)*, b) *acetochlor herbicide*, c) *hand spray* and d) *claearys 3336F (fungicide)*

Key Terms

- **Fertilizer:** a chemical or natural substance added to soil to increase its fertility.
- **Pesticide:** a substance used for destroying insects or other pests of plants or animals.
- **Herbicide:** a chemical substance used to destroy unwanted vegetation or weeds from farming sites.

Does crop rotation practice require biological knowledge?

Crop rotation consists of growing different crops in succession on the same land. For instance, a farmer can possibly rotate corn, bean and teff in succession. The rotation of crops helps to reduce the effect of pests and keep the soil fertile; moreover, it increases the yield.

Does preservation of soil require biological knowledge?

Poor agricultural practices like overgrazing, burning the vegetation cover, over fertilizing, and vertical ploughing of steep land reduce soil fertility. So, protecting the top surface of the soil from effects, such as erosion, is very important in agriculture.

Medicine

How is biological knowledge and skill utilized in medicine?

Medicine is the science and art of diagnosing, treating and preventing disease and injury. Medical scientists engage themselves in a constant search for new drugs, effective treatments, and more advanced technology. Biology is one of the central foundations for knowledge and techniques in medicine.

Word Roots and Origins

Medicine from a Latin word 'medicus' which means physician.

Does the study of effect and use of drugs require biological knowledge?

Biological knowledge and skills are found to be important to analyze the effects of drugs on human body. A drug is a medicine or any substance which has a marked physiological effect when taken into or applied on the body.

Antibiotics (Greek anti, "*against*"; bios, "*life*") are chemical compounds used to kill or inhibit the growth of bacteria. All antibiotics share the property of selective toxicity: They are more toxic to an invading organism than to an animal or human host. These drugs are used to fight diseases.

Did You Know?

Tobacco smoke contains about 4000 chemicals; one of which is nicotine and it stimulates nerves and makes the heart beat faster.

Does the practice of correcting drug abuse require biological knowledge?

Drug abuse is a pattern of using a substance that leads to significant problems or distress. It can be taking more than the recommended dose of prescribed drugs such as stimulants or depressants without medical supervision and it can also be taking antibiotics without prescription. The major drug abuse, however, is illegally using substances like marijuana, cocaine, heroin, or other illegal substances that are not allowed by governments.

Food

How is the biological knowledge utilized in food industries?

Food production and processing industries utilize biological knowledge and skills to produce good quality food and to keep it safe and longer. Food is anything nutritious and taken into the body in order to maintain life. Food is made up of compounds known as nutrients, which can be used by organisms after the process of digestion. Biological knowledge is needed to know the end products of digestion, absorption and utilization by our body.

Food producing and processing industries utilize biological knowledge and skills to provide safe and quality foods.

Does the understanding of deficiency diseases require biological knowledge?

The food we eat should contain the nutrients in a balanced proportion. The increase or decrease of nutrients in the diet causes diseases. Deficiency diseases are diseases caused by a lack of nutrients in the diet. See Table 1.2 for some of the deficiency diseases that result due to lack of minerals, vitamins or other nutrients in the diet of a person. See also Figure 1.6 for the effect of some of the deficiency diseases.

Table 1.2 Lack of nutrients in diet and their associated deficiency diseases

Deficient Nutrient	Deficiency disease
Iodine	Goiter
Iron	Anemia
Vitamin A	Night blindness
Vitamin B (thiamine)	Beriberi
Vitamin B (niacin)	Pellagra
Vitamin D	Rickets
Vitamin C	Scurvy
Carbohydrate	Marasmus
Protein	Kwashiorkor

a) Rickets b) Kwashiorkor c) Marasmus

Figure 1.6 Effects of lack of nutrients in the food

Does the study of agro-chemical residues on / in food need biological knowledge?

Agro-chemical is a general name given to those chemicals used commonly during agricultural practices and these include fertilizers and pesticides. These chemicals have been used for long to increase productivity in agriculture. However, most of the chemicals used remain as residues on plants and can cause health problems when consumed by people. Furthermore, when plants with chemical residues are consumed by other animals and when the animals are eaten by people, the concentration of the chemical increases several times and cause more serious health problems.

Does the practice of selective breeding require biological knowledge?

Selective breeding is a practice of controlled mating in plants and animals. It is done to produce organisms that better serve human needs. It is a technique by which offspring are made to have superior quality (*high yield, disease resistant, drought tolerant,* etc.) to that found in either parent.

Exercise 1.2

Choose the best answer among the given alternatives.

1 One of the following aspects of agriculture does not need biological knowledge?

A studying requirements for plant growth
B preservation of soil
C the use of a tractor
D the use of manure

2 Antibiotics are drugs used to
- A reduce pain
- B avoid infection
- C cure disease
- D prevent diseases

3 Drug abuse is the use of
- A drugs to fight diseases
- B drugs to reduce pain
- C drugs with out the order of doctors
- D drugs with the order of doctors

4 Deficiency diseases are caused by a lack of
- A lack of agro-chemicals in food
- B lack of balanced diet
- C lack of drugs
- D A and B

5 Biology is useful in food industries to improve
- A quality of food
- B safety of food
- C preservation of food
- D all of the above

1.3 The Relevance of Biology to Society

By the end of this section, you will be able to:

- explain the relevance of biology to society.

Biology contributes to society in many different ways. Biologists use their knowledge of organisms and their interaction to make contributions in medicine, agriculture, nutrition, population control, conservation and many other industries. Biotechnology is the applied branch of biology that uses living organisms and bioprocesses in engineering, technology, medicine, agriculture, and environment.

Did You Know?

Acid rain or acid deposition, is air pollution from burning fossil fuels. Fossil fuel burning releases large amounts of acid chemicals that rain down as acids.

Health

Is biology relevant to study drugs that combat diseases in our body?

Biology is involved in understanding the human body and describes its normal and abnormal conditions. All professionals in medicine study biology. The study of biology is necessary to understand the normal body processing, cause of diseases, methods of prevention, to identify the causes of diseases, and to develop drugs.

Key Terms

- **Disinfectant:** a substance used for destroying germs from non-living surfaces.

Drugs are used to fight diseases by curing sick people or by preventing diseases before they occur. Some people may use drugs without the instruction of physicians or illegally. The use of drugs illegally or too much of instructed drugs is known as *drug abuse*. The knowledge and techniques in biology are useful to discover drugs (*antibiotics*), analyze their interaction with the body, and their action against disease causing organisms. Antibiotics have the property of magic effects. Drugs like penicillin is a well-known antibiotic that has been used to fight many infectious diseases, including syphilis, gonorrhea, and tetanus.

Word Roots and Origins

Antibiotics: from two Greek words 'anti' meaning against and 'bios' meaning life.

Is biology relevant to characterize effects of antiseptics and disinfectants?

Antiseptics and disinfectants are antimicrobial chemical substances, which reduce potential germs. Antiseptics are antimicrobial substances that destroy potential germs. Disinfectants are chemical substances that are used to destroy microorganisms that contaminated nonliving objects. These chemical substances are necessary for us to keep our places free of potential germs. The preparation and testing the effects of these chemical substances against potential germs require the knowledge of biology.

Did You Know?

* Antibiotics are chemicals used to kill disease causing bacteria.

Is biology relevant to describe the healthy status of an individual?

Biology is involved in analyzing the human body and describes its normal and abnormal conditions. Healthy people are those people whose body parts properly work, have good mental status and interact with other people properly. Unhealthy people are those either their body parts, mental condition or interaction with other people is affected in a negative way, or all of them are affected. Analyzing the body weight of and describing the health status of an individual requires knowledge of biology.

Nutrition

Is biology relevant to nutrition?

Nutrition is a branch of biology that studies different aspects of food we eat. The studies in nutrition include how organisms obtain food, digest it, its composition and its uses to the body of an organism. Biologists study foods and their contents. We depend on biological knowledge to analyze nutrition and its health impacts. Our body requires food to grow, reproduce, and maintain good health. Without food, our bodies could not stay warm, build or repair tissue, or maintain a heartbeat. Eating the right foods can help us avoid certain diseases or recover faster when we are ill. These and other important functions of our body are fueled by chemical substances in our food called *nutrients*. Nutrients are classified as carbohydrates, proteins, fats, vitamins, minerals, and water.

Is biology relevant to identify major groups of foods?

All foods at least contain one of the six basic nutrients: carbohydrates, lipids, proteins, vitamins, mineral and water. Each nutrient plays a different role in keeping an organism healthy.

Knowledge from biology is required to understand the composition food, digestion and function of food that is consumed by organisms. Techniques from biology are also required to test the presence and amount of these nutrients in the food.

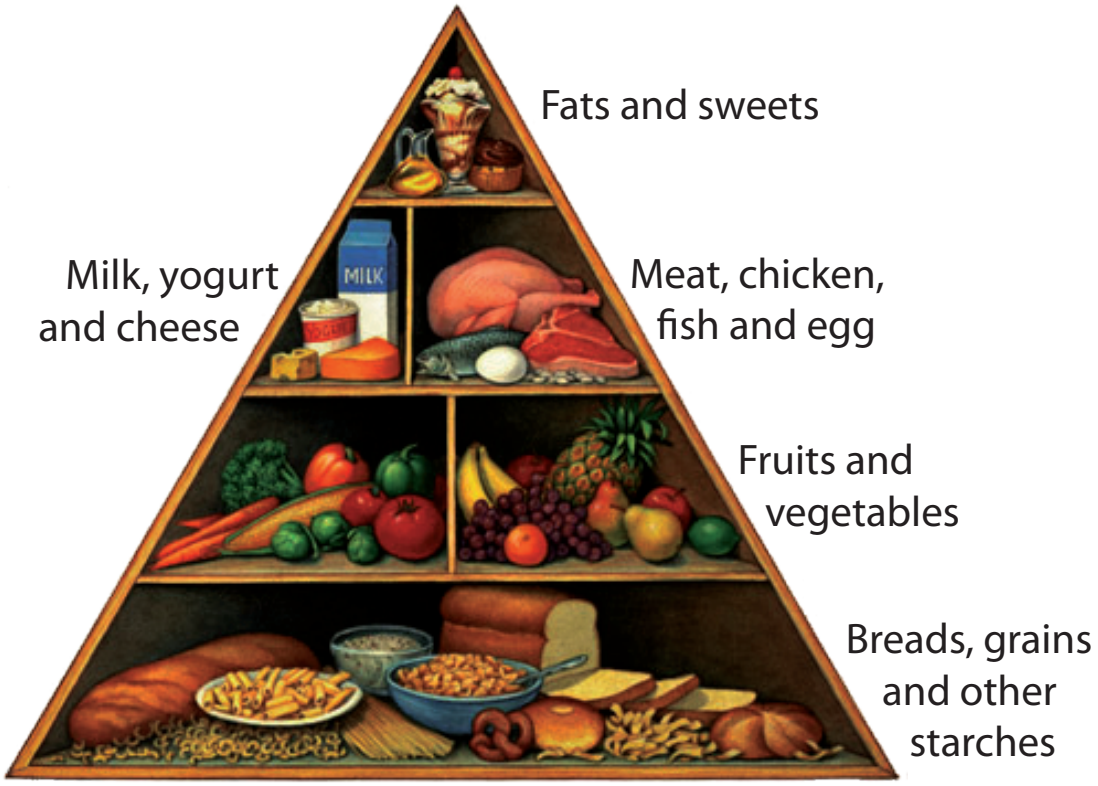


Figure 1.7 The five major food groups

Based on their function biologists classify foods into five groups. These groups of food include meat and legumes, milk and cheese, fruits and vegetables, bread and cereals, and fats and sweets (Figure 1.7). Each group of food contains the six nutrients in different proportions. So, the food that an individual consumes should contain the five groups in a balanced form as balanced diet. Knowledge of biology is necessary to identify the major groups of foods, their sources and workout the balanced diet an individual requires consuming.

Did You Know?

The daily requirement of the five major food groups are:

- Group A (milk and cheese) – 300-600 gm.
- Group B (fruit and vegetables) – Four servings (Example: 1 fruit is one serving).
- Group C (meat and legumes) – Two servings (Example: 55-85 gm of meat is one serving).
- Group D (bread and cereals) – Four servings (Example: 2 slices of bread is one serving).
- Group E (fats and sweets) – in small amounts.

Activity 1.2

Constructing a balanced diet

1 Look at the picture (Figure 1.8) and classify the food components into nutrient groups.

2 In a group, list down food items in the food you had for your breakfast; from the list prepare a balanced diet combination and discuss with the other groups.

Figure 1.8 Ethiopian dish

Environment

Is biology relevant to study environment?

With growing population, rapid industrialization and urbanization the use of all resources is rising. Bad farming practices and deforestation created additional problems as well. It is feared that unless proper measures are taken to conserve them in time, we will face serious problems like loss of species and pollution of the environment.

Biologists study the environment, organisms and their interaction. We rely on biological knowledge and skills not only to investigate environmental problems but also to find their solutions.

Is biology relevant to increase agricultural productivity?

Farming is a collection of activities done in an area of land and its buildings to grow crops and to rear animals. The main activities in farming include cultivation of soil, growing plants, and animal husbandry practices. These practices can either be good (*friendly*) or bad (*unfriendly*) to the environment. Loss of top soil reduces the fertility of the soil and agricultural productivity. Biological knowledge is necessary to examine whether the farming practices techniques in biology can also be used to reduce problems associated with bad farming practices.

Key Terms

- **Resource:** any natural or artificial substance, energy or organism, which is used by human being for living.
- **Environment:** the surroundings or conditions in which organisms live and operate.
- **Conservation:** the proper management of a natural resource to prevent its exploitation, destruction or degradation.
- **Biodiversity:** variety of organisms living at a given region.
- **Deforestation:** is clearing away of trees and vegetation that hold water and soil in place.
- **Pollution:** is contamination of the environment with materials that harm health, quality of life or the natural functioning of living organisms and their surroundings.
- **Population:** all inhabitants of a particular place.

The bad farming practices consist of:

- ☑ cutting trees to get space of crop cultivation,
- ☑ plowing horizontally steep lands,
- ☑ monoculturing (*growing a single crop in a given area year after year*),
- ☑ burning vegetation cover and
- ☑ allowing overgrazing.

Good farming practices, on the other hand, protect the soil from erosion and increase agricultural productivity of the land. The good farming practices contain:

- ☑ planting trees,
- ☑ contour farming (*farming step land horizontally*),
- ☑ terracing,
- ☑ crop rotation,
- ☑ reduce overgrazing.
- ☑ manuring or using fertilizer

If good farming practices are not used and soil erosion is allowed to continue at its current rate in Ethiopia, it will lead to continuous loss of the top fertile soil. Knowledge and techniques in biology are needed to reduce soil erosion and conserve the top fertile soil. Conserving the top fertile soil is important to increase agricultural productivity.

Is biology relevant to conserve natural resources?

Conservation is the wise use and protection of the environment. The environment consists of natural resources including plants, animals, minerals, soils, water air and fossil fuels. The environment is conserved for its biological, economic, and recreational value, as well as its natural beauty and importance for survival of human beings. In general, conservation of natural resources requires understanding of basic biological concepts. Therefore, the conservation of natural resources requires knowledge from biology.

The way in which one natural resource is managed has a direct effect upon other natural resources. For instance, cutting a forest near a river increases erosion, loss of top soil, and can lead to flooding. Appropriate conservation methods are used to conserve different natural resources. These include reducing planting trees, practicing good farming activities like terracing (Figure 1.9a), reusing or recycling natural resources, and protecting or preserving when necessary. The actual practices of these conservation activities require biological knowledge.

Is biology relevant to control the effect of deforestation?

Deforestation is a human activity that leads to removing plant cover from a given land for agricultural, firewood or settlement purposes (Figure 1.9b). These practices expose the soil and lead to loss of top soil due to wind erosion and water erosion. On the other

hand, forestation or planting tree (Figure 1.9c) has many advantages like reducing soil erosion. Plants are also an important defense against global climate change. Forests produce life saving oxygen and consume carbon dioxide and reduce global warming. Knowledge of biology is necessary to select and grow the appropriate plant suitable for a given area and to care as well for the growing plant.

Did You Know?

* The Ethiopian Red Fox is found at Simen and Bale Mountains. It is the most endangered Fox with only about 550 adults remaining.

a) b) c)

Figure 1.9 **Good farming practices.** a) *Planting trees;* b) *Terracing;* c) *Crop rotation*

Is biology relevant to study the effects of atmospheric pollution?

Pollution is contamination of the environment with materials that harm health, quality of life or the natural functioning of living organisms and their surroundings. Kinds of pollution include air (*atmosphere*), water and land pollution. Among the major sources of pollution are power and heat generation, the burning of solid wastes, industrial processes, and, especially, transportation (Figure 1.10). Evaluation of the effects of pollution to human, other organisms and the environment requires knowledge from biology. The solution towards reducing the effect of practices that increases the rate of pollution needs an understanding of biological concepts.

Library Research

Go to the library and answer the following questions.

1. List activities that you consider as harmful to the environment.
2. Describe the importance of planting trees and the effects of deforestation.
3. List down the effects of population growth on the environment.



a) b) c)

Figure 1.10 Sources of air pollution: a) *Cars*, b) *Industries* and c) *Burning forest*

Activity 1.3

Discussion on harmful activities to the environment

Method: in groups,

- discuss and list activities that are harmful to the environment,
- discuss and describe the importance of tree planting and effects of deforestation.
- discuss the effects of population growth on the environment.
- present your summary to the class.

Population

Is biology relevant to control growth of world population?

A population refers to the total number of individuals of the same kind that are living in a specified space. Biologists commonly use the term population to refer to the number of the same kinds of animals, plants or other living things. But, most of the time, population refers to human beings.

For instance human population means the number of humans living at a given area (such as in the *village, town, city, country* or *the Earth*). Since human population has a very strong effect on the environment than any other living things, here we will consider human population.

The effects of population growth are different and vast. Population growth may be beneficial to a certain extent, like increasing labor force. But, there may come a time when the number in the population exceeds the natural resources available to feed and house it. The consequences of such an event are severe. Therefore, controlling the number of population is necessary. Knowledge of biology is relevant in designing the activities that are used to control the number of population.

Did You Know?

- The prevalence of Female Genital Mutilation (FGM) in Ethiopia is reported to be 62% between ages of 15-19, (estimates of Population Bureau, 2010 (2002 EC)).
- In Ethiopia, 19% of girls were married by age 15 (Population Council, July 2004 (1996 EC)).

Is biology relevant to develop vaccine?

Figure 1.11 Immunization: A child receiving a vaccine

Immunization is one of the most effective weapons available to combat the spread of infectious disease. Immunization is the process of making the body resistant or immune to a specific disease by using a vaccine. A vaccine is a chemical substance that stimulates the body to create antibodies to fight a specific disease causing organism. It is the process of safe and effective use of a small amount of a weakened virus or bacteria to prevent infection (Figure 1.11). For instance vaccines developed to fight many infectious by biologists include tetanus vaccine, meningitis vaccine, small pox vaccine, polio vaccine, hepatitis vaccine and many others. Knowledge of biology is relevant to develop vaccine and to immunize the population against different communicable diseases.

Is biology relevant to reduce the rate of harmful traditional practices in Ethiopia?

Harmful cultural practices that are commonly practiced by many societies include female genital mutilation, early marriage, rape and illegal abortion. These traditional practices are common in Ethiopia. In Ethiopia it is possible to relate these practices to low level of education and poverty. Education as a whole and biology education in particular is relevant to reduce the extent of these harmful traditional practices.

Exercise 1.3

Choose the best answers for the following questions.

1 Biology is relevant to society to ensure
   - A over population
   - B health
   - C pollution
   - D deforestation

2 Biology is important to solve social problems of
   - A harmful traditional practices
   - B poor diet
   - C recycling natural resources
   - D All of the above

3 Which of the following agricultural practices is harmful?
   - A overgrazing
   - B crop rotation
   - C reforestation
   - D contour farming

4 Which of the following can not be the effect of over population?
   - A increasing famine
   - B increasing poverty
   - C increasing stress
   - D increasing quality of life

5 Tree planting reduces

A oxygen production
B global warming
C soil fertility
D CO_2 consumption

1.4 Biology and Technological Innovations

By the end of this section, you will be able to:

- give examples of technological innovations derived from biological knowledge.

From early times in history, humans have been studying other living things and tried to copy what they are doing. After observing the processes and features in living systems humans tried to apply knowledge and biological principles to meet practical needs. Some of the discoveries made in the past were copied from the understandings of biological principles; these include the invention of camera, airplane and submarines. You can easily recognize how valuable the discoveries are and their importance in changing the living pattern of humans.

Did You Know?

New robotic cars avoid collisions by using sensors based on bumble-bee's compound eyes.

Human Eye and Camera

How is a camera related to a human eye?

A human eye and a camera share a number of features. Both the human eye and a camera are composed of comparable parts, such as a lens, iris/diaphragm, pupil/aperture, retina/film and choroid/black paint, which actually work in different ways. Refer to Figure 1.12 to observe the common parts that a human eye and a camera share.

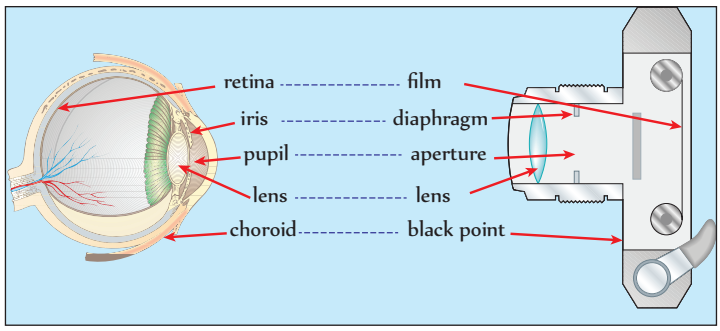


Figure 1.12 A camera and a human eye

Activity 1.4

Look at Figure 1.12 and describe similarities and differences between a camera and a human eye in a tabular form.

Birds versus Airplane

Do birds and airplanes share features?

The desire to fly dated back to the pre-historic period. Many stories from olden times involve flight, such as the Greek legend of Icarus and others. Long in history humans were attracted by the flying of birds, and they tried to fly like birds. Wings made of feathers or lightweight would be attached to arms to test their ability to fly. The results were often disastrous as the muscles of the human arms are not strong like birds.

The first successful piloted flight with self-powered aircraft was done in 1903 by Orville Wright and Wilbur Wright (Figure 1.13).

Key Terms

- **Submarine:** war-ship that moves underwater for a long period.

Did You Know?

A number of anatomical, physiological and behavioral adaptations enabled birds to meet the requirements of flight.

- Have hollow bones that reduce weight.
- Have strong keel-shaped breast bone (sternum), to which the flight muscle is attached to.
- Have feathers, which are light, and smoothly shaped body.
- Have efficient four chambered heart.

a) b) c)

Figure 1.13 a) *showing air lifting*, b) *an airplane*, c) *a bird flying*

Fish versus Submarine

Do submarines relate to fish?

The practice of human swimming has been known since prehistoric times. The earliest record of swimming dated back to Stone Age paintings from around 7,000 years ago. The first submarine appeared during the 19th century (Figure 1.14). Obviously, fish came earlier than the submarines, which are constructed by humans. Beyond doubt, humans tried copying the body plan, structures and functions of fish into submarines long ago.

a)

b)

Figure 1.14 a) *A swimming fish* and b) *Submarine*

Activity 1.5

Library reading. Go to your school library

- in group, research on the study of Icarus.
- research the early attempts made by people who worked under water in huge bells containing air.

Exercise 1.4

Choose the best answers for the following questions.

1 Which of the following functions like our eyes?

A microscope C camera

B handlens D A and B

2 Which of the following is made possible by observing birds?

A submarine C Car

B an aeroplane D B and C

3 Which of the following machines moves like a millipede?

A tank C train

B excavator D A and B

4 A boat looks like a

A duck C frog

B tortoise D Lizard

5 A robot is analogous to

A dog C human

B monkey D cat

1.5 Values in Biology Education

By the end of this section, you will be able to:

- identify values developed in learning science;
- maintain a more proactive environmentally conscious population.

Both the theoretical and practical activities during biology lessons will give you the opportunity to develop different values. Biology, as an experimental science, involves activities like critical thinking, reasoning and problem solving.

Did You Know?

- Values in education are principles, rules or standards of behavior that are realized in school life and afterwards.
- Biology education similar to other science is intended to achieve the three major educational objectives, which include the development of values, skill and knowledge.

Nowadays, biology education has received special attention due to its rapid progress and its influence on our daily lives.

Biology raises a wide range of issues (for example, ethics in relation to using animals during experiment, conservation of nature, environmental protection, sustainable development). These issues can serve as a base for an economically efficient, socially reasonable and environmentally sustainable development (see Figure 1.15 and Table 1.4).

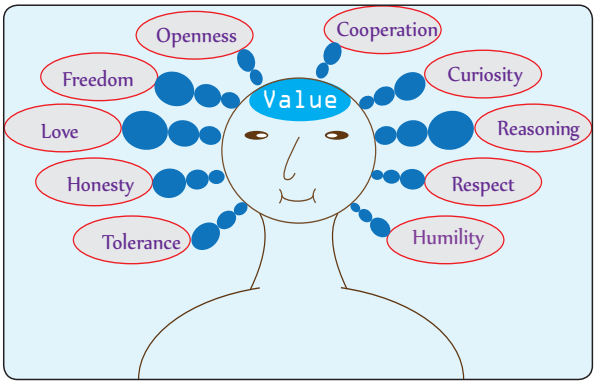


Figure 1.15 Values developed in biology education

Table 1.3 Values you can develop by learning biology

Curiosity	Curiosity is the strong desire of learning more, which is the driving force to develop skills that enable success in the study of the subject and beyond.
Love	Biology gives the chance to value life, living things and the environment. While learning biology we develop love and compassion for life, humanity, living things and environment.
Freedom	As a branch of science, while you are studying biology you will practice the freedom of thinking and expression of your observation.
Honesty	Honesty is very important in science. As a young science student you have to honestly collect, organize, analyze and summarize your data.
Respect	Learning about living things and environment at school is usually being done in groups, during which you learn and practice how to interact with others and respect the ideas of others.
Cooperation	Group activities in a class while learning science are strong foundations for the collaborative nature of scientific and technological works. It is important to develop respect for others and to learn from one another.
Tolerance	While working in a group during biology lesson you will develop the quality of tolerating the view of others.
Humility	Humble way of listening to what others are saying, respecting and accepting the view of others: and accepting ones mistakes and weakness.
Reasoning	In science to make a conclusion or a summary one needs to critically evaluate and develop sense of pattern among pieces of information collected.
Openness	During science lesson you should not restrict yourself to what you are only told, without examining it. You should be open-minded to learn more than limiting yourself to what you only learn in the class.

Exercise 1.5

Choose the best answers for the following questions.

1 The interest that one develops to know about things around is known as
   A humility
   B curiosity
   C reasoning
   D cooperation

2 The determination that one shows to keep going until getting a solution is
   A honesty
   B respect
   C tolerance
   D love

3 The values that you give to the natural environment and people around you is _____.
   A respect
   B openess
   C freedom
   D all of the above

4 The loyality and humbleness that one shows in all activities is called
   A freedom
   B openess
   C cooperation
   D respect

5 The power to be critical of yourself and the information that you collect is called _____.
   A cooperation
   B reasoning
   C humility
   D honesty

Unit Summary

- Biology is a natural science that studies living things (life).
- Biology is divided into many branches, such as botany, zoology, micro biology, cytology, ecology, physiology and genetics.
- Biology is related with chemistry, physics, geology and other sciences.
- Biological knowledge is utilized in various industries such as agriculture, medicine and food science.
- In agriculture, biological knowledge is useful to utilize fertilizers, pesticides and weed killers to increase crop productivity. Biology is also useful in determining soil composition, identifying plant growth requirements, practicing crop rotation and soil preservation.
- In medicine biological knowledge is utilized in making drugs to combat diseases, and in food industries, to supply the right quality and quantity of nutrients in the diets.
- Biology is relevant to human society in aspects of health, nutrition, environment and population.
- In relation to health, biology is useful in using drugs against diseases, effect of drug abuse, recognizing the physiology of healthy people, determine the effects of antiseptics and disinfectants.
- Regarding nutrition biology plays important roles to classify foods, identify nutrients, determine sources of nutrients and balanced diet.

- Biology is relevant for the environment in many ways including practice in good farming, preventing species loss, avoiding deforestation, preventing pollution and also in conserving natural resources.
- Biology is relevant to world population growth and enables provision of medical care, immunization and avoiding harmful traditional practices.

Review Exercise for Unit 1

Part I: ***Choose the best answers for the following questions***

1 The study of living things is the concern of
- A Chemistry
- B Physics
- C Biology
- D Geology

2 The concern of taxonomy is
- A Classifying living things
- B Naming living things
- C Identifying living things
- D All of the above

3 Which branch of science studies the chemical substances in nature?
- A Physics
- B Chemistry
- C Mathematics
- D Taxonomy

4 Which of the following field of studies does not require the knowledge of biology?
- A Agriculture
- B Electricity
- C Medicine
- D Nutrition

5 Biology is needed for a human society to improve
- A health
- B nutrition
- C life style
- D all of the above

6 Which of the following innovations is derived from biological knowledge?
- A Bicycle
- B Airplane
- C Train
- D Television

7 A good scientist has to be
- A curious
- B dishonest
- C incooperative
- D intolerant

8 All natural sciences are
- A interacting
- B overlapping
- C interrelated
- D all of the above

Part II: ***Match the items in column 'B' with items in column 'A'***

	Column A		Column B
9	Antiseptic	A	Aspirin
10	Disinfectant	B	Global
11	Drugs	C	Reasoning
12	Value	D	Alcohol
13	Pollution	E	Shisha

Part III: *Fill in the blanks with appropriate terms.*

14 Humans invented _____ by copying the flying of birds.

15 As retina is to an eye a film is to _____.

16 A food that contains a healthy proportion of the six nutrients is _____.

17 Humans invented a _____ by copying the swimming ability of fish.

Part IV: *Give short answer to the following questions.*

18 Define biology?

19 List down bad agricultural practices.

20 What is the risk of trying to fly like birds? Why?

Part V: *Word search.*

Think about some words related to the relevance of biology to the society. Can you find them in the word search table below? Look down, diagonally and sideways. Be careful, some words overlap and some are written diagonally.

C	B	G	Z	D	S	T	A	E	T
T	P	I	U	R	X	C	W	N	E
X	D	O	M	U	E	J	U	P	C
D	U	M	I	G	W	T	K	Q	H
V	U	M	L	Q	R	E	M	R	N
S	H	U	W	I	L	X	T	Y	O
V	B	O	T	A	N	Y	S	X	L
A	S	I	Y	L	P	N	T	M	O
H	O	N	E	S	T	Y	Z	I	G
N	T	E	X	V	O	L	D	N	Y

Unit 2

Cell Biology

Unit Outcomes

By the end of this unit, you will be able to:

- *define microscopes;*
- *classify them into simple and compound;*
- *identify their parts and tell the functions of each part;*
- *define cell, list parts of plant and animal cells seen under a compound microscope;*
- *tell the functions of each part and compare a plant cell with an animal cell;*
- *examine plant and animal cells under a microscope and draw and label the structures seen under a microscope; and*
- *show types, shapes, and sizes of cells using diagrams.*

Main Contents

2.1 Microscope and its Uses
2.2 The Cell
2.3 Observation of Cells
2.4 Cell Type, Shape and Size
Unit Review

Introduction

Is discovery of cells related to invention of microscope?

Biologists use different types of instruments to study life and life systems. Microscope is one of the most important tools that biologists use to study living things. In fact, it is the invention of microscope that led to the discovery of cells. Cells are the smallest units from which all life forms are made. Both multi-cellular organisms, like you, and an eucalyptus tree, and single-celled organisms like amoeba, paramecium and bacteria are made up of cells.

Microscope is a very useful instrument which is used to observe and study different types of cells. With a microscope biologists not only observe cells but also identify their type, shape and size.

In the following sections you will learn more about the types, parts and uses of compound light microscope.

2.1 Microscope and its Uses

By the end of this section, you will be able to:

- define microscope;
- classify microscope into simple and compound;
- identify parts of a microscope;
- tell the functions of parts of a microscope.

Did You Know?

- Electron microscope magnifies up to 100,000 x of the sample size under study.
- Most cells are less than 50 µm (micrometer = 1/1000 mm) in diameter, much smaller than the dot at the end of this sentence.

When were cells first detected?

Today we commonly get used to think of living things as being composed of cells. However, the word was not used until the seventeenth century. The first observation of cells was made in 1665 by the English scientist *Robert Hooke*. Hooke, using a microscope of his own invention, observed and named it cell. But, he did not understand its significance. In 1673, *Anton van Leeuwenhoek*, a Dutch merchant pioneered the invention of one of the best microscopes of the time. He was the first to observe, draw, and describe a variety of cells including bacteria, other one-celled organisms and sperm cells.

Word Roots and Origins

Microscope: is made up of two smaller Greek words. Micro which means small and, scope meaning to 'look' or 'see'.

What is a microscope?

A microscope is an instrument that is used to observe objects too small to be seen clearly with the naked eye. Microscope uses lenses or system of lenses to produce a magnified image of an object under study. The science of investigating small objects using such an instrument is called *microscopy*. Microscopic means invisible to the eye unless aided by a microscope.

Have you ever had a chance to see and use a microscope? Tell your experience to the class.

What is the use of a microscope?

A microscope offers a chance to closely study and learn more about smaller organisms. Even if biology is one of the oldest in the history of science, recognition of cells came very late. The use of magnifying lenses was vital for their recognition and study (see Figure 2.1).

Figure 2.1: Students observing a sample under a microscope

Types of Microscopes

A microscope enlarges the size of the object observed so that it looks bigger than its actual size. This is called *magnification*.

There are two types of microscopes. These are *simple microscope* and *compound microscope* (see Figure 2.2).

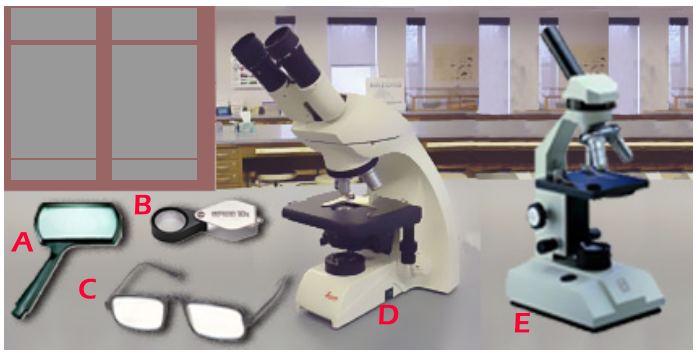


Figure 2.2: Different types of simple microscopes: **A)** and **B)** *magnifying lenses;* **C)** *reading lenses;* **D)** *binocular two eyepieces* and **E)** *monocular (single eye piece)*

Key Terms

- ☑ **Monocularcompound microscope:** A compound microscope with single eye piece lens.
- ☑ **Binocular compound microscope:** A compound microscope with two eye pieces.
- ☑ **Microscope:** an optical instrument used to observe very small objects.
- ☑ **Microscopic:** very small objects which are only viewed with microscope.
- ☑ **Magnification:** ability of a microscope to enlarge the size of the specimen.
- ☑ **Lens:** a piece of glass used to converge or diverge light and form optical images.

What is a simple microscope?

A *simple microscope* consists of a single convex lens that is capable of magnifying an object. A microscope which consists of only one curved lens is simple microscope. A hand lens is an example of simple microscope. The magnifying glass, reading lens and hand lens magnify between 10 times to 20 times (*usually written as* 10X *to* 20X). It means that the object you are looking through these simple microscopes will appear 10X larger than its normal size (see Figure 2.3).

Did You Know?

When an object is magnified with a microscope, it looks bigger, but its true size remains the same.

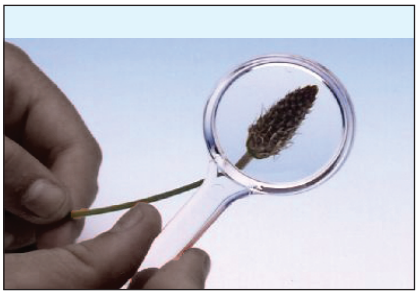


Figure 2.3: Observation of sample with a hand lens

Activity 2.1

Observing different plants using hand lens

Materials you require:

- ☑ Hand lens
- ☑ Flowers from different plants (from rose and chrysanthemum plant)
- ☑ Leaves from different plants
- ☑ Body parts of small insects (like house fly, ants and grasshopper)

Procedure:

1. Collect flowers and leaves from different plants and bring samples of insects to the laboratory.
2. Pick your hand lens and the objects you are going to observe.
3. Sit in an area with good lighting or sunlight.
4. Observe the flower from a rose plant (try to observe the anther and the stigma) with your naked eyes and note what you observe.
5. Hold the rose plant flower on the opposite side of the hand magnifier from your eyes.
6. Move the object or the hand lens until you are able to see clearly through the lens and draw what you see.

Important: while you look through the lens, hold the object close to the hand lens or magnifier, probably less than an inch away (see Figure 2.3).

7. Do the same for the other samples you have brought to the class or laboratory; and note the difference between what you have observed with your naked eyes and with the hand lens.

Also observe the skin at the back of your hand, and note the difference between your observation with the hand lens and with your naked eye.

What is a compound microscope?

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 eyepiece lens usually magnifies ten times and is labeled 10X. The objective lenses magnify four to hundred times. The total magnification is the product of the eye lens and objective lens magnifications. For example, if the magnification of the eye lense is 10X and the magnification of the objective lense is 4X, then the total magnification is 40X.

Did You Know?

Recent models of compound microscope can have a total magnification up to 2,000X.

Activity 2.2

Discussing total magnification.

In groups, discuss the total magnification of a compound microscope. Take as an example a medium power objective and an eyepiece lens with a 10X magnifcation.

Parts of a Compound Microscope

The compound light microscope is a type of microscope which is commonly used in many laboratories. This light microscope consists of different parts through which the sample under study is magnified and observed.

Table 2.1 is based on the diagram of the compound microscope. The column on the left lists the parts, and the column on the right gives its function. See also Figure 2.4 to help you identify the parts.

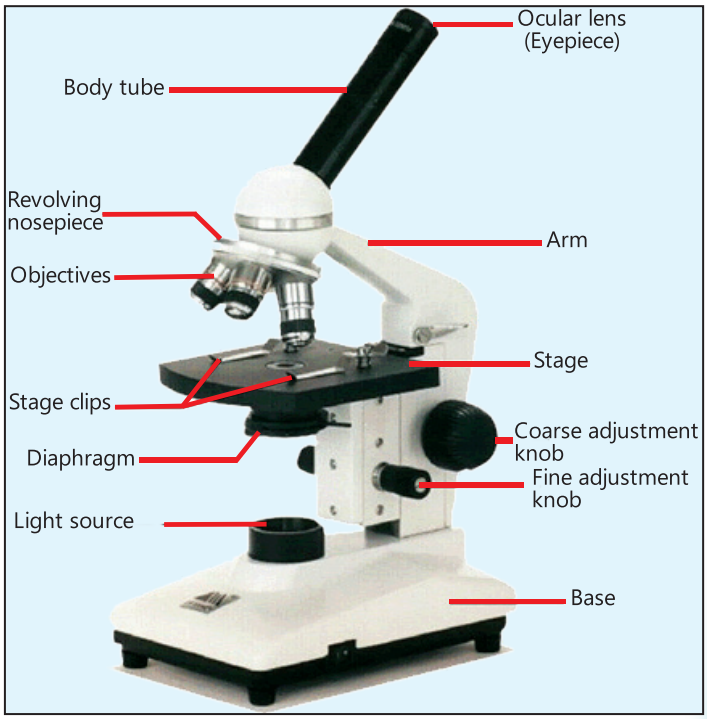


Figure 2.4: Compound light microscope and its parts

Table 2.1: The compound microscope parts

Structure (part)	Function (job)
Ocular (eyepiece lens)	A convex lens used to magnify the image (usually 10X)
Body tube (barrel)	Supports the eyepiece and the nosepiece.
Coarse adjustment knob	Moves the tube up and down and produce a rough focus of the image.
Fine adjustment knob	Moves the tube up and down by very small amount and produce a sharp focus of the image.
Arm	Used to carry the microscope.
Nosepiece	Contains the high- and low-power objectives.
Low-power objective lens (LP)	A convex lens used to magnify the image (usually 4X)
Medium-power objective (MP)	A convex lens used to magnify the image (usually 10X)
High-power objective lens (HP)	A convex lens used to magnify the image (usually 40X)
Oil immersion objective	A convex lens used to magnify the image (usually 100X)
Stage	Supports the glass slide and contains the specimen being observed.
Stage clips	Hold the slide in place.
Diaphragm (iris)	Adjusts the amount of light passing through the stage.
Light source (lamp or mirror)	Illuminates the specimen.
Base	The bottom of the microscope, used for support.

N.B: Your teacher will provide you with a microscope so that you can identify the parts and their functions.

Mounting: is preparing a specimen for observation under a microscope.
Focusing: is adjustment of focus to observe specimen clearly.

Activity 2.3

Practicing mounting and focusing

Materials you require:

- ☑ Clean slide and cover slip
- ☑ A dot on a piece of paper
- ☑ Dropper with nipple
- ☑ Forceps
- ☑ Water in a beaker
- ☑ Compound light microscope

CAUTION

- *Specimen to be observed under a microscope should be thin enough to pass light through it.*
- *Slides and cover slips should be clear because dirt can interfere and confuse the observation.*
- *If your specimen is too thick, then the cover slip will swing on top of the sample like a see-saw.*

Procedure:

1 Lay down the piece of paper with a dot on a clean microscope slide as shown in the diagram. (Figure 2.5)

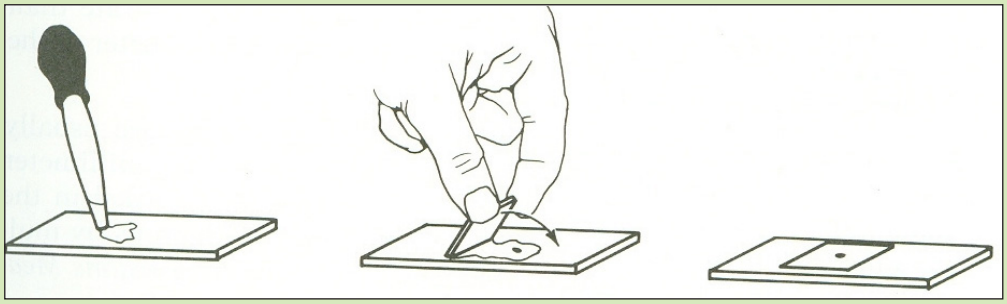


Figure 2.5: Illustration showing how to place the cover slip on the sample

2 Place one drop of water directly over the specimen and cover it with a cover slip.

3 If you put too much water over the specimen, cover slip will float on top of the water. This makes it harder to observe the specimen!

This process, if done correctly, there should be no air bubble trapped in the water between the slide and the cover slip.

☑ Air bubbles confuse the observer.

☑ Cover slips protect objective lens and keep the specimen in position.

4 Place the slide on the microscope stage, with the specimen directly over the center of the glass circle on the stage (directly over the light).

5 Always start and end with Low Power objective. Lower the objective lens to the lowest point, then focus using first the coarse knob, then with the fine focus knob.

6 Adjust the Diaphragm as you look through the Eyepiece, and you will see that more detail is visible when you allow in less light! Too much light will give the specimen a washed-out appearance. Try it out!!

7 Once you have found the specimen on low power, then, without changing the focus knobs, switch it to medium power. Move the object or the hand lens until you are able to see clearly through the lens.

8 Once you have it on Medium and High Power remember that you only use the fine focus knob! (Never use the oil immersion lens).

9 Click the high power objective lens in position and only use the fine adjustment knob to focus on specimen. At this point, if the specimen is too light or too dark, try adjusting the diaphragm.

10 Then, focus using the fine adjustment for sharp focusing. Do not use the coarse adjustment/

11 Is the dot compact or diffused? Draw it.

Exercise 2.1

Choose the best answer for each of the following questions

1 One of the following is not the function of a microscope.
- A Magnifying the image of the sample.
- B Showing the details of the sample.
- C Enabling one to observe something difficult to see with naked eye.
- D Enlarging the size of the sample.

2 Which of the followings is a simple microscope?
- A Compound binocular microscope.
- B Compound monocular microscope.
- C Hand lens.
- D A microscope with eye piece and objectives.

3 Why are a hand lens and a compound microscope known as light microscopes?
- A Because they produce light.
- B Because they use light as a source of energy.
- C Because they are not heavy in their weight.
- D None of the above.

4 A simple microscope consists of?
- A three lenses
- B two lenses
- C one lens
- D four lens

5 Magnification power of a microscope is related to its ability to:
- A increase the size of the image.
- B showing the fine details of the sample.
- C resolving the image.
- D all of the above.

2.2 The Cell

By the end of this section, you will be able to:

- define cell as the smallest unit of life;
- list parts of plant and animal cells seen under a compound microscope;
- tell the functions of parts of plant and animal cells seen under a compound microscope;
- compare a plant cell with an animal cell.

Word Roots and Origins

The word "Cell" come from Latin word, cellula, means "small room".

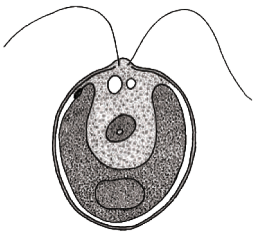
The cell is the basic structural and functional unit of all living organisms. Most cells are very small in size. Since they are so tiny they can only be seen with the aid of a microscope. Your body is composed of billions of cells! Can you estimate the number of cells in an elephant?

Did You Know?

Our body is made up of trillion (10^{13}) of cells

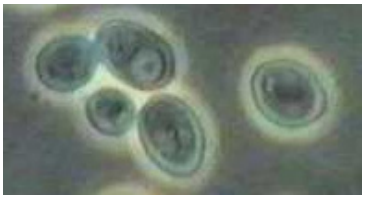
What is a cell?

A cell is the smallest unit of life and is often called the building block of life. All plants and animals are made up of one or more cells. Based on the number of cells they have, organisms can be grouped as unicellular (*consisting of a single cell*) or multicellular (*made up of many cells*). Unicellular organisms are those organisms composed of one cell. Examples of unicellular organisms include different bacteria, most algae and protozoans such as, amoeba and paramecium (see Figure 2.6).



a) *Chlamydomonas (an alga)*

b) *Paramecium (a protozoa)*



c) *Yeast (Fungi)*

e) *Amoeba (a protozoa)*

d) *Rod shaped bacteria*

f) *Euglena (Protozoa)*

Figure 2.6: Different unicellular organisms

Multicellular organisms: plants and animals are examples of multicellular organisms. Within your body, cells have different functions. You have blood cells, skin cells, brain cells, heart cells and many types of other cells.

Plants are multicellular organisms, for instance, a rose plant has also different types of cells: like stem cells, root cells, and many other types. Despite their differences, cells in living organisms have similar structures and functions.

Did You Know?

Every living thing - from the smallest bacterium to the largest whale - is made of one or more cells.

Under a compound microscope a cell is observed to have three main parts. These are cell membrane or plasma membrane, cytoplasm and nucleus (see Figure 2.7).

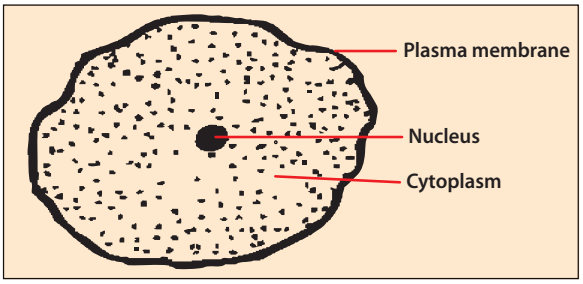


Figure 2.7: Common parts of cells (*structure of an animal cell*)

Key Terms

- ☑ **Unicellular organism:** an organism which is made up of a single cell.
- ☑ **Multicellular organisms:** an organism which is made up of many cells.
- ☑ **Cell membrane:** part of a cell, which is very thin and delicate envelope (membrane) that covers and contains the internal parts of a cell.
- ☑ **Cytoplasm:** the internal fluid component of the cell.
- ☑ **Nucleus:** part of a cell and found within the cytoplasm. It is membrane bound structure which contains the genetic material of the cell.

Activity 2.4

Comparison of unicellular and multicellular organisms

- ☑ In groups, discuss the differences and similarities between unicellular and multicellular organisms. You may consider the difference between yourself and an amoeba.
- ☑ What is the difference between you and an amoeba?
- ☑ What are the common feature(s) between you and an amoeba?

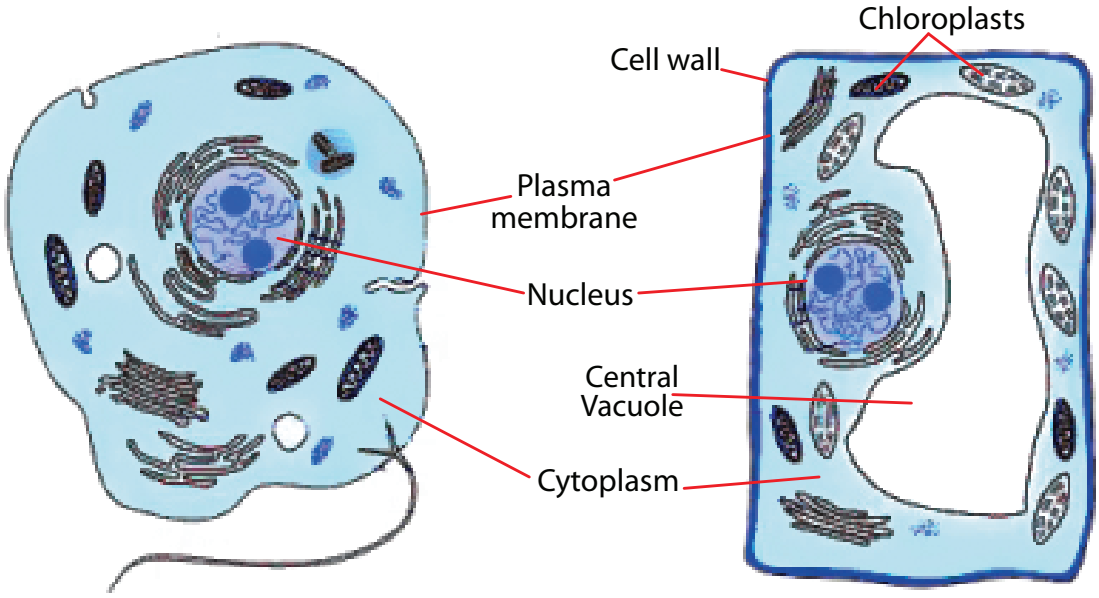
Structures of Plant and Animal Cells

What are the common cellular parts of both animal and plant cells?

Cells, the tiny structural units of life, are made up of different parts. The parts of cells are known as sub-cellular structures or organelles. Different sub-cellular structures carry out different functions in cells. When observed under compound microscope, both animal and plant cells have common cellular parts (see Figure 2.8a and b). The three main parts that can be seen under a compound microscope are:

- ☑ the cell membrane (*plasma membrane*)
- ☑ an inner region called the cytoplasm and
- ☑ the nucleus

In fact, animal and plant cells share some more common features like the cell membrane, nucleus and cytoplasm. The cell membrane controls materials that get in and out of the cell. The nucleus controls reproduction and the activities of the cell. The cytoplasm contains different sub-cellular structures in which chemical processes take place.



a) *Animal cell* b) *Plant cell*

Figure 2.8: Parts of animal and plant cells

Comparing Plant and Animal Cells

Do animal and plant cells have different parts?

Animal and plant cells have some key similarities (Figure 2.7) and differences as well (Figure 2.8; Table 2.2). One of the primary differences between animal and plant cells is that plant cells have a cell wall made up of cellulose. Plant cells have chloroplast, which contains the chlorophyll pigment in which they make their own food in the process known as photosynthesis. Although both animal and plant cells have vacuoles, the vacuoles in plant cell merge together at maturity and form large vacuole.

Table 2.2: Differences between plant and animal cells

Animal cells	Plant cells
• Cells are smaller in size • Have no cell wall • Have no large central vacuole • Have no chloroplast	• Cells are larger in size • Have cell wall • Have large central vacuole • Have chloroplast

Did You Know?

Cells differ from each other within the body of an organism according to their function.

Key Terms

- **Vacuole:** a smaller cavity which is both found in animal and plant cells.
- **Large vacuole:** large-sized which is only found in mature plant cells.
- **Cell wall:** a rigid and protective external cover of plant cells, which is made up of cellulose.
- **Chloroplast:** sub-cellular part of plant cells which contains chlorophyll and in which photo-synthesis takes place.
- **Chlorophyll:** a green pigment found in chloroplast and responsible for absorption of light by plants to provide energy for photosynthesis.
- **Photosynthesis:** the process in which plants use sunlight energy to synthesize food from carbon dioxide and water.

Activity 2.5

Comparison of Animal and Plant Cells

- ☑ In groups, compare and contrast animal and plant cells. Show your comparison (similarities and differences) in a table form.
- ☑ What do you think is the possible reason for the absence of chloroplast in root cells?

Exercise 2.2

Choose the best answer for each of the following questions.

1 One of the following is true about cells.
- A Cells are generally too small to be seen with the naked eye.
- B Cells are the structural and functional units of all life forms.
- C Cells are the smallest units that carry out all process of life.
- D All of the above

2 One of the following is part of a cell and only found in a plant cell?
- A Cell membrane
- B Cell wall
- C Cytoplasm
- D Nucleus

3 One of the followings is a characteristic of a unicellular organism.
- A It is made up of many cells.
- B It is made up of a single cell.
- C It requires the assistance of other cells for its biological activities.
- D It is seen with the naked eyes.

4 One of the followings is a unicellular organism.
- A A tree
- B A cat
- C A man
- D A bacterium

5 One of the following parts of a cell is common to all type of cells.
- A Cell wall
- B Large vacuole
- C Small vacuole
- D Chloroplast

2.3 Looking at Cells

By the end of this section, you will be able to:

- examine plant and animal cells under a microscope;
- draw and label the structures of plant and animal cells seen under a microscope.

In the previous sub-unit you have been familiarized with parts of a microscope and their functions. Now, you will practice observing different cell samples obtained from different organisms under compound light microscope. This will give you the opportunity to observe different types of cells.

Precaution to be Exercised When a Using Microscope

- ☑ Make sure the working table is clean and without any unnecessary items.
- ☑ When the microscope is not in use, place the low power objective in position.
- ☑ Avoid tilting the microscope and do not touch lenses with your finger.
- ☑ Carry the microscope by the arm with one hand and support its base with the other hand.
- ☑ Treat your microscope respectfully and according to proper instructions.

General Procedures on How to Set a Microscope

- ☑ Put the microscope on the working table, keeping the arm towards yourself and stage away.
- ☑ The base of the microscope should be kept several centimeters away from the edge of the table.
- ☑ Rotate the nosepiece to make the low power objective in line with the body tube.
- ☑ By using the coarse adjustment, raise the body-tube about 2 cm above the stage.
- ☑ Open the diaphragm of the condenser for passing the light on the stage.
- ☑ Look through the eyepiece, adjust the light source so that it is directed upwards.
- ☑ Do not use coarse adjustment when viewing through the high power objective.
- ☑ Keep the microscope always in upright position.

What are pollen grains?

Pollen grains are male reproductive cells of plants, which are equivalent to the mammalian sperm cells.

Activity 2.6

Observing pollen grains under a microscope.

Materials you require:

- ☑ Compound microscope
- ☑ Microscope slides
- ☑ Flowers
- ☑ Cover slip
- ☑ Beaker with dropper

Procedure:

1. Gather some pollen from a flower.
2. Place it on a slide.
3. Cover with cover slip and observe the pollen under the microscope.
4. Draw the cells you see on your note book.

Activity 2.7

Making a Wet Mount

Materials you require:

- ☑ Compound microscope
- ☑ Microscope slides
- ☑ Flowers
- ☑ Cover slip
- ☑ Beaker with dropper
- ☑ Water

Procedure:

1. Gather some pollen from a flower.
2. Place it on a slide and add a drop of water.
3. Cover with cover slip and observe the pollen under the microscope.
4. Draw the cells you see on your note book.

Key Terms

- ☑ **Scanning objective:** the low power objective used to scan the slide in order to spot the specimen to be observed.
- ☑ **Specimen:** a sample to be examined under the microscope.
- ☑ **Stain:** a dye used to color and make visible the whole or part of specimen under the microscope.
- ☑ **Wet mount:** a process during which water is used as mounting medium to examine specimen under study.
- ☑ **Pollen grains:** are male reproductive cells of plants, the botanical equivalent of the mammalian sperm.

What are Stains?

Not all parts of cells are observed clearly while examining cellular samples under a microscope. Certain parts of cells will be observed clearly only when samples are stained. Stains are coloring agents. Staining is the process of adding stains or dyes to specimen while observing the specimen under a microscope. Adding stains make the whole or parts of the sample colored and render it easy to be examined.

What are plant epidermal cells?

Generally, the surface of the leaf is covered by thin layers, which are tough skin cells (called the *epidermis*); the upper and lower epidermis. The epidermis is made of a single layer of cells.

Did You Know?

An onion is an edible bulb, which is made up of many layers of modified leaves. The surface of each leaf is covered by a thin layer of cells, the epidermis.

Activity 2.8

Observing onion epidermal cells

Materials you require:

- ☑ Compound microscope
- ☑ Forceps
- ☑ Microscope slides
- ☑ Iodine solution
- ☑ Onion
- ☑ Eye dropper
- ☑ Cover slips
- ☑ Beaker with water

Procedure:

1. Place a drop of water in the middle of a clean slide.
2. Using forceps, gently remove a section of the skin from the inside layer of the onion and place it on the slide on a drop of water.
3. Put the cover slip over the top gently using the forceps to hold it.
4. Observe through the microscope (*by first using low-power and then focusing under medium-power*).
5. Did you see cells?
6. Put two drops of iodine solution closer to one side of the cover slip, and leave the solution to diffuse for some minutes.
7. Observe under low and medium power objectives. Compare your specimen with Figure 2.9 below.
8. Which structures of a cell can be seen under a light microscope?
9. Draw one cell and label all the parts identified.

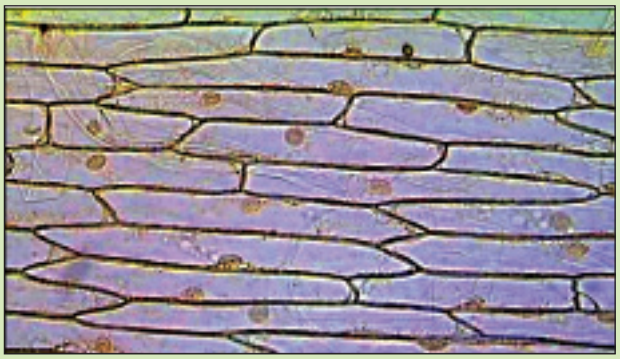


Figure 2.9: Image of onion epidermal cells see under a microscope

Activity 2.9

Observing the Epidermis of Elodea (Water Plant)

Materials you require:

- ☑ Compound microscope
- ☑ Forceps
- ☑ Microscope slides
- ☑ Elodea
- ☑ Iodine solution
- ☑ Eye dropper
- ☑ Cover slips
- ☑ Beaker with water

Procedure:

1. Place a drop of water on the slide again, and put an Elodea (water weed) leaf in the water.
2. Put the cover slip in place as you did before and observe the leaf through the microscope.
3. Observe a cell under low power and medium power.
4. Make a drawing of the cell and label all of the structures that you see. Compare with Figure 2.10.

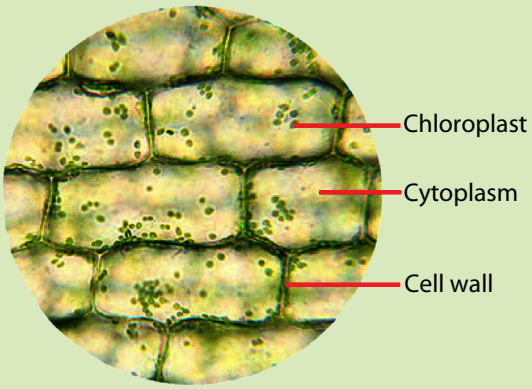


Figure 2.10: Elodea leaf cells seen under a microscope

- ☑ What cellular structures did you observe?
- ☑ Compare onion epidermal cell and Elodea leaf epidermal cell.

What is the shape of cheek cells?

Unlike plant cells, all animal cells lack the rigid and protective cover, the cell wall. As a result of the absence of cell wall in animal cells, they look irregular in their shapes. Due to having a cell wall, plant cells have regular rectangular shapes (*plant epidermal cells*). Remember, you are going to observe your own cells, cheek cells.

Key Terms

- ☑ **Epidermis:** the outer layer of tissue in plants.

Activity 2.10

Observing Animal Cells (Cheek Cells)

Materials you require:

- ☑ Compound microscope
- ☑ Microscope slides
- ☑ Methyl blue
- ☑ Eye dropper
- ☑ Cover slips
- ☑ Toothpicks
- ☑ Beaker with water

Procedure:

1. Place a drop of methyl blue in the middle of the slide.
2. With the end of the toothpick scrap the inside of your cheek, then stir the toothpick in the methyl blue, then cover it with a cover slip.
3. Observe starting with the low power objective and working up to the high power objective. Compare your specimen with Figure 2.11.

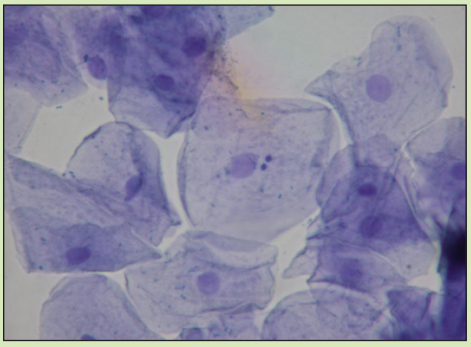


Figure 2.11: Cheek cells observed under the microscope

4. Make a drawing of one or more cells and label all of the structures that you see.
   - ☑ Can you now distinguish the nucleus, the cytoplasm and the cell membrane?
   - ☑ Compare the size, shape, position of the nucleus of the cheek cell and onion epidermal cell.

Exercise 2.3

Choose the best answer for each of the following questions

1. What is pollen grain?
   - A Small plant.
   - B A flower.
   - C Part of pistil.
   - D Part of stamen.
2. One of the following is true about onion epidermal cells observed under a microscope.
   - A Are flat and regular in their shapes.
   - B Irregular in their shapes.
   - C They look green without staining.
   - D Are flat and irregular in their shapes.

3 One of the following is true about cheek cells observed under a microscope, they:

A look green without staining.

B are irregular in their shapes.

C are flat and irregular in their shapes.

D are flat and regular in their shapes.

4 Wet mounting is:

A permanent mounting.

B mounting procedure without water.

C mounting procedure with water.

D similar to staining.

5 Stains are used during microscopic observation of cellular structures is to:

A enlarge the size of the image.

B make some parts of cells coloured and easily observable.

C make the specimen to be observed more beautiful.

D resolve the parts of the cell.

2.4 Cell Type, Shape and Size

By the end of this section, you will be able to:

- show types, shapes, and sizes of cells using diagrams.

Key Terms

- ☑ **Muscle cell:** a cell that forms a muscle tissue and which is tapered at both ends for easy contraction and relaxation.
- ☑ **Skin cells:** epithelial cells that cover our body and are thin and flat.
- ☑ **Nerve cell:** a cell that is involved in transmission of nerve message, which is long and branched.
- ☑ **Red blood cells:** very small in size and nearly circular in shape.

The cell is the smallest unit of living things that can carry out all processes of life. Not all cells are alike. In the previous sub-unit you have seen that there are differences between animal and plant cells (see Figure 2.8). Even cells within the same organism show differences in type, size, and shape.

Cell Type

Do different types of cells exist?

Not only cells of different organisms, but also cells within the same organism are different. The cells that form our body are of different types. Some of the cells that compose our body include skin cells, red blood cells, nerve cells, bone cells, muscle cells and many others (Figure 2.12).

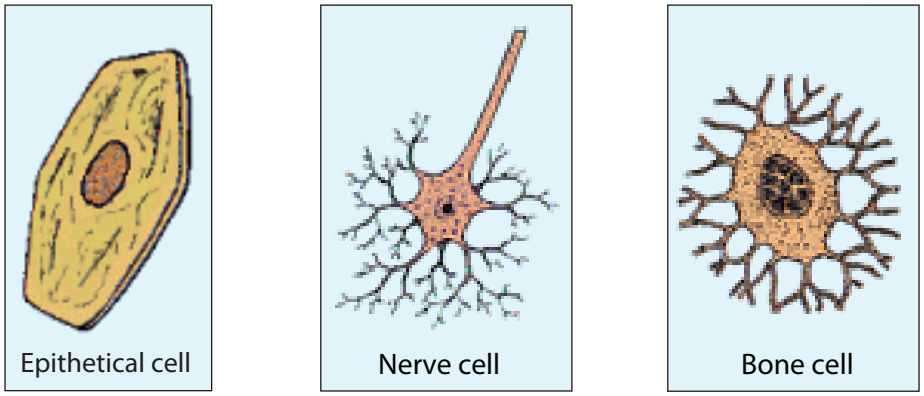


Figure 2.12: Different cells that form part of our body

Cell Shape

Are there differences in shape among cells?

Shapes of cells of different unicellular organisms vary (see Figure 2.6). For instance the shape of Paramecium is slippery, yeast cells's shape is oval, amoeba's shape is shapeless, and chlamydomona's shape is round. You may take as a second example of shape of cells that make our body, a nerve cell is long and branched, skin cells are flat and thin, red blood cells are round disks, and muscle cells are pointed at both ends.

Key Terms

- **Regular shape:** the defined shape (rectangular/hexagonal) of plant cell is due to the presence of the tough and rigid external cover, the cell wall.
- **Irregular shape:** absence of defined shape in animal cells, is due to lack of cell wall in animal cells.

Cell Size

Do cells differ in their size?

Majority of cells are microscopic in their size. There is diversity in size among cells that form the same organism. If we take the same example, our body, different cells in our body vary in their size (see Table 2.3). Eggs of animals including that of humans are exceptionally big size as compared to other microscopic cells.

Table 2.3: Some different types of cells, their shapes and sizes

Cell Type	Size in Micrometer (µm) (1 µm or 1/million of mm)	Cell Shape
Red blood cell	9	Round disk
Human egg	100	Oval
Amoeba	90	Shapeless
Most of our cells	10-30	Different
Frog egg	2 mm	Circular

Did You Know?

One of the longest cells is the giraffe's nerve cell that extends from spinal cord to its feet, which is about 2 m long.

Activity 2.11

Associating variation in cells to their functions

Materials you require:

- ☑ drawings on your text and some more provided by your teacher.
- ☑ drawing from your previous activities (Activity 2.6 and 2.7).

Procedure:

In groups, discuss the possible reason why cells that form our body vary in their type, size and shape. Present your summary to the class (use specific types of cells in our body when presenting your summary).

Exercise 2.4

Choose the best answer for the following questions

1 One of the following statements is true about all cells.

A They are similar in their size.

B They are similar in their shapes.

C They are similar in their size and shape

D They vary in their sizes and shapes.

2 One of the following is true about cells in our body.

A They are all similar in their sizes, shapes and types.

B They are different in their shapes, sizes and types.

C They are all different only in their sizes but similar in their shapes and types.

D They are all different only in their shapes but similar in their sizes and types.

3 A nerve cell in a human body can be characterized as:

A circular in shape.

B pointed at both ends.

C long and branched.

D flat and round.

4 The shape of a muscle cell is:

A circular.

B branched.

C flat.

D pointed at both ends.

5 Skin cells are:

A circular.

B pointed.

C flat and thin.

D rounded.

Unit Summary

- Cells are generally microscopic in their size.
- Cells are the smallest biological units that carry out all processes of life.
- All organisms are made up of cells.
- Unicellular organisms are those organisms that are made up of single cell.
- Multicellular organisms are those organisms that are made up of many cells.
- All cells commonly have cell membrane, cytoplasm, and nucleus.
- Unlike animal cells, plant cells have additional cellular parts like cell wall, chloroplast and large vacuole.
- Because of the presence of cell wall, plant cells have regular shapes when observed under the microscope.
- Because of the absence of cell wall, animal cells have irregular shapes when observed under the microscope.
- Cells of different unicellular organisms vary in their shapes and their sizes.
- Cells that make up a multicellular organism like us, are different in their sizes, shapes, and types according to their functions.

Review Exercise for Unit 2

Part I: ***Choose the best answer for each of the following questions.***

1 One of the following cell structure is not seen through a light microscope.

A Nucleus.

B Cell membrane.

C Ribosome.

D Cell wall.

2 The magnification power of low power objective is:

A 10X

B 4X

C 40X

D 100X

3 One of the following is the function of condenser.

A Magnifying the image

B Scatering the image

C Collecting light and passing it through the stage openings

D Holding a specimen at the stage.

4 One of the following is true about coarse adjustment. It is used to:

A focus under high power objective.
B adjust the amount of light.
C focus under low power objective.
D move back and forth the stage of the microscope.

5 One of the following makes a plant cell different from an animal cell?

A Cytoplasm
B Cell wall
C Nucleus
D A and B only

6 One of the following is found in both animal and plant cells.

A Chloroplast
B Large vacuole
C Cell wall
D Cell membrane

7 The regular shape of plant cells which is observed under the microscope is due to having:

A vacuoles
B cell membrane
C cytoplasm
D cell wall

8 Plant cells manufacture their own food due to the presence of a cell part known as:

A vacuole
B cell membrane
C chloroplast
D cell wall

9 The shape of a human red blood cell is:

A disk-like
B flat
C short and branched
D pointed at both ends

10 The sizes of most of our body cells are about:

A 1 µm
B 1 mm
C 100 µm
D 20 µm

PART II: *Match items given in column 'B' with items given in column 'A'*

	Column A		Column B
11	Coarse adjustment knob	A	Sharp focusing
12	Plant cell	B	With out large vacuole
13	Animal cell	C	Inner region of a cell
14	Cell membrane	D	Rough focusing
15	Fine adjustment knob	E	Outer region of a cell
16	Cytoplasm	F	With large vacuole

Part III: *Fill in the blank spaces with correct answer.*

17 The ability of the microscope that makes the specimen appear large is known as _____.

18 The objective lenses of a compound microscope are _____ , _____, _____ , and _____.

19 Cell membrane allows materials get _____ and _____ of the cell.

Part IV: *Give short answers for the following questions.*

20 Why do we use stains?

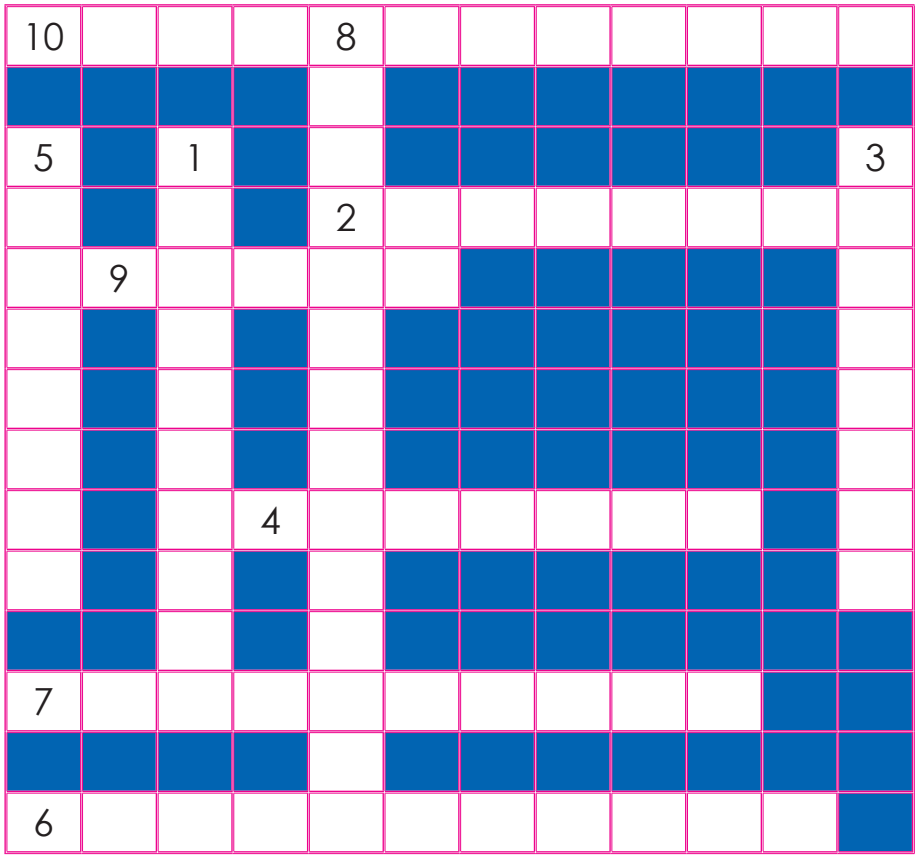
21 What structures make plant cells different from animal cells?

22 Where do you find sub-cellular structures of a cell?

23 Which parts of a microscope are used for focusing the image of a specimen?

24 How do unicellular organisms differ from multicellular organisms?

Part V: *Copy the crossword puzzle below and use the numbered clues to complete and solve the puzzle.*



The numbers in the bracket indicate the number of letters in each word.

Across

2 Controls cell reproduction (7)

4 Cell cavity with fluid filled cavity in a cell (7)

6 Cell structure for photosynthesis (11)

7 Instrument used to see small objects (10)

9 A dye used to identify cell parts (5)

10 Cell part for materials enter and leave a cell (12)

Downward

1 Contains sub-cellular structures (9)

3 Preparing specimen for observation through a microscope (8)

5 Protects plant cell (8)

8 Enlarges image of specimen (13)

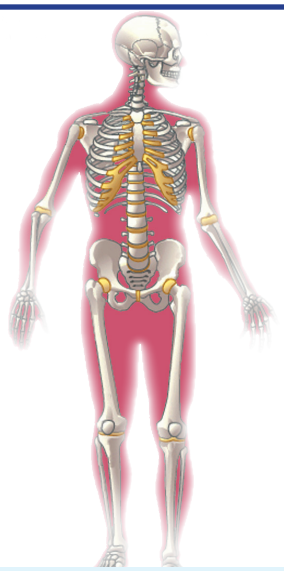
Unit 3

Human Biology and Health

Unit Outcomes

By the end of this unit, you will be able to:

- *describe the structure and functions of human skeleton and divide it into axial and appendicular skeleton;*
- *list types of bones and joints, state their functions, give examples for each and demonstrate by using models;*
- *list types of muscles, explain their structures and functions and demonstrate how they work using models;*
- *describe how muscles and the skeleton work together;*
- *describe the importance of physical exercise and proper diet for health of bones, muscles and joints;*
- *name the different types of human teeth and relate them with their functions;*
- *define dental formula;*
- *show the dental formula of humans and compare it with that of some other animals.*



Main Contents

3.1 The Muscular and Skeletal Systems

3.2 Human Dentition

Unit Review

Introduction

Human beings are able to walk, run, play sports, work and do exercises. All of these activities are carried out because of the interaction of the skeletal and muscular systems. The human skeleton is similar in design to the skeletons of other vertebrates (*animals with an interior spinal column*). All vertebrates (including *mammals*, *birds*, *fish*, *reptiles*, and *amphibians*) have a spine, a skull and ribs. A spine supports their body, a skull protects their brain, and ribs protect their heart and lungs.

As in humans, skeletons give animals their shape and ability to move in particular ways. Skeletons can give us clues about the way an animal lives. For instance, some animals (like a *rabbit*) need to run very fast. Such animals have very long, large back legs compared to the rest of their body. The bones of bats and most birds are very thin and lightweight, making it easier for them to fly.

The other creatures are invertebrates that do not have a skeleton inside their body. A few types of invertebrates (such as *insects*, *spiders*, and *crabs*) have a special exoskeleton (*a hard outer casing*) on the outside of their bodies. However, most invertebrates (including *mollusks*, *worms*, and *sponges*) do not have a skeleton at all. Since the skeletal system works with the muscular system, this unit deals also with the types and functions of muscles.

Because the human teeth development and arrangement is related to the skeleton this unit also deals with the types and functions of teeth.

3.1 The Muscular and Skeletal System

By the end of this section, you will be able to:

- divide human skeleton into axial and appendicular skeleton;
- describe the structure and functions of human skeleton;
- list types of bones;
- give examples of each type of bone;
- list types of joints;
- tell the functions of each type of joint;
- classify joints into movable and immovable;
- demonstrate movable joints using models;
- list types of muscles;
- explain the structure and functions of muscles;
- demonstrate how muscles work using models, describe how muscles and skeleton work together;
- describe the importance of physical exercise and proper diet for the health of bones, muscles and joints.

Can you define a skeleton?

The skeleton is the entire collection of bones inside our body. See Figure 3.1 below that shows the human skeleton.

Did You Know?

* There are 206 bones in adult human body.

Activity 3.1

Investigating the human skeletal system.

Materials you require:

A drawing or a model of the skeletal system.

Procedure:

- ☑ in groups, examine the drawings of the human skeletal system; and
- ☑ identify the axial and the appendicular skeleton.

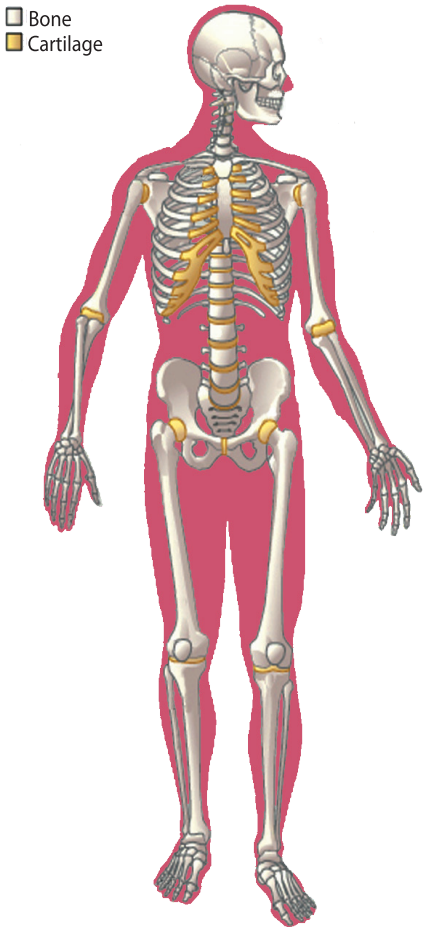


Figure 3.1: The human skeleton

Axial and Appendicular Skeleton

What are the parts of the skeletal system?

The bones of the skeleton can be categorized into two: the *axial* and *appendicular skeleton*.

What is the axial skeleton?

The part of the skeleton along the axis of the body is the axial skeleton. The axial skeleton consists of *Skull*, *Sternum*, *Ribs* and *Vertebral column* (see Figure 3.1).

What is the Skull?

The *skull* is a bony outline of the head formed from *cranial* and *facial* bones. The cranium protects the brain. However the facial bones provide structure for the upper and lower jaws, cheeks and nose.

What is Sternum?

The *sternum* is the breast bone found in the middle of the rib cage attached to it by cartilage.

What are Ribs?

The *Ribs* are 12 pairs of thin and flat bones. They are slightly curved and connected to sternum in the middle of the chest. The ribs form a protective cage around the internal organs in the upper body.

What is the vertebral column?

The *vertebral column* also referred to as the back-bone or spine vertebral column is extending from the end of skull to the pelvis (hip). The vertebral column serves to connect all other bones of the skeleton and support the body.

The vertebral column with its continuous hollow tube keeps the spinal cord in and protects it.

Key Terms

- **Cranial bones** are parts of the skull serving as brain case.
- **Facial bones** are parts of the skull that maintain the shape of the face.

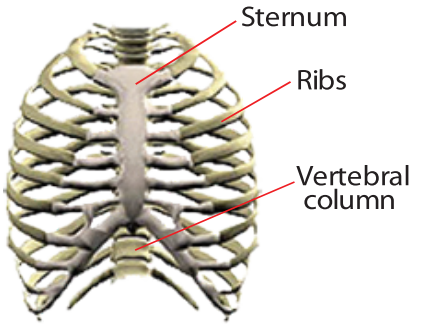


Figure 3.2: The human rib cage

Did You Know?

* The ribs help you to breath.

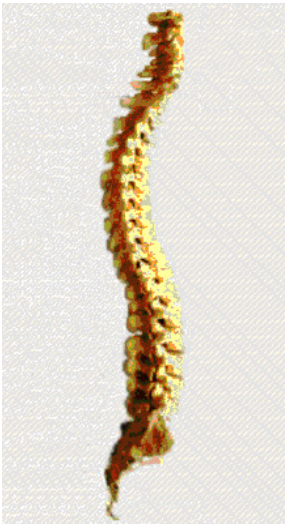


Figure 3.3: The vertebral column

Activity 3.2

Looking at the axial skeletal system of humans

Materials you require:

A drawing or a model of the axial skeletal system

Procedure:

- ☑ in groups, examine the drawing or model of the human vertebrae, skull, and chest, then
- ☑ identify the bones of the vertebral column.

Key Terms

- ☑ **Axial skeleton** is the axis of the skeletal system.
- ☑ **Appendicular skeleton** is the appendage of the skeletal system.
- ☑ **Skull** is part of the axial skeleton with the bones of head and face.
- ☑ **Sternum** is breast bone at the center of the chest cavity.
- ☑ **Ribs** are chest bones that form the chest cavity.
- ☑ **Vertebral column** contains back bones that give support to the other body parts.

What is the appendicular skeleton?

The second category of the human skeleton is called the *appendicular skeleton*. It supports the limbs and connects them to the axial skeleton. It is composed of all the bones of *shoulder*, *hip* and *limbs or appendages*.

Word Roots and Origins

Skeleton from Greek word skeleton, dried body.

What are shoulder bones?

The shoulder bones are composed of clavicle and scapula. The *clavicle* or *collar bone* is connected to the sternum in front while the *scapula* bone is at the back (see Figure 3.4).

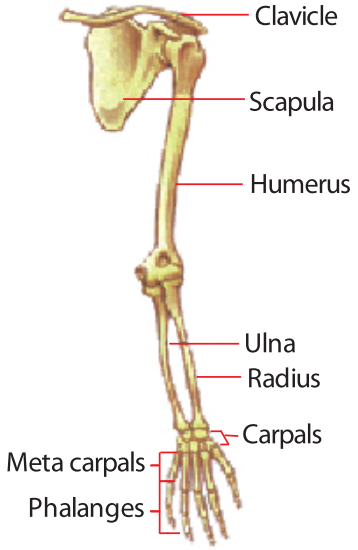


Figure 3.4: The shoulder and fore limb

What are limbs or appendages?

The *fore limbs* are the front limbs that refer to the arms, the forearms and the hands. It consists of various bones (See Figure 3.4). These bones are: *Humerus* (upper arms), *Radius* (inner lower arm), *Ulna* (outer lower arm), *Carpals* (wrists), *Metacarpals* (hands) and *Phalanges* (fingers).

What are hip bones?

The hip bones are also known as *hip girdle* and composed of two hip bones.

What are the hind limbs?

The *hind limbs* are the back limbs or appendages and consist of different bones (See Figure 3.5). These bones include: *Femur* (upper leg or thigh), *Tibia* and *Fibula* (lower legs or shin), *Patella* (kneecap) *Tarsals* (ankles), *Metatarsals* (feet), and *Phalanges* (toes).

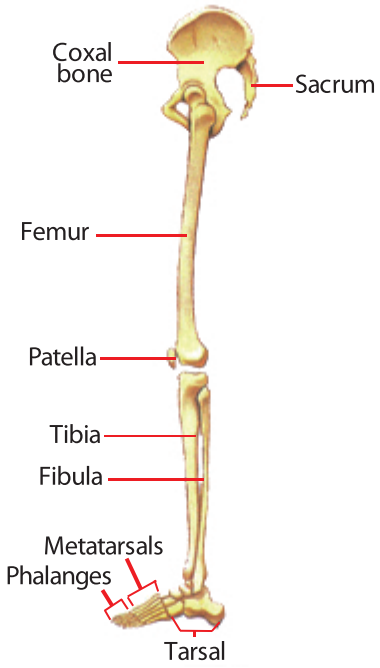


Figure 3.5: The hip bones and hind limb

Activity 3.3

I Looking at the pectoral and pelvic girdles and appendages

- ☑ in groups, examine the bones of the appendicular skeleton, and
- ☑ identify the shoulder bone and hip bone and appendages.

II Constructing models of the human skeleton

Method

- ☑ in groups, construct a model for a human skeletal system using paper or other local materials.
- ☑ try to trace on card board, by cutting and connecting them in the appropriate position.
- ☑ label each bone.

Word Roots and Origins

Appendicular from latin word appendicula, appendage.

Structures and Functions of the Skeleton

What does the skeleton do?

The skeletal system is one of the major systems of the human body, and has four major functions:

- ☑ it *protects vital organs*, such as the brain, heart, and lungs.
- ☑ it *supports the body* and *gives* us our distinctive *shape*. Without our skeleton, we would look more like a slug.
- ☑ it *allows us* to *move* in particular ways.

Did You Know?

- ✶ Hydrostatic pressure or water inside the body of small plants and animals serves as a skeleton.
- ✶ Femur is the largest while stapes (ear bones) are the smallest bones.
- ✶ When humans are born they have around 350 bones, but have only 206 bones at adult stage. What is the reason?

- it *makes new blood cells* to maintain a healthy bloodstream.

The skeletal system, besides providing support, movement, and organ protection, is also the storage area for substances. It stores calcium phosphate that is needed for blood clotting, nerve function, and muscle activity. With so many important jobs to do, the skeleton is a vital part of the human body.

Types of Bones

Can you list down types of bones in our body?

Bones are living organs. They are made up of *living cells*. These are cells surrounded by hard and dead *mineral substances* with an outermost layer of *thin membrane*. The cells enable bones to grow and repair themselves while the minerals give strength and shape. The membranes are supplied with nerve and blood vessels to nourish the bone. Bones are the strongest materials in the body but only represent about 14 percent of a body's weight.

Do our bones have the same size and shape?

Bones of the skeleton vary in shape and size so do in their structure. Based on their structures bones can be grouped into:

- ***Long bones*:** are compact bones with hollows or cavities filled with yellow bone marrow. Their ends contain spongy bones covered with cartilage for cushion. They are designed for strength. Upper and lower limb bones are the best examples of long bones.
- ***Short bones*:** are compact bones with chambers or partitions but without marrow. Bones of fingers and toes are some examples.

Did You Know?

- Limbs compose more than 50% of our bones in number.
- Clavicle are the most commonly broken bone in the body.
- Bones continue to grow until people are 18-25 years old.

Word Roots and Origins

Pectoral from Greek word pechys, for arm.

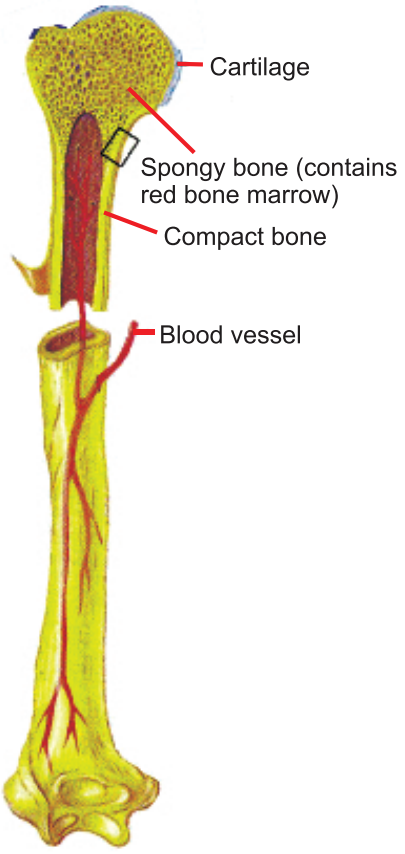


Figure 3.6: Anatomy of long bones

Flat bones are compact bones that have no cavity or hollow. Examples are bones of ribs, sternum and scapula.

The outermost layer is a thin membrane containing nerves and blood vessels that nourish the bone. On the surface there are small holes for entry and exit of materials in and out of the bones.

Activity 3.4

Classifying bones of cattle in accordance with size and strength

Materials you require:

Bones of cattle

Procedure:

- ☑ in groups, collect bones of cattle from a butcher or a village, and
- ☑ identify and classify the bones according to their types size and strength.

What is a bone marrow?

In many bones the middle part holds *bone marrow*. Bone marrow makes new red blood cells for the body. Not all bones contain marrow.

To keep our bones strong and healthy, we should be able to get plenty of *calcium* in our diet. Calcium is the most abundant metallic mineral element in the human body, and 99% of it is stored in the bones. Along with building strong bones, calcium also helps your heart, muscles, and nerves function.

Key Terms

☑ **Bone marrow** is soft structure in the bones where blood cells are made.

Types of Joints

What are the types of joints in our body?

The place where two bones meet is called a *joint*. Joints have two main jobs to perform. One is to keep bones far apart so that they don't rub together. The other job is to hold the bones in place as they move or rotate.

What is an immovable joint?

There are two different types of joints: *fixed* (*immovable*) joints (see Figure 3.7) and *movable* joints (see Figure 3.8).

- In an *immovable joint*, the bones are fixed in place and do not move at all. The skull has many of these joints. Although it looks like one solid piece of bone, it is actually made up of bones fused together with fixed joints.
- ***Moving joints*** allow a person to twist and bend. Some moving joints allow us to move a lot and others only allow us to move a little.

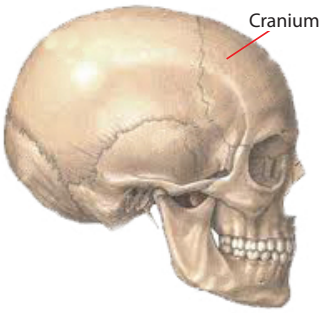
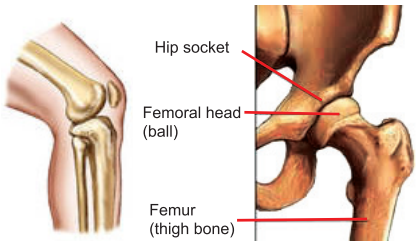


Figure 3.7: Immovable joint (skull)

There are two main kinds of moving joints.

- A ***hinge joint*** is like a hinge on a door, allowing movement back and forth in a single direction. Elbows and knees have hinge joints, as do fingers and toes.
- A ***ball and socket joint*** is made of the round end of one bone (the "*ball*") fitting into a cup-shaped socket in another. Such joints allow movement in all planes (in every direction). Shoulders and hips have these joints.



a) *Hinge joint* b) *Ball and socket joint*

Figure 3.8: Types of moveable joints

- ***Gliding joints*** allow sliding surface movements between adjacent bones. Vertebrae bend our neck and waist by gliding movements.
- ***Pivot joints*** allow twisting movements. For instance, when someone is saying 'yes' or 'no' using his/her head. Another occurs when a person twists a screw driver. You can turn your head and look up and down because of this joint.

Activity 3.5

Discussion on the Types of Joints

- in groups, write down the different types of joints.
- discuss the type of movement allowed by each type of joint.
- give example for each from your body.
- make model joints.

What is a ligament?

Bones are held together at the joints by stretchy bands of tissue called *ligaments*. In between the bones of a joint, there is a firm, rubbery tissue called *cartilage*. Cartilage supports and cushions the bones, acting like the body's natural shock absorber. It also gives shape to boneless parts of our body like our ears and noses.

Activity 3.6

Constructing models of different types of joints

Materials you require:

Cardboard, papers, and glue.

Procedure:

- ☑ Observe carefully the types of joints and then cut the cardboard or any thick paper accordingly, and
- ☑ Put them together or connect them.

Structures and Function of Muscles

Did You Know?

* Our body is made up of over 600 muscles.

What are muscles?

In unit two, you have learnt about cells. Now, in this sub-unit you are going to learn about a particular tissue, i.e., *muscle*, *its structures*, *types* and *functions*.

Muscles are tissues composed of cells that are called *muscle fibers*.

Muscles are needed for all types of *movement*. They are also needed to pump blood, breathe, produce body heat, regulate body temperature, and protect internal organs.

Figure 3.9: The muscular system

Types of Muscles

What are the types of Muscles?

There are three types of muscles in human body. They are skeletal muscles, the smooth muscles and cardiac muscles.

Skeletal Muscles

What are skeletal muscles?

***Skeletal muscles*:** are muscles attached to the bones of the skeleton by tissues called *tendons*. They are capable of permitting body movement. When these muscles contract, skeletal parts move. The contraction of the skeletal muscles is under conscious or voluntary control and occurs faster than other muscles (see Figure 3.10).

Smooth Muscles

What are smooth muscles?

***Smooth muscles*:** are muscles found in the walls of viscera (*intestine, stomach*, and *other internal organs*) and blood vessels. Their contraction is involuntary and contract more slowly than the skeletal muscles. However, they can remain contracted for a long time. They are not connected to bones (see Figure 3.11).

Cardiac Muscles

What are cardiac muscles?

***Cardiac muscle*:** is found only in the walls of the heart. Unlike the skeletal muscles its contraction is involuntary for the most part. Its contraction pumps blood and accounts for the heart beat (see Figure 3.12).

Key Terms

- ☑ **Skeletal muscles** are muscles found attached to the skeleton.
- ☑ **Smooth muscles** are muscles found attached to the internal organs.
- ☑ **Cardiac muscles** are muscles found in the heart.
- ☑ **Tendons** are connective tissues that connect bones to muscles.

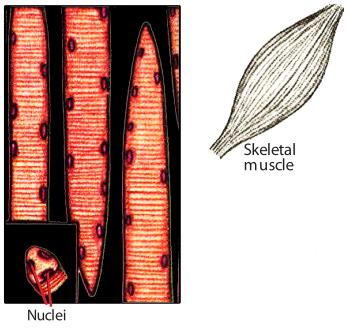


Figure 3.10: Skeletal muscles

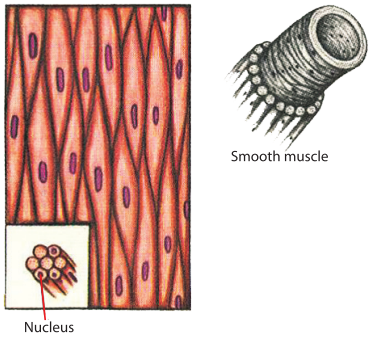


Figure 3.11: Smooth muscles

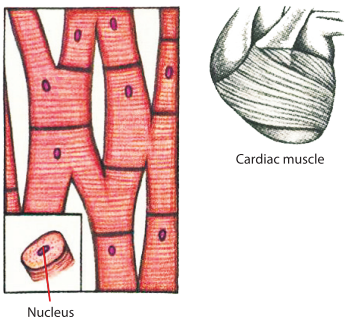


Figure 3.12: Cardiac muscle

Did You Know?

Heart never rests and beats between 2 and 3 billion times in a person's life time

How do muscles work?

When muscles are involved in body movement, they actually work in pairs in antagonistic manner. While one muscle in the pair contracts the other must relax. For instance, if you were to bend your arm at the elbow, the following sequence of events would take place. The biceps contracts and bulges and at the same time the triceps relaxes (see Figure 3.13). You can see the bulge in your arm as the biceps contract.

To lower the arm to the original position, the muscles work in reverse of what was just described. The biceps relax while the triceps contract. Try this by yourself!

In your heart also, when the upper chamber (*auricles*) contract, the lower chambers (*ventricles*) relax.

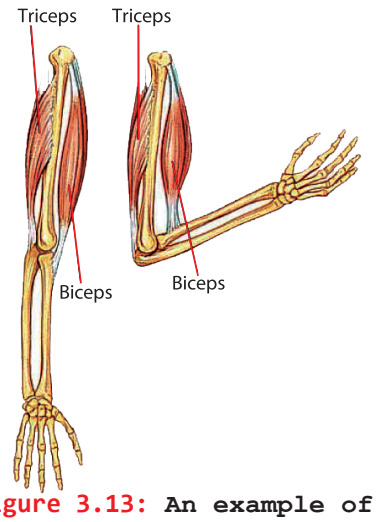


Figure 3.13: An example of antagonistic function of muscles

Activity 3.7

Looking at how muscles work

- ☑ in groups, use two bones from models you have constructed before.
- ☑ attach coiled wires to the bones to their front and back sides.
- ☑ move one of the bones up and down while holding the other.
- ☑ observe what is happening to the coils.
- ☑ how do you associate this to the action of skeletal muscles?

Muscles and Skeletal Health

Do our skeleton and muscles require health care? Yes, they do.

To take proper care of your skeletal and muscular systems, there are three things you can do. You should do physical exercise; have a healthy diet; and plenty of rest.

How does physical exercise affect muscle and skeletal health?

Exercise is needed to help muscles and skeleton grow and develop. When muscles and skeleton are not used, they shrink and become weaker and smaller. Exercise helps to keep muscles strong. Physical exercise can improve muscular and skeletal strength, endurance and flexibility in all adults regardless of age (see Table 3.1).

Key Terms

- ☑ **Antagonistic muscles** are a pair of muscles that work oppositely.
- ☑ **Biceps** are the front muscles of the upper arm.
- ☑ **Triceps** are the back muscles of the upper arm.
- ☑ **Involuntary muscles** are muscles that are not under conscious control.
- ☑ **Voluntary muscles** are muscles that are under conscious control.
- ☑ **Striations** are bands or lines formed by actin and myosin fibers in muscle cells.
- ☑ **Contraction** is the shortening of muscles.
- ☑ **Relaxation** is the stretching of muscles.

Table 3.1: Recommended physical exercise for different age groups

Children 7-12	Teenagers 13-18	Adults 19-55	Elders>55
Vigorous activity for 1-2 hours	Vigorous activity for 3-5 times a week	Vigorous activity for 1/2 hrs, 3 times a week	Moderate exercise 3-4 times a week
Free play	Build muscles with physical exercise	Exercise aerobics, stretching exercise	Plan a daily walk
Develop motor skill of Team sports, dancing, swimming	Pursue tennis , swimming, horseback riding	Take active vacation, bicycle, cross country	Daily stretching exercise
Encourage more exercise outside HPE	Continue team sports, dancing	Join a running club, bicycle club, outing group	Try low-impact aerobics

HPE: Health and Physical Education

How does a proper diet help muscle and skeletal health?

A proper diet helps your bones and muscles get the nutrients needed for their healthy growth and functions. Meat supplies proteins needed for cell growth and the creation of new cells. Dairy products supply minerals, such as calcium, that are needed to make bones strong and hard. Fruits and vegetables provide vitamins like vitamin D that are good for bone structure. Breads and cereals provide carbohydrates and minerals for muscles to move the bones.

How does rest help skeletal and muscle health?

Rest is also critical to good health. When muscles move, food molecules are burned and waste products are left behind in the muscles. Rest provides an opportunity for the circulatory and excretory system to remove these wastes. Rest also helps prevent muscles from being overused.

Activity 3.8

Discussion on the importance of physical activities and proper diet for healthy muscles and skeleton

☑ In groups, discuss and suggest exercises required to keep muscles and skeleton healthy.

Exercise 3.1

Choose the best answers for one of the following questions.

1 One of the following is part of the axial skeleton?

A skull C tibia

B humerus D metatarsals

2 Which of the following is part of the appendicular skeleton?
A vertebrae C sternum
B ribs D metacarpals

3 The pectoral girdle consists of the bones of:
A collar and scapula C tibia and fibula
B radius and ulna D wrist and ankle

4 The hind limb consists of:
A tibia C femur
B metatarsals D all of the above

5 Which of the following bones are found in both fore and hind limbs?
A wrist C ankle
B phalanges D ribs

6 Knee is an example of which type of joints:
A ball and socket C pivot
B gliding D hinge

7 Ball and socket joints are found in the:
A hip C elbow
B shoulder D A and B

8 As the ribs protect the lungs, _____ protects the brain.
A facial bones C sternum
B cranium D metacarpals

9 Which type of bones is wrongly paired with its example?
A long bone-humerus C short bone-vertebrae
B flat bone-ribs D A and B

10 One of the following is wrong?
A Skeletal muscles move skeletal bones.
B Smooth muscles are found in blood.
C Cardiac muscles work life long.
D Muscles work antagonistically.

3.2 Human Dentition

By the end of this section, you will be able to:

- mention the different types of human teeth;
- relate types of human teeth with their functions;
- define dental formula as a short way of indicating the numbers, types and arrangement of teeth;
- show the dental formula of humans;
- compare human dental formula with that of some other animals.

What are teeth?

Before you learn human dentition it will be helpful to see the structures of tooth for your understanding of the lesson (see Figure 3.14).

Teeth of humans and other animals are hard structures that grow from jaw bone. These teeth are used to bite and chew food. Each tooth consists of crown, neck and root. A crown is the part above the gum level. A neck is the part surrounded by gum; and a root is the part embedded in jaw bone. The crown is a surface for biting food and composed of outer layer enamel. Both root and inner part of the root contain a living substance dentine. A tooth is also composed of a central region called pulp cavity that contains nerves and blood vessels.

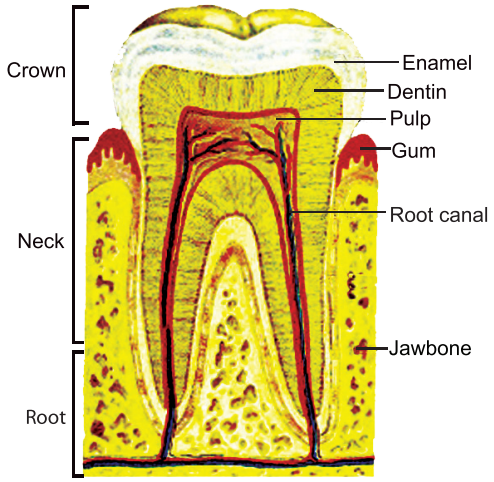


Figure 3.14: Structure of a tooth

Activity 3.9

Identifying parts of a tooth

Materials you require:

Model or drawing of teeth.

Procedure:

- ☑ in groups, identify parts of a tooth, and
- ☑ label the parts.

What are milk and permanent teeth in humans?

Humans grow two sets of teeth in their lives. The first set has 20 teeth called *milk teeth*. Milk teeth loosen and fall out when a child is about 6 years old. The second set has 28 teeth that replace the milk teeth and are called *permanent teeth*. When a person is around 20 – 25, four additional back teeth grow called *wisdom teeth*.

This development and arrangement of teeth is known as *dentition*. It differs among mammals according to their feeding habit.

Key Terms

- ☑ **Dentition** is the arrangement and development of teeth in the mouth.
- ☑ **Gum** is the flesh that covers the jaw.
- ☑ **Crown** is the white part of a tooth seen above the gum.
- ☑ **Enamel** is the hardest outer covering of the crown.
- ☑ **Dentine** is the living tissue of a tooth.
- ☑ **Pulp cavity** is the inner part of a tooth, with blood vessels and nerves.
- ☑ **Root** is the part of the tooth that is inserted into the jaw.

Types of Human Teeth

Can you list the types of human teeth?

Humans have four types of teeth (see Figure 3.15.) These are:

- ***Incisors*:** are front teeth with chisel edge.
- ***Canines*:** are side teeth beside incisors and with pointed edge.
- ***Premolars*:** are side teeth behind the canines with fairly flat ridges having depressions.
- ***Molars*:** are far back side teeth with wider and stronger ridges having depressions.

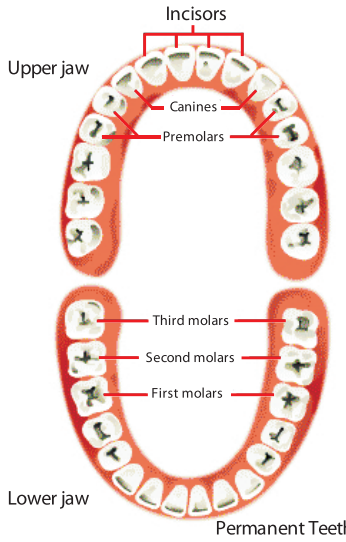


Figure 3.15: Types of Teeth

Activity 3.10

Looking at different types of teeth

Materials you require:

Models or drawings of teeth.

Method:

- In groups observe closely the types of teeth in humans.
- Notice the different types of teeth and label them.
- Write their respective functions.

Key Terms

- **Milk teeth** the first and replaceable set of teeth.
- **Permanent teeth** the second and non replaceable set of teeth.
- **Wisdom teeth** the last four teeth that appear in adulthood.
- **Upper jaw**: jaw in the upper row.
- **Lower jaw**: jaw in the lower row

Functions of Each Type of Teeth

Can you tell the functions of each type of teeth?

There is correlation between the type of tooth and its function. Each type of tooth is suitable for its function.

- ***Incisors*** being chisel-shaped used for biting, cutting and gnawing food. They function as scissors.
- ***Canines*** as they are sharp pointed used for tearing and piercing food. They function as pincers.
- ***Premolars*** because they have flat ridges used for grinding.
- ***Molars*** since they have wider and stronger ridges are used for crushing and grinding foods.
- Both *molars* and *premolars* function as grinders.

Dental Formula

How do you define dental formula?

Dental formula is a short way of indicating or representing the number of teeth, type and arrangement. It shows the number and type of teeth in one half of the upper and lower jaws. In dental formula each type of tooth is symbolized by the first letter of its name. Also, the types and number of teeth are written according to their location in the mouth from the front to the back sides. As a result, incisors (I) are the first, canines (C) the second, premolars (P) the third and molars (M) the last.

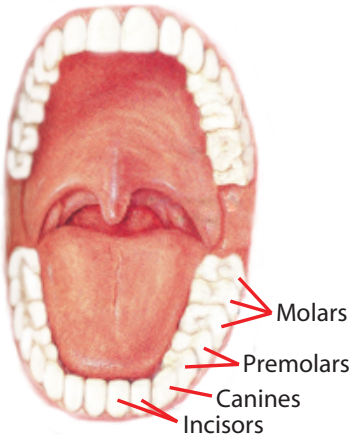


Figure 3.16: Dental formula of humans

How do you write dental formula of a mammal?

Dental formula of a given mammal can be written by counting the number and type of teeth in one half of the upper and lower jaws. From Figure 3.16, the dental formula of an adult human is:

$$I = 2/2,\ C = 1/1,\ P = 2/2\ M = 3/3$$

Therefore, the total number of teeth in a given mammal can be calculated. First add the number of teeth in upper and lower jaws, and then multiply each jaw by two. Finally, sum up the product. For instance we can calculate the total number of teeth in adult human as follows:

$$\frac{2+1+2+3}{2+1+2+3} = \frac{8}{8},\ \frac{8\times 2}{8\times 2} = \frac{16}{16}$$

Total teeth $= 16 + 16 = 32$

Library Reading 3.1

Go to the library and read about the dental formula of different mammals then, answer the following questions.

1. Write down the dental formula of a cat, a dog and a cow.
2. Explain why dental formula differs among mammals.
3. Can you write the dental formula of human milk teeth and calculate the total number of teeth?

Did You Know?

- *Enamel* is the hardest substance in our body
- *Lower incisors* are the first to grow out in childhood.

Exercise 3.2

Choose the best answers for each of the following questions.

1 Which of the following types of teeth function as scissors?

A Molars C Canines
B Premolars D Incisors

2 Types of teeth with the widest upper surface are:

A Molars C Canines
B Premolars D Incisors

3 The shapes of teeth in humans is related to their:

A size C function

B location D A and B

4 The dental formula of mammal is representing the number and type of:

A teeth in one half of the upper jaws

B teeth in one half of the lower jaws

C full set of teeth in the mouth

D A and B only

5 Which of the following shows the formula for incisors in the dental formula of an adult human?

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

6 Compared with the dental formula of human, a mammal having a dental formula $\frac{0123}{3123}$ is having

A less number of incisors C more number of molars

B less number of canines D less number of molars

Unit Summary

- In this unit, we have first taken a brief look at the skeletal and muscular systems of the human body.
- Each of these systems is important to the functioning of our complex bodies.
- The skeletal system of humans has axial and appendicular parts.
- The axial includes the skull, sternum, ribs and vertebrae bones.
- The appendicular comprises the pectoral girdle (clavicle and scapula), limbs (fore and hind) and pelvic girdle (hip) bones.
- The skeletal system carries out five important functions.
- It provides structure and framework for the entire body, allows movement, protects vital tissues and organs inside the body, stores some substances needed in body activity, and produces new blood cells.
- The skeletal system is structurally composed of bones, cartilage, joints, tendons and ligaments.
- Bones are living organs made up of cells surrounded by hard minerals of calcium phosphate.
- Bones can be long, short and flat.
- Joints are junction of bones which can be movable or immovable.
- Movable joints can be hinge, ball and socket, gliding, and pivot.
- The muscular system makes movement possible by working with the skeletal system.
- There are three types of muscles. They are skeletal, smooth, and cardiac muscles.
- Skeletal muscles are voluntary muscles attached to skeleton for movement.
- Smooth muscles are involuntary muscles that are found in internal organs (lung, intestine) and blood vessels.
- Cardiac muscle is found in the heart to pump blood.
- Skeletal muscles are found in pairs and work in antagonistic manner; when one contracts the other relaxes.

- Programmed Physical training and proper diet with good rest are needed for the health of the skeletal and muscular system.
- Dentition is the development of teeth and their arrangement in the mouth.
- The four types of teeth in human dentition are Incisors, Canines, Premolars and Molars.
- The four types of teeth vary in their shape and are suitable for their functions.
- Dental formula represents the number and type of teeth in one half of the upper and lower jaws.

Review Exercise for Unit 3

Part I: ***Choose the best answers for each of the following questions***

1 Axial skeleton does not include

A Clavicle C Vertebrae
B Skull D Ribs

2 The shoulder consists of clavicle and

A cranium C scapula
B skull D sternum

3 The rib cage consists of the bones of the ribs and

A humerus C patella
B skull D sternum

4 Bones are attached to one another with a tissue called _____.

A ligaments C cartilage
B tendons D joints

5 Which of the following types of muscles never tire?

A Smooth muscles C Skeletal muscles
B Cardiac muscles D Ligaments

6 The up and down movement of the head is an example of one of the following joints?

A ball-and-socket C pivot
B hinge D gliding

7 The bones of the skull are examples of one of the following joints?

A ball-and-socket C pivot
B hinge D fixed

8 Which of the types of teeth are not found in a six years old baby?

A Incisors C Molars
B Canines D Premolars

9 If a given mammal has a dental formula of 0/3, 2/2, 2/3, 3/3, how many total teeth does the animal have?

A 26 C 46
B 36 D 56

10 Which one is necessary for healthy bones, muscles and teeth?

A proper diet
B physical exercise
C restlessness
D A and B

PART II: *Match the items in column B with items in column A*

	Column A		Column B
11	Skull	A	pumping action of the heart
12	Ribs	B	front teeth
13	An example of pivot joint	C	protect lungs
14	An example of hinge joint	D	side teeth
15	Smooth muscles	E	knee
16	Cardiac muscles	F	blood vessels contraction
17	Incisors	G	wrist bones
18	Canines	H	protect brain

PART III: *Fill in the blanks with the appropriate terms.*

19 The human skeleton is divided into _____ and _____ skeleton.
20 Front teeth with chisel edge are known as _____.
21 Muscles in a pair _____ and _____ antagonistically.
22 The development and arrangement of teeth in the mouth is known as _____.
23 Dental formula of mammals varies in accordance with their _____ habit.

PART IV: *Give short answers for the following questions.*

24 Which part of the skeleton is axial?
25 Where do you find the scapula part of the human skeleton?
26 How does hinge joint differ from pivot joint?
27 When does your cardiac muscle stop work?
28 Why are molar teeth used for crushing and grinding foods?

PART V: *Copy this table into your exercise book. Draw a pencil line through each of the words related to skeletal system. Words go up and down in both directions.*

P	E	L	V	I	C	G	I	R	D	L	E	Q	H
E	B	E	E	T	W	E	N	A	E	U	C	U	E
O	G	F	R	T	T	N	Q	D	T	C	B	E	L
P	K	P	T	I	B	I	A	I	H	Y	D	E	L
L	D	Z	E	U	K	D	H	U	M	E	R	U	S
E	V	W	B	P	L	S	M	S	O	T	I	L	K
M	N	J	R	E	A	T	S	O	V	H	B	N	U
A	M	O	A	R	F	H	Q	T	E	I	S	A	L
N	S	F	I	B	U	L	A	H	R	O	J	T	L
A	X	I	A	L	S	K	E	L	E	T	O	N	R

Unit 4

PLANTS

Unit Outcomes

By the end of this unit, you will be able to:

- *tell that plants are diverse in size, type and distribution and demonstrate love and respect to plants;*
- *classify plants into flowering and non-flowering and mention mosses, ferns and gymnosperms as non-flowering plants;*
- *give examples of flowering plants, state their general characteristics and explain the structures and functions of the root, stem and leaves;*
- *identify stomata using a microscope;*
- *classify flowering plants into mono-cotyledons and dicotyledons, distinguish between the two, and give examples for each;*
- *explain vegetative reproduction and give examples of flowering plants that reproduce by vegetative reproduction;*
- *draw and label the structures of a flower, state their functions and examine pollen grains and ovaries using a hand lens; and*
- *tell the importance of pollination and the process of fertilization, state how fruits and seeds develop, state the functions of the structures of a seed and draw and label these structures.*

Main Contents

4.1 DIVERSITY OF PLANTS

4.2 FLOWERING PLANTS

UNIT REVIEW

Introduction

Plants are essential for our survival because they produce our foods. We eat them directly as grains, vegetables, and fruits. We also eat plants indirectly by eating animals that consume them. Plants also serve as sources of medicines, cosmetics, perfumes, papers, for making shelters (*houses*), fuels and other many products (Figure 4.1). Can you add more?

Figure 4.1: The use of plants

Plants are multicellular organisms with the ability to produce their own food by the process of photosynthesis. They are known as *autotrophs*. Thus, plants are known as *producers*. They have cellulose cell wall and store their food as starch.

Have you ever tried to classify plants around you?

You may look outside and observe plants around you. You will observe that they appear in different sizes, forms, and colours. It is true that plants show great diversity. They include living organisms from very small to big trees. They differ in the type with no flowers and with flowers. Up to now, about 350, 000 different species are identified and studied by botanists. They are distributed from tops of big mountains to deserts.

Flowering plants make about 80% of all known plants. These plants have flowers as their organs for sexual mode of reproduction. The flowering plants produce seeds and fruits. On the basis of their seeds there are two major groups of flowering plants, namely the monocots (*plants with seeds made up of single cotyledon*) and dicots (*plants with seeds consisting of two cotyledons*).

Did You Know?

* Algae, which mainly live in water and are photosynthetic organisms were used to be included with the plants, but they are now classified with the protists. Currently, plants include organisms that live primarily on land, excluding algae that live mostly in water.

Key Terms

- **Autotrophs:** organisms that synthesize their own foods from simple inorganic substances like carbon dioxide and water.
- **Producer:** autotrophic organisms.
- **Flower:** the sexual reproductive structure of flowering plant.
- **Seeds:** a flowering plant's unit of reproduction and which is capable of developing into another plant of the same type.
- **Fruit:** the seed bearing structure of flowering plants which developed after fertilization; which is usually sweet and fleshy in its nature.
- **Cotyledon:** an embryonic leaf which is found in seeds of flowering plants.
- **Monocot:** types of flowering plants that have a single cotyledon in their seeds.
- **Dicot:** types of flowering plants that have two cotyledons in their seeds.

In this unit, you will begin studying plant biology. You will examine the diversity of plants together with the characteristics of non-flowering and flowering plants. You will also identify the parts of flowering plants and their functions.

4.1 DIVERSITY OF PLANTS

By the end of this section, you will be able to:

- tell that plants are diverse in size, type and distribution;
- demonstrate love and respect to plants;
- classify plants into flowering and non-flowering;
- mention mosses, ferns and gymnosperms as non-flowering plants.

Activity 4.1

Examining the general characteristics of plants

- ☑ In groups discuss and summarize the main characteristics of plants. Consider different plants that you know and refer to the general features given in your text.
- ☑ Summarize your discussion in the form of a table.

Diversity of Plants

What are the general characteristics of plants?

Basically, plants are groups of living organisms that prepare their own food. Most of them live on land. They include different types of organisms – with large number of known living species.

Do plants appear in different sizes?

When we look at plants living around us, yes, they exist in different sizes. Some of them appear as big trees and some look very small like the moss (less than 7 cm in its height) and grasses (Figure 4.2).

Key Terms

- ☑ **Mosses:** small non-flowering plants with leafy-like structures and which commonly grow in moist places closely packed together (Figure 4.2a).
- ☑ **Ferns:** leafy non-flowering plants with an under ground stem with roots from which leaves (fronds) grow.
- ☑ **Gymnosperms:** plants that form unprotected seeds, which are not covered by ovary or fruits.
- ☑ **Cones:** reproductive structures which contain male and female gamete forming units.

a) *Mosses*

b) *Big trees*

Figure 4.2: Plants of different size

Activity 4.2

Looking at Plants

You are going to look at plants growing in your school compound. Classify them according to:

- ☑ their size.
- ☑ having flower or not.
- ☑ having cones or not.
- ☑ the color of their flowers.

You may do observation of different types of plants growing on the roadside while coming to school or going back home.

- ☑ Do all plants you have been observing contain the same part?
- ☑ Do all look similar?

Classifying Plants into Flowering and Non-Flowering Plants

Are there different types of plants in our surroundings?

Plants not only differ in their sizes, they also vary in the presence or absence of flowers. The non-flowering plants are those plants that do not have flowers and they include mosses, ferns and gymnosperms (Figure 4.3). The flowering plants are those plants having flowers as their sexual reproductive structure. Out of the 390,000 known species of plants about 352,000 species are flowering plants. Thus, plants that use flowers for their sexual reproductive system make the largest production of the total land plants so far identified. The non-flowering plants use other structures instead of flowers for their sexual reproduction. For instance pines (*a gymnosperm plant*) use cones (Figure 4.4) for their sexual mode of reproduction.

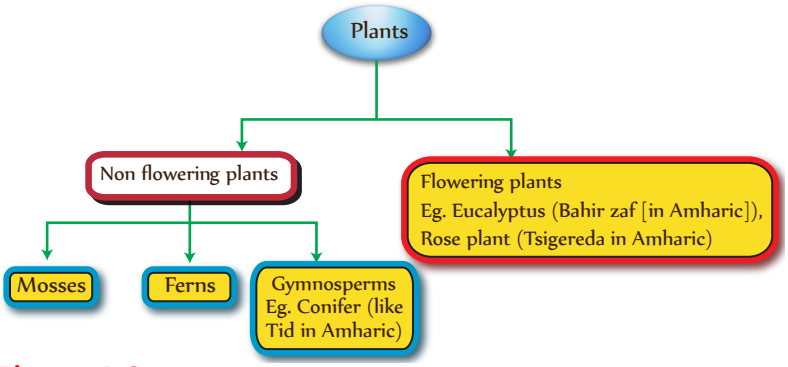


Figure 4.3: Classification of plants based on presence or absence of flower as reproductive structure

Figure 4.4: Cone of Gymnosperm

Activity 4.3

Checking whether a plant has flower or any other reproductive structure

Materials you will require:

- ☑ cones of gymnosperms
- ☑ flower of chrysanthemum or any other plant

Procedure

1. Collect cones of conifers and flowers of chrysanthemum or any flowering plant.
2. Examine them carefully. Note that seeds of conifers are found attached with cones. Flowers of flowering plants are structures that develop into seeds and fruits.
   - ☑ Do all plants have flower

Do plants that live at different places differ?

Plants are found in all parts of the world in different numbers and types. They live in different climates (*wet to dry places*); at different altitudes (*in highlands and lowlands*) and on different soil types (*sand, silt, clay and loam*). Plants living in a particular place or habitat have special features that allow them to live there. Features suitable for a given habitat might make it difficult for the plant to live in a different place. For instance, you wouldn't see a *cactus* on the top of Ras Dashen Mountains (Figure 4.5). Nor would you see tall trees in *grass lands* (Figure 4.6).

Key Terms

- ☑ **Cactus:** succulent (with much water) plant with thick fleshy and spiny stem that live in dry places (Figure 1.3a).
- ☑ **Grasslands:** a large area of land mainly covered with grass and especially used for grazing.

Did You Know?

Mosses are very small green plants. Typically they consist of a stem not much thicker than a thick hair. A moss plant stem is covered by many tiny leaves.

Figure 4.5: Succulent plants, agave (Ret in amharic) cactus (Kulkual in Amharic)

Figure 4.6: A grassland region with a vast stretch of grass without any visible tall trees

Exercise 4.1

Choose the correct answer from the alternatives for each of the following questions.

1 Which of the following plants are useful in making household materials?
- A Mosses
- B Rose plants
- C Ferns
- D Conifers

2 Plant materials can be used:
- A for preparing the textbook you are now using.
- B as direct food sources.
- C for preparing chairs.
- D all of the above.

3 Types of plants in a given area can be affected by:
- A the type of the climate.
- B the elevation.
- C the type of the soil.
- D all of the above.

4 A flower is the reproductive structure of:
- A mosses.
- B ferns.
- C conifers.
- D a coffee plant.

5 A moss plant is commonly found in:
- A dry places.
- B on sunlight exposed areas.
- C in water bodies.
- D on shady areas.

4.2 Flowering Plants

By the end of this section, you will be able to:

- state the general characteristics of flowering plants;
- give examples of flowering plants;

- explain the structures and functions of the root;
- explain the structures and functions of the stem;
- explain the structures and functions of the leaf;
- identify stomata using a microscope;
- classify flowering plants into monocotyledons and dicotyledons;
- distinguish between monocotyledons and dicotyledons;
- give examples of monocotyledons and dicotyledons;
- explain vegetative reproduction in flowering plants;
- give examples of flowering plants that reproduce by vegetative reproduction.

General Characteristics of Flowering Plants

What are the general characteristics of flowering plants?

The flowering plants are the most common types of plants on Earth. They make the largest proportion of all land plants and majority of all known seed plants. They are the only group of all plants that have flowers as their sexual reproductive structures. Flowers are unique structures of these plants that ensured their dominance on Earth. Flowering plants are also known as *Angiosperms*, which literally mean '*hidden seeded plants*'. Economically they are important sources of our food, wood fire, shelter, fences, spices, beverages, clothes, fodders, dyes, and medicines. They include about 352,000 different species; as a result botanists consider them as the most abundant, varied, familiar and economical plants.

Flowering plants or *Angiosperms* are generally characterized as plants:

- ☑ having flowers, special sexual reproductive structures.
- ☑ having seeds and fruits, where their seeds are enclosed in fruits.
- ☑ having unique fertilization system.
- ☑ in addition to wind, use different pollination agents.

Key Terms

- ☑ **Angiosperms:** group of plants that have flowers and produce their seeds within containers.
- ☑ **Fodder:** food for cattle and other livestock.
- ☑ **Seed:** a part of flowering and a gymnosperm plant and which is capable of developing into another such plant.
- ☑ **Fruit:** usually sweet fleshy part of flowering plants that cover their seeds.
- ☑ **Pollination:** the process of the transfer of pollen grains from one flower to another or within the same flower.
- ☑ **Pollination agent:** an agent which is involved in transferring pollen grains from flower to flower or within the same flower.

Did You Know?

The size of flowering plants ranges from giant Eucalyptus (Bahir zaf) to the smallest type like Wolffia (1 mm across).

Activity 4.4

Examining the general characteristics of flowering plants.

In groups:

- ☑ Discuss the general characteristics of flowering plants. (You may even raise the issue like why they become so successful of all plants that live on land)
- ☑ Mention some of the examples of flowering plants that grow in your locality.

What are the main parts of flowering plants?

From your lesson of Unit 2, you are aware of a flowering plant has three major parts namely; the *stem*, the *leaf*, and the *root*. At maturity these plants will have an additional fourth component, the *flower* (Figure 4.7). These structures in turn may be organized as reproductive and vegetative structures. The only sexual reproductive structure of a flowering plant is flower. The stem, leaf and root make up the vegetative part of the plant. Commonly, the stem, the leaves and the flower are above ground parts of plants. These parts of a plant work together to keep the plant fixed at a given place, erected above ground, photosynthesize and reproduce. The root is an underground part of plants. In fact, each of these structures has an important set of functions.

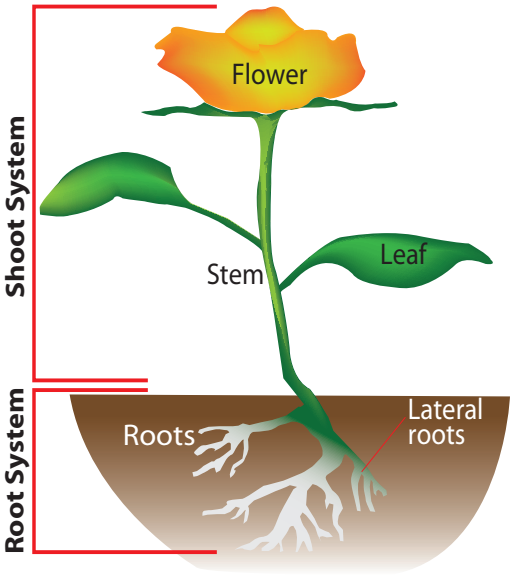


Figure 4.7: The main parts of a flowering plant

Key Terms

- ☑ **Vegetative:** parts of a plant which are not directly related to sexual reproductive system.
- ☑ **Shoot system:** the above ground parts of the plant, which included the stem, the leaf and the flower.
- ☑ **Root system:** the underground part of the plant, which consists of the main root, lateral roots, root hairs, root tip and the root cap.
- ☑ **Stem:** the main body or stalk of a plant that supports a fruit, leaf and flower: and helps the whole plants to be erected.
- ☑ **Leaf:** a flat and blade like structure of a plant in which photosynthesis mainly takes places.
- ☑ **Root:** a part of a plant that grow below the ground and which absorbs water and minerals from the soil.

Did You Know?

* Welwitschia – a unique gymnosperm plant that grows in Namib desert (Southern Africa), and lives up to 2000 years in these extreme conditions! But only makes two leaves throughout its life. It takes water from sea mist (water vapor).

Activity 4.5

Examining the main parts of flowering plants

You will require:

☑ bean plant, ☑ hand lens, ☑ maize/grass

Procedures:

Working in groups, carefully uproot bean and maize/grass plants grown for the purpose in pots.

1 Identify the major parts of these plants as the stem, the root, the leaves and the flower.

2 Draw and label the parts.

What are the major functions of roots to plants?

The root is one of the important parts of the plant that grows underground and fixes it to the soil. The root not only attaches the plant into the soil, but it also absorbs water and minerals. The main functions of the roots of a plant include:

- ☑ absorption of water and minerals from the surroundings.
- ☑ attaching the plant to the ground and structurally supporting the plant.
- ☑ conducting absorbed water and minerals to the above ground parts of the plant.
- ☑ food storage.

What are the main external features of the root?

The root system of a plant contains different parts. The main (primary) root, lateral roots, root hairs, root tip and root cap form the root system (Figure 4.8). Root systems can be bigger than the plant they support. The root system of the plant tends to grow in length and not width, in order to search for water, and minerals.

Key Terms

- ☑ **Primary root:** the main root that first grow from the base of the stem.
- ☑ **Lateral roots:** secondary roots that branch from the primary or main root. They are commonly thinner than the main root and are uniform in their size.
- ☑ **Root hairs:** very fine roots that are branching from lateral roots or main root. They are involved in absorption of water and minerals.
- ☑ **Root tip:** the part of the root which is growing down wards into the soil.
- ☑ **Root cap:** a very hard part of the root which covers and protects the growing region of the root, the root tip.
- ☑ **Tap root system:** a main or central root that grows deep down wards and from which lateral roots grow.
- ☑ **Fibrous root system:** a system in which many smaller roots with equal width grow from the stem base.

The Root

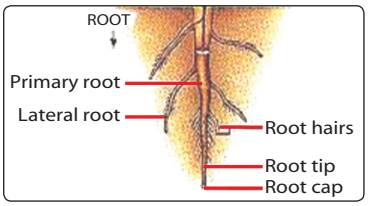


Figure 4.8: The root systems

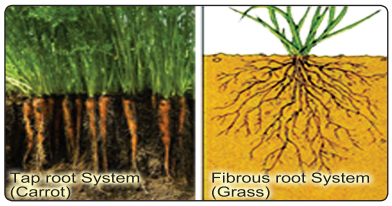


Figure 4.9: The tap (Example: *carrot*) and fibrous (Example: *grass*) root systems

What are the main root systems?

Generally, there are two main kinds of root systems in plants, namely the *tap root system* and the *fibrous root system* (Figure 4.9). In *tap root system* a single central main root grows deep downward into the soil and lateral branches developed sideways. In this root system the main root is wider in diameter and the lateral roots are narrower. A carrot root is a good example for the *tap root system*. *Fibrous root system* is a type of root system which contains many smaller roots of similar diameters. Roots of corns make the best example of fibrous root system.

Activity 4.6

Examining fibrous and tap root systems

You will require:

- ☑ bean plant,
- ☑ hand lens,
- ☑ maize/grass,
- ☑ carrot plant.

Procedure:

1. Working in groups, carefully uproot bean, carrot and maize/grass plants grown for the purpose in pots.
2. Brush away a little of the soil and wash off the rest so that the roots are well-cleaned.
3. Identify the root system as fibrous or tap root system.
4. Draw and label parts of the root system.

What are the main internal features of the root?

All plant body parts, the stem, the leaf and the root have similar internal features. These parts of the plant are made up of two major parts; the external cover and the internal component (Figure 4.10). The main parts of a plant are externally covered by the *epidermis*. In addition, the internal part of the root and stem is made up of different parts like the *cortex*, the transport elements and the *pith* (*not commonly found in roots*). The transport component, which is also known as *vascular bundles* contains the *xylem* and the *phloem*. The *cortex* and the *pith* are located to the outside and inside of the transport component.

Unlike parts of the shoot system, such as the stem and the leaf, the root is not exposed directly to sunlight. Thus, its external cover, the *epidermis* is not covered by a waxy substance; the *cuticle*. The cuticle covers mainly leaves and the stem epidermal layer in order to reduce the loss of water from the plant body.

Key Terms

- ☑ **Epidermis:** the outer layer of tissue in a plant.
- ☑ **Cortex:** the outer layer of tissue immediately below the epidermis of a stem and root.
- ☑ **Pith:** the central part of tissue found commonly in a stem.
- ☑ **Vascular bundles:** food and water transporting tissues in higher plants that include the phloem and xylem.

The root is part of the plant which is found below the soil. As a result it is not exposed to sunlight, and it is not involved in the process of photosynthesis. The cells that make up the internal part of the root do not have chloroplast. Chloroplasts are sub-cellular structures that contain the photosynthetic pigments like chlorophyll. Unlike the root, the stem and the leaf are the above ground parts of the plant. Especially, cells that make up the leaf contain high numbers of chloroplasts.

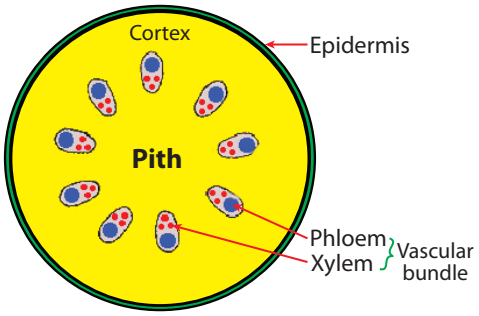


Figure 4.10: The cross section of major internal parts of roots and stems of flowering plants

The Stem

What are the main functions of stems to plants?

The stem is part of a plant which is found above ground, above the soil. The stem together with the leaf and the flower (*at the time of maturity*) make up the shoot system of the plant. It is part of the plant that erects and keeps the whole plant body above the soil. There are many different ways to describe plants in a given environment. Based on softness or strength the stem, there are two types of flowering plants: herbaceous (*non-woody*) and woody (Figure 4.11).

Key Terms

- **Herbaceous plant:** a type of flowering plant with soft and usually green stem, which is commonly small in size. The stem surface is covered by epidermis.
- **Woody plant:** a type of plant with tough and mostly non-green stem, commonly large in size and its surface is covered by bark.

The main functions of the stem include:

- Transporting water and minerals from the root to other parts of the plant.
- Erecting the plant above the ground and holds there so that it receives maximum sunlight.
- Supporting above ground part like leaves and flowers; even fruits.
- Transporting photosynthetic products from leaves to other parts of the plant.
- Providing the attachment of climber plants.

a) *A woody plant*

b) *Herbaceous plant*

Figure 4.11: Woody and herbaceous plant

Activity 4.7

Examining transport of water and minerals up through the stem.

You will require:

- ☑ bean plant,
- ☑ beaker/tin
- ☑ blue/red dye
- ☑ blade/knife/scalpel

Procedures:

1. Working in groups, carefully uproot bean plants grown for the purpose in pots.
2. Brush away a little of the soil and wash off the rest so that the roots are well-cleaned.
3. Place the plant carefully into a beaker that contains a dye.
4. Leave the plant in the ink for an hour.
5. Cut the stem with a blade (be careful not to hurt yourself or your friend) into pieces and observe the progress of the dye through the stem from the root.
   - ☑ Is the dye moved upwards through the stem?
   - ☑ What do you think about the movement of water within the stem of a big tree?

Did You Know?

* There are carnivorous plants which together with photosynthesis obtain their additional nutrients by digesting other organisms (like insects). This jug-like plant traps insects into rolled leaves which contain digestive enzymes.

The Leaves

What are the main functions of leaves to plants?

Leaves are one of the parts of the shoot system, which are found attached to the stem. They are parts of plants which are flat and broad; as a result, they have a large surface area. Thus, the larger part of leaves is exposed to the environment, and makes them suitable for their functions, being the site of photosynthesis (Figure 4.12).

Figure 4.12: Leaves

The most important functions of leaves include:

- ☑ Carry out photosynthesis to make food
- ☑ Gaseous exchange
- ☑ Transpiration (water loss)
- ☑ Store food

What are the main parts of leaves?

Commonly, a leaf has the *blade* or *lamina*, (*the broad leaf part*), and the *petiole* (*leafstalk*) that fixes it to the stem. The petiole extends into the blade and branches into veins (Figure 4.13). A leaf is made of tissues, which are sandwiched between two tough layers (*upper* and *lower epidermis*). The *epidermis* also secretes a waxy substance called the *cuticle*. The epidermal layers protect the leaf from insects and other pests. Among the epidermal cells are pairs of sausage-shaped *guard cells*. Each pair of guard cells forms a pore (called *stoma*; *the plural is stomata*). Gases enter and exit the leaf through the *stomata*. Most food production takes place in cells called *mesophyll tissue* (Figure 4.14).

Key Terms

- **Pest:** an animal like an insect that feeds and attacks part of the plant.
- **Blade:** the broad and flat part of the leaf.
- **Midrib:** the large strengthened or the main vein along the midline of the leaf.
- **Mesophyl tissue:** the tissue of leaves which is found in between the upper and lower epidermis, and with many chloroplasts.
- **Stoma (stomata):** minute opening in the leaf epidermis.
- **Guard cells:** a pair of curved cells that surrounded the stoma.

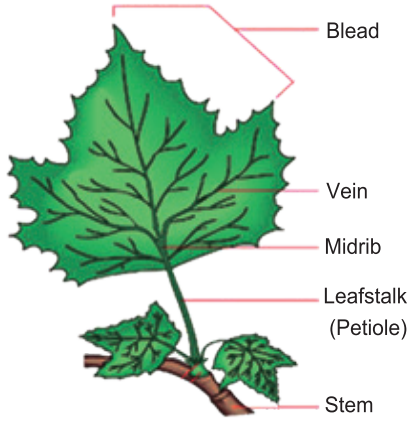


Figure 4.13: External structure of a leaf

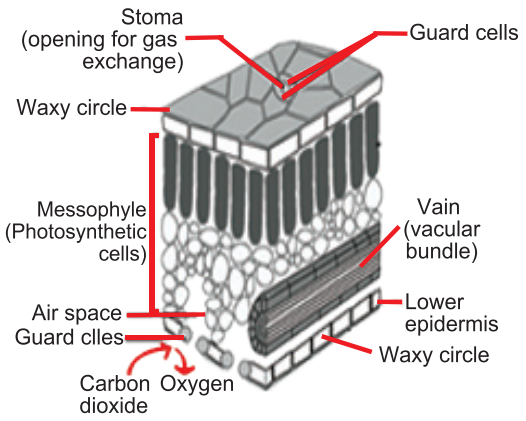


Figure 4.14: The internal structure of a leaf

Activity 4.8

Examining the Leaf

You will require:

- ☑ Leaf of Cana indica (Qey abeba) or leaf from any other plant,
- ☑ Blade/scalpel
- ☑ Nail varnish
- ☑ Microscope
- ☑ Hand lens
- ☑ Glass slide
- ☑ cover slip
- ☑ beaker, dropper and water

I Observing under the Microscope or using a Hand Lens

Procedures

1 Cut a very small section of the leaf (about 2 mm^2).

2 Place it on the microscope slide and add a drop of water.
3 Cover it with a cover slip (be careful not to trap air bubble in between).
4 Identify the stoma using medium power objective.
5 Observe the under side of the leaf directly using a hand lens and identify the stoma.

II Observing the Underside of the Leaf using Nail Varnish

Procedures

1 Paint the underside of a leaf (*Cana indica leaf*) with clear nail varnish and leave it to dry.
2 When nail varnish dried, peel off the part very carefully.
3 Examine the imprints of the stoma using hand lens.
   ☑ Can you observe the stomata and the guard cell?
   ☑ What do you think is their function?

Monocotyledons and Dicotyledons

What are the two major groups of flowering plants?

Key Terms

- ☑ **Dicots:** are flowering plants basically with two cotyledons in their seeds.
- ☑ **Monocots:** are flowering plants basically with one cotyledon in their seeds.

The two main groups of flowering plants are the *monocots* and the *dicots*. Both have flowers as their reproductive organs. Actually, the names monocots and dicots refer to the number of cotyledons, or food storage structures, in the seed. There are *two cotyledons* in *dicots* and only *one cotyledon* in *monocots*. Naturally, the number of dicots (about 170, 000 different species) are more in the environment than the number of monocots (about 65, 000 different species). It is because of this that we commonly come across a dicot plant than a monocot. But, remember that *grasses* including the edible ones (*teff, barely, wheat* and *maize*) are *monocots*.

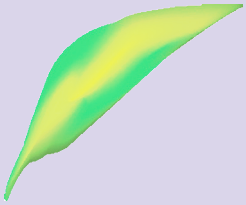
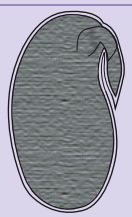
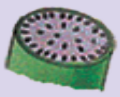
What are the similarities between monocots and dicots?

The *monocots (monocotyledons)* and the *dicots (dicotyledons)* are two groups of flowering plants that share many features, like having *flowers* as their sexual reproductive structures, *seeds* and *fruits*, and the *vegetative body parts* (*the stem, the leaf and the root*).

What are the differences between monocots and dicots?

In addition to the number of cotyledons they have in their seeds, the monocots and dicots differ in many aspects. Examples of dicot plants include most flowering trees, all of the common shrubs, most common vegetables we eat, sunflowers, Venus's flytrap, beans, and peas. Examples of monocot species include wheat, corn, rice, barley, all grasses, and palms. The differences between dicots and monocots are summarized in Table 4.1.

Table 4.1: Main differnces between monocots and dicots

Character	Monocots	Dicots
Leaf venation	 *Parallel venation*	 *Net venation*
Flower parts	 *Flower parts in threes*	 *Flower parts in four or fives*
Number of seed cotyledons	 *One cotyledon*	 *Two cotyledons*
Vascular component arrangement	 *Distributed through out*	 *Arranged in circle*

Key Terms

- ☑ **Cotyledon:** a leaf-like structure in seeds. It serves as stored food for embryos in seeds.
- ☑ **Venation:** the arrangement of veins in a leaf.
- ☑ **Parallel venation:** venation in which veins are arranged in parallel to the mid rib across the leaf surface.
- ☑ **Net venation:** venation in which veins are branching sideways from the mid rib on the leaf surface.
- ☑ **Vascular bundles:** the food transporting (phloem) and water transporting (xylem) tissue.

Activity 4.9

Examining Monocotyledonous and Dicotyledonous Plants

Materials you will require:

- ☑ different plants in the school compound
- ☑ tapes
- ☑ paper

Procedure:

1. Arrange yourself in groups and collect one specimen for each flowering plant main group from your school compound.
2. Bring the specimens to the class, arrange and tape the specimens on a piece of paper, examine them carefully.
3. Label the samples as a monocot or dicot.

What are the differences between seeds of monocots and dicots?

Seeds of monocotyledonous and dicotyledonous plants have one cotyledon and two cotyledons, respectively. A cotyledon contains stored food and serves as a food reservoir.

Activity 4.10

Examining the Seeds of Flowering Plants

You will require:

- ☑ corn and bean seeds (soaked in water 1 day before)
- ☑ iodine
- ☑ peanut
- ☑ knife (not sharp) to cut seeds
- ☑ worksheet

Procedure:

- ☑ In this practical you will differentiate between monocot and dicot seeds.
- ☑ Make sure you soak the seeds in water one day prior to the laboratory session.
- ☑ Examine the seeds carefully and draw exactly what they see.

Reproduction in Flowering Plants

How do plants reproduce?

Flowering plants reproduce both through sexual and asexual means in order to produce new individuals or offspring. Sexual reproduction is a means of reproduction during which offsprings are produced by the union of gametes formed from female and male parents. This results in the formation of offspring genetically different from the parent or parents. Asexual reproduction is a type of reproduction during which an organism produces new individuals without the need of union of gametes. The offspring produced are genetically identical to the parent plants and each other. Flowering plants use flowers for their sexual mode of reproduction. They use their vegetative body parts such as the stem, the leaf and the root during their asexual mode of reproduction.

Key Terms

- ☑ **Sexual reproduction:** a type of reproduction during which two parents are involved and that requires union of gametes.
- ☑ **Asexual reproduction:** a type of reproduction during which a single parent is only involved with out the union of gametes.
- ☑ **Offspring:** the child or children of a person, or young of an animal or a plant.
- ☑ **Genetics:** the study of heredity and variation among organisms.

Did You Know?

In seed plants, the offspring can be packaged in a protective seed, which is used as an agent of dispersal.

Vegetative Propagation

What are the main characteristics of asexual reproduction in flowering plants?

Asexual reproduction is production of new individuals without the fusion of gametes. It requires only one parent and produces large number of new plants within a very short

period of time. It does not involve flowers, *pollination* and seed production. Instead, a new plant grows from a vegetative part. During asexual means of reproduction in flowering plants, the new plants are obtained from non-reproductive parts such as the root, stem and leaf. The process is known as v*egetative propagation*.

In asexual reproduction:

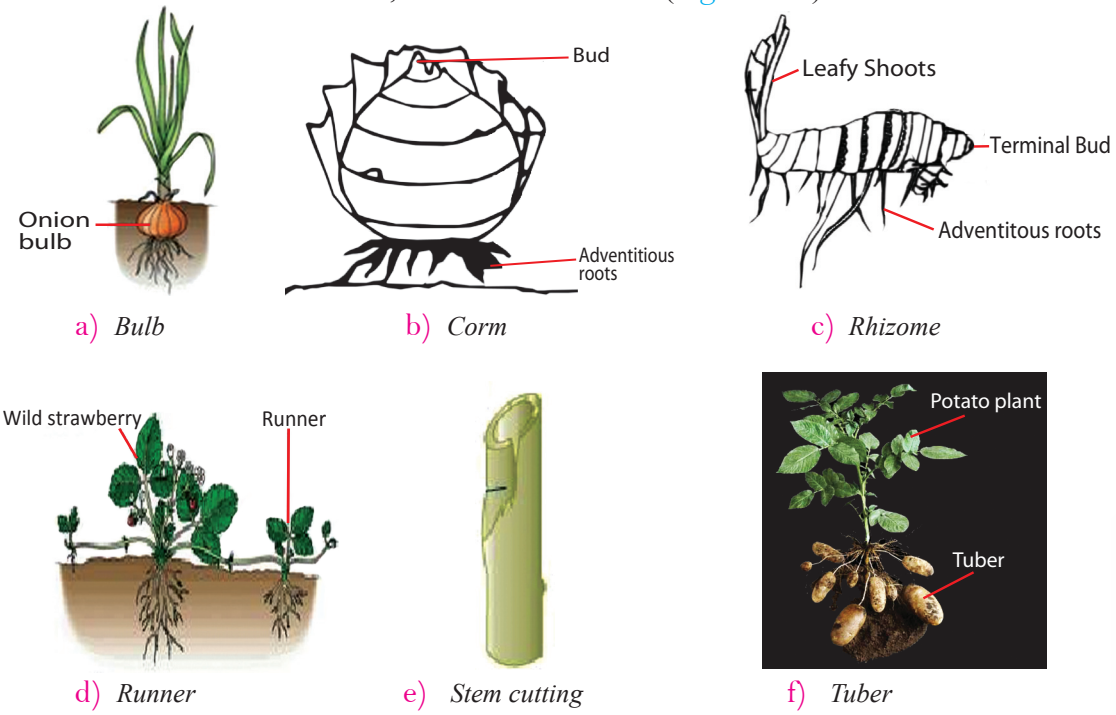
- ☑ a single organism is involved in reproduction.
- ☑ there is no production of gametes.
- ☑ offsprings produced are *genetically identical*.
- ☑ it is relatively rapid mode of multiplication.

Key Terms

- ☑ **Clones:** a group of organism or cells, produced asexually from one ancestor to which they are genetically identical.
- ☑ **Pollination:** the transfer of pollen from anther to stigma.
- ☑ **Natural vegetative propagation:** a type of reproduction during which plants naturally use vegetative body parts for asexual reproduction.
- ☑ **Artificial vegetative propagation:** a type of vegetative reproduction that humans utilize the vegetative means of reproduction in flowering plant to asexually reproduce them.

Vegetative propagation in flowering plants can be *natural* or *artificial*. Commonly, plants which can reproduce asexually almost always reproduce sexually as well, with flowers. During natural vegetative propagation a vegetative part of a plant like the stem develops into a plant rather than forming branches.

Natural vegetative propagation is a type of asexual reproduction during which a flowering plant produces new individuals naturally using vegetative parts. The main part of the plant body which is involved in natural vegetative reproduction is the stem. ***Vegetative propagation*** by stem includes both underground stems such as *tubers, rhizomes*, and corms or sub-aerial stems like *stolons*, *runners* and *suckers* (Figure 4.15).



a) *Bulb* b) *Corm* c) *Rhizome*

d) *Runner* e) *Stem cutting* f) *Tuber*

Figure 4.15: Types of vegetative propagations

What are the underground stems used for natural vegetative propagations of flowering plants?

The underground stems of flowering plants that are commonly used for vegetative propagation include *bulbs*, *tubers*, *rhizomes*, and *corms*.

Bulbs

For plants such as onions and garlic, the bulb is the unit of vegetative propagation. A bulb contains an *underground stem* (Figure 4.15a). Fleshy leaves are attached to the stem. These leaves contain stored food. As the plant grows and develops it will form a new bulb underground.

Key Terms

- **Terminal bud:** embryonic tissue that supplies cells allowing a plant to grow in length; found at the tips of roots and stems.
- **Lateral bud:** an auxiliary or side bud from which branches grow.

Corms

These are thick underground stems with upright position and function like a bulb. However, *corms* consist of a layer of stem tissue storing food instead of fleshy leaves. As with bulbs, the terminal bud grows into a flowering shoot and the lateral buds produce new plants. A common example of a corm is crocus (Figure 4.15b).

Rhizomes

Rhizomes are horizontal underground stems that can give new shoots. In some cases the underground stems are swollen with food reserves. The terminal bud produce the flowering shoot and the lateral buds may grow out to form new *rhizomes*. Common examples of plants that propagate by using rhizomes are *Cana indica (Qey abeba in Amharic)* and Ginger (*Zingible in Amharic)* (Figure 4.15c).

Runners

Runners are also horizontal stems growing from the parent plant, but they grow above-ground. When their terminal buds touch the ground they take root and produce new plants (Figure 4.15d). Common examples of plants that can be vegetatively propagated using stolons or runners are grasses like *Cynodon dactylon* ("*Serdo*") and *wild strawberry*.

Suckers

A form of budding called *suckering* is the regeneration of a plant by shoots that arise from an existing root system. Banana do not produce seeds and are propagated by suckers that develop from buds on underground stems. Production of new plants is by vegetative means, and propagation is from suckers that develop at the bases of the old plants.

Activity 4.11

Examining Natural Vegetative Plant Propagation Methods

Materials you will require:

- ☑ Onion
- ☑ Ginger
- ☑ Corms
- ☑ Serdo

Procedure:

1. Arrange yourself in groups and examine very carefully the plant samples you are provided with.
2. Identify their axial buds and auxiliary buds and categorize according to their vegetative means of propagations.

What are the methods of artificial vegetative propagations of flowering plants?

The methods by which gardeners and farmers commonly vegetatively propagate plants using non-reproductive parts of the plant is known as *artificial vegetative propagation*. The common methods of artificial vegetative propagation methods used by gardeners or farmers are *stem cuttings*, *layering* and *grafting*.

Stem Cuttings

It is a process in which a vegetative portion from a plant is taken and is rooted in the soil to form a new plant. The portion used is called a *cutting*. Stem cuttings are most commonly used for this purpose (Figure 4.15e). The factors to be considered for cutting are optimal length with a few nodes and internodes, diameter of the cutting, age of the plant and the season. Examples of plants that are commonly propagated using stem cuttings include roses, grapes, sugarcane, and citrus plants.

Grafting

Grafting is a technique of transplanting a part of one plant on to another plant so that they grow as one plant. Both plants are selected for their best characters. The supporting (*rooted*) portion of the plant is called a *stock*, whereas the transplanted plant is known as *scion* (Figure 4.16). For example, the shoot part of one plant that produces large, sweet fruit can be grafted to the rooted portion of another plant which is drought resistant. Common examples of plants that can be propagated using grafting include *Citrus fruits* (*orange* and *lemon*), *rubber*, *apple*, *pear*, and *mango*.

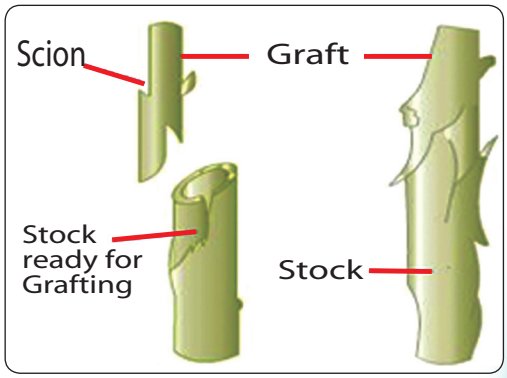


Figure 4.16: Grafting

Layering

Layering is an artificial vegetative propagation methods during which plants that have long slender stem are induced to form roots before it is detached from the parent plant.

In layering, the lower branch close to the ground is bent down and covered with moist soil (Figure 4.17). After some days roots develop from the branch, which can be cut and grown independently. *Rhamnus* "*Gesho*" can be propagated by layering.

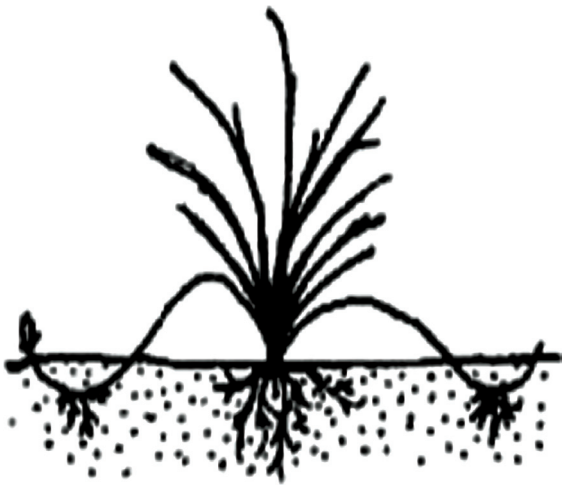


Figure 4.17: Layering

Activity 4.12

Project work on methods of artificial vegetative plant propagation

Materials you will require:

- ☑ Scalpel
- ☑ Hibiscus (Yachaina rose abeba in Amharic), Geranium or rose plant

Procedure:

1. In groups, remove from the parent plant a portion of rose stem 11 to 20 cm long with the leaves attached.
2. For most deciduous plants, a tip, simple, or straight cutting will suffice. For most evergreen plants, use tip or heel cuttings.
3. Remove leaves (or *needles*) which would contact the rooting medium (the bottom 4 to 5 cm of stem) to prevent rotting of these leaves. Do not remove the remaining leaves as they will continue to produce substances that aid in root formation on the cutting.
4. Prepare the ground by digging not less than 20 cm deep and moisten it. Plant the cutting into the ground at a depth of 5 cm.
5. Keep the above ground portion of the cutting moist and cool.
6. Observe rooting for not less than 2-3 weeks.

Activity 4.13

Examining the effect of plant hormones on stem cuttings

Materials you will require:

- ☑ Scalpel
- ☑ Rose plant
- ☑ Auxin powder

Procedure:

1. In groups, prepare 10 rose stem cuttings and the ground for planting as in Activity 4.12.
2. Prepare auxin solution by adding 5 mg in a liter of clean water.
3. Dip 2/3 of the 5 cuttings into the solution prepared and plant them as indicated in Activity 4.12. Dip the other 5 into clean water and plant them as well.
4. Plant them in two rows, row 1 cuttings dipped in rooting solution and row 2 of stem cuttings dipped in pure water.
5. Keep the above-ground portion of the cutting moist and cool.
6. Observe rooting of the cuttings.
   - ☑ Do the stem cuttings begin rooting?
   - ☑ What do you conclude from this experiment?

Sexual Reproduction in Plants

What are the general characteristics of flowers?

Of all parts of the flowering plant, the flower is the most unique and ensures efficient sexual reproduction of the plant. A flower is the part of the plant that makes the seeds. A flower has four specialized parts; *sepals*, *petals*, *stamens*, and *carpels* (Figure 4.18).

A *carpel* is the female part of a flower. Within this closed structure, egg develops, fertilization takes place, and seed matures. The male part of a flower is the *stamen*. A stamen contains a *filament* and an *anther*. An anther has containers within which pollen grains develop. The functions of the parts of a flower are given in Table 4.2.

Key Terms

- ☑ **Sepals:** usually are small green leaves found below the flower.
- ☑ **Petals:** usually are large colorful attractant part of a flower.
- ☑ **Stamens:** a male fertilizing organ of a flower, it consists of a pollen, anther and a filament..
- ☑ **Pistil or carpel:** a female reproductive organ of a flower, it consists of an ovary and a stigma.
- ☑ **Receptacle:** the base of a flower.

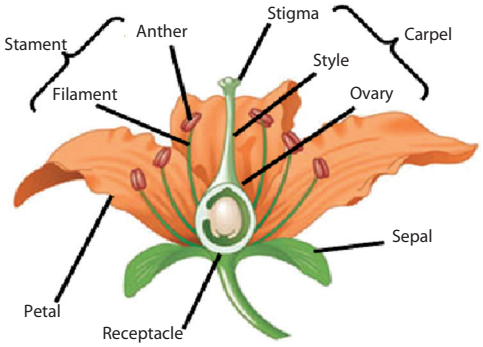


Figure 4.18: A longitudina section of a typical flower

Table 4.2: Flower parts and their functions

Floral part	Function
Petals	Brightly colored. They are used to attract insects by their bright color and scent.
Stamens (has two parts) ☑ Filament ☑ Anther	This is where pollen is made. It is the male part of the flower. ☑ A thin long structure that supports the anther. ☑ A sack like structure that contains pollen grains.
Carpel (has three parts) ☑ Stigma ☑ Style ☑ Ovary	The carpel is the green stalk in the middle of the flower: ☑ top of pistil and where pollen lands on ☑ the neck of the pistil and supports the stigma ☑ swollen bottom part and contains the ovule, where seed is formed
Sepals	Green leaves around the outside of the flower. Sepals are usually smaller than the petals. Used to protect the flower while it is still in bud.

Activity 4.14

Examining Flowers

Materials you will require:

☑ Flowers ☑ Blade or scalpel ☑ Paper

Procedure:

1. Using a blade dissect flowers provided.
2. Identify the parts and then draw and label the parts as petals, anthers, filaments, style, stigma, ovary, nectaries, calyx and corolla.

How are flowers designed for sexual reproduction?

Flowers are the reproductive organs of the angiosperms. A flower is the plant organ where fertilization occurs, seeds are formed and fruits develop. Flowers can have either male part (*stamens*), female part (*pistil* or *carpel*), or a combination. Flowers that have either

the male part or the female part are called *imperfect* (*cucumbers, pumpkin and melons*). On the other hand, flowers that have both male and female parts are called *perfect* (*roses, lilies, dandelion*).

What is pollination?

The process of the transfer of *pollen grains* from the male part (*anther*) to the female part (*stigma*) is *pollination*. Since *pollen grains* or any part of flowers can not move by their own, agents that move *pollen grains* from the *anther* to *stigma* are required. These agents are known as pollinating agents. The agents that are involved in transferring *pollen grains* include wind, water and animals. The major pollinating agents for land plants are wind and animals. Of all animals, insects and birds are the most important *pollinating agents* (Figure 4.19a-c).

Flowers are adapted in many different ways to ensure the transfer of *pollen grains* to *stigma*. For instance, pollens of wind-pollinated plants like grasses are lightweight, smooth, and small.

Plants that are wind pollinated generally occur as large populations so that the female flowers have a better chance of receiving pollen. These plants also produce large numbers of pollen grains.

Key Terms

- **Pollinating agents:** pollen grain carriers that are involved in transferring pollen grains from the anther (part of the stamen) to the stigma (part of the pistil).
- **Wind pollination:** a plant that uses wind as a pollinating agent.
- **Animal pollination:** a plant that uses animals as its pollinating agents.
- **Cross pollination:** pollination between flowers of separate plants of the same species.
- **Self pollination:** pollination within the same flower or between flowers of the same plant.
- **Perfect flower:** a flower that has both the male (stamen) and female (pistil) parts.
- **Imperfect flower:** a type of flower that has either the male or the female part.

a) *Wind pollinated flower (note the stigma that funs out) (Example, Grasses)*

b) *Bird pollinated flower (note the pollen grains on the forehead of the bird) (Example, Hibscus)*

c) *Insect pollinated flower (Example, Rose flower)*

Figure 4.19: Pollinating agents

The two types of pollination in flowering plants are *self-pollination* and *cross-pollination*. Self-pollination is a type of pollination during which pollen grains are transferred from

the anther to stigma of the same plant. *Cross-pollination* is a type of transfer of pollen grains from anther to stigma of a different plant, which involves two separate plants of the same species.

Did You Know?

Flowers are composed of modified leaves. Each floral structure represents a different modification of a leaf. Not all flowers have the same parts, but male and/or female structures are essential.

Activity 4.15

I Comparing Wind and Animal Pollination

In groups, make a comparison between wind and animal pollinated flowers based on the following characteristics.

Character	Flowers	
	Wind pollinated	Animal pollinated
Petal		
Color of petals		
Smell		
Nectar		
Pollen grains		
Nature of the anther		

II Identifying flowers as wind or animal pollinated types.

Materials you will require:

- ☑ Flowers from different plants

Procedure:

1. In groups, identify the flowers you have obtained from your school compound as wind or animal pollinated types.
2. Give your own reasons as to why you have categorized the flowers as wind or animal pollinated type.

III Examining pollen grains

Materials you will require:

- ☑ Scalpel
- ☑ Flowers from different plants
- ☑ Magnifying lens (hand lens/microscope)

Procedure:

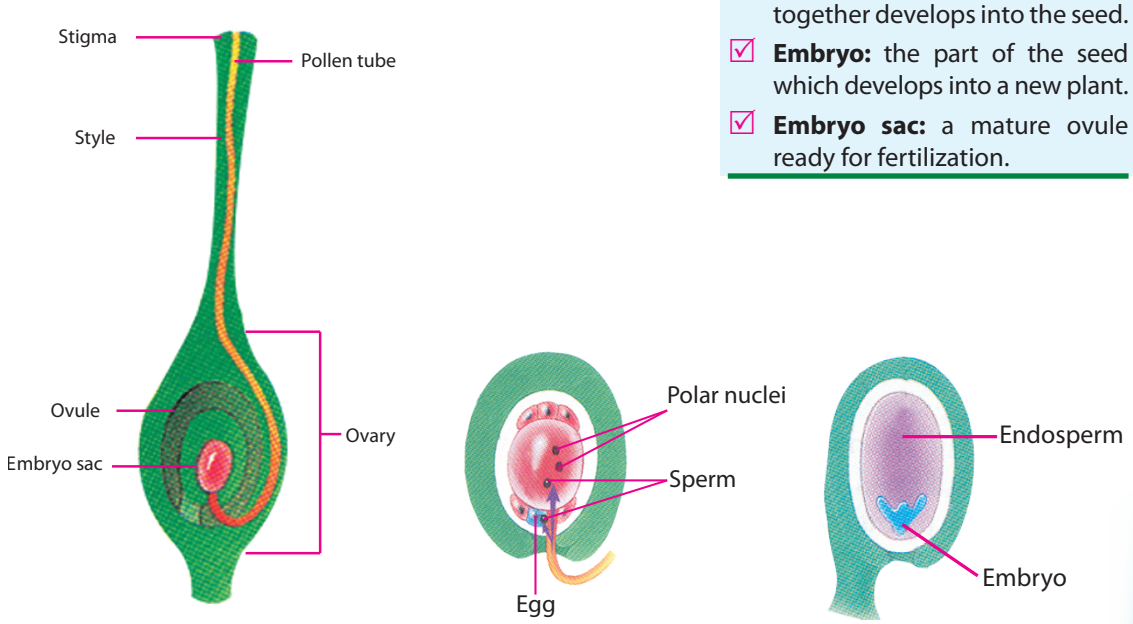
1. Remove the sepals and the petals by pulling down the receptacle of the flowers.
2. Remove the stamens and crush the anther on a glass slide and prepare a wet mount and observe it under a microscope. If there is no microscope you can use hand lens.
3. Do the same for different plants and observe if different plants have similar pollen grains or not.

What is the unique feature of fertilization in flowering plants?

As pollen grain lands on the stigma of the same plant, a pollen tube grows through the style to the ovary. The pollen tube enters into ovule through the opening of ovary known as micropyle. By the time the pollen tube enters the ovule it has two sperm cells. One of these sperm cells fertilizes the egg (*ovum*) and the other one fertilizes two polar nuclei. The fertilized egg develops into an embryo. The fertilized polar nuclei form an endosperm (*nutritive tissue*) of the seed (Figure 4.20). After fertilization the ovule develops into a *seed* and the ovary develops into a *fruit* that covers the seed(s).

Key Terms

- **Pollen tube:** a tube that develops from a germinating pollen grain and that carries the sperm cells of a pollen to the ovule of the pistil down through the style.
- **Micropyle:** an opening of the ovary through which the pollen tube delivers the sperm cells to the ovule.
- **Ovule:** the part of the pistil that contains the egg and the embryo sac which after fertilization all together develops into the seed.
- **Embryo:** the part of the seed which develops into a new plant.
- **Embryo sac:** a mature ovule ready for fertilization.



a) *Pollen tube development* b) *Embryo sac* c) *Fertilization*

Figure 4.20: Fertilization in flowering plants

What is pistil?

The female part of the flower, the pistil, is made up of different parts. In fact, it is part of the flower which fertilizes and develops into a seed. Do Activity 4.16 to identify parts of the pistil.

Activity 4.16

Examining the pistil

Materials you will require:

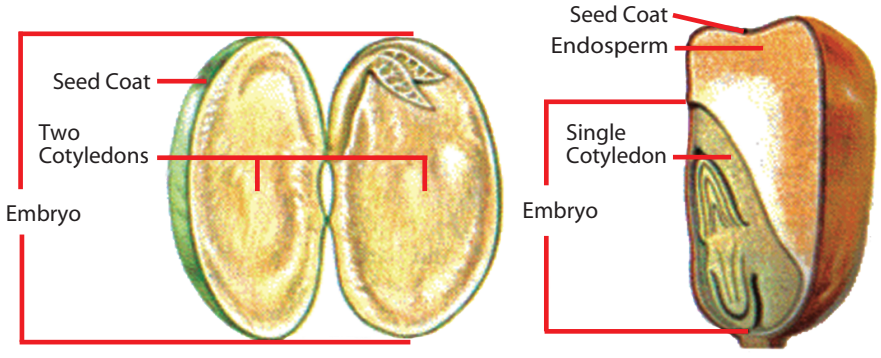
- ☑ Scalpel
- ☑ Flowers
- ☑ Magnifying lens (hand lens/microscope)

Procedure:

1. Remove the sepals and the petals by pulling down the receptacle of the flowers.
2. Get the central part of the flower, the pistil and using the scalpel cut it lengthwise into two equal halves (Be careful; make sure that your fingers are out of the way).
3. Use the hand lens to identify parts of the pistil.
4. Draw and label the parts.

How are seeds and fruits formed?

Following fertilization the ovules mature into a *seed*. The zygote inside the ovule develops into seed embryo, which consists of the *radicle* (*future root*), the *plumule* (*future shoot*) and *cotyledon*(s). The seed is covered by a *seed coat* or *testa*. A seed of an angiosperm may have one cotyledon (*monocot*) or two cotyledons (*dicot*). The embryo in both types of seeds consists of *epicotyls*, *hypocotyls*, *radicle, plumule* and *cotyledon* (Figure 4.21).



a) *A Dicot (Bean)* b) *A Monocot (Corn)*

Figure 4.21: Seeds of dicot and monocot

Activity 4.17

Studying parts of the seed

Materials you will require:

- ☑ Soaked (for a day or two) seeds of bean and corn (maize)

Procedure:

1. In groups, examine the seeds carefully by removing the external soft cover (may be impossible for a corn seed).
2. Identify the parts of the seeds and discuss their respective functions.

Did You Know?

* The endosperm of a monocot seed is larger than the dicot seed. In general, monocots tend to store food in their endosperms, and nutrients are transferred to the cotyledon. In contrast, many dicots tend to store food in their cotyledons, where the endosperm is reduced to a papery coating around the embryo.

Exercise 4.2

Choose the best answer for each of the following questions

1. One of the following statements is false about flowering plants.
   - A They all have flowers.
   - B They all have stems, roots and leaves.
   - C They all form seeds and fruits.
   - D None of the above.
2. Flowers can be characterized as:
   - A vegetative means of reproduction of flowering plants.
   - B always perfect types.
   - C do not have sterile parts.
   - D being modified to be pollinated by different agents.
3. One of the following is common for both monocots and dicots.
   - A Parallel venation.
   - B Fibrous root system.
   - C Number of petals in fours.
   - D Production of seeds.
4. The site of plants in which gas exchange with the environment takes place is:
   - A epidermis.
   - B mesophyll tissue.
   - C stomata.
   - D vascular bundles.
5. One of the following is used as a pollination agent for *teff*:
   - A Birds
   - B Bees
   - C Butterflies
   - D Wind

Unit Summary

- Plants are photosynthetic organisms and are diverse types.
- Plants can be classified into non-flowering and flowering plants (angiosperms).
- Non flowering plants include mosses, ferns, and gymnosperms. They have no flower and except gymnosperms, the others do not produce seeds.
- Flowering plants, which are also known as *Angiosperms* are the only group of plants that, have flowers as their sexual reproductive structures.
- Flowers are organs of sexual reproduction in *Angiosperms*.
- Flowering plants are economically the most important group of plants.
- A flowering plant has three major parts namely; the stem, the leaf, and the root. At maturity these plants will have an additional fourth component, the flower.
- The root is a plant part that grows underground and anchors into the soil.
- The root absorbs water and minerals from the surroundings, it supports the plant, conducts absorbed water and minerals to the above-ground parts of the plant, and stores food.
- The main (primary) root, lateral roots, root hairs, root tip and root cap form the underground plant system or the root system.
- The two main kinds of root system in plants are the *tap root system* and the *fibrous root system*.
- All plant body parts, the stem, the leaf and the root have similar internal features. Especially the stem and roots of higher plants have the outer covering epidermis, the cortex, vascular elements and the pith to the centre.
- The stem is part of a plant which is found in the above-ground, above the soil. The leaf and flower (at the time of maturity) together make up the shoot system (above ground system) of the plant.
- Based on softness or toughness of the stem, there are two types of flowering plants: herbaceous (non-woody) and woody.
- The main functions of stem include erecting the plant above the ground so that it receives maximum sunlight. It is involved in transporting water and minerals from the root to other parts of the plant, supporting above ground part like leaves and flowers; even fruits. It also serves in transporting photosynthetic products from leaves to other parts of the plant.
- The leaves are responsible for both converting sunlight, water, and carbon dioxide into food through photosynthesis and gas exchange.
- The main parts of the leaf include the blade (lamina, the broad part), the mid rib and a petiole (leafstalk) that fixes it to the stem.
- The two main groups of flowering plants are the monocots and the dicots.
- The monocots have one cotyledon and dicots have two cotyledons in their seeds.
- Flowering plants reproduce both sexually and asexually.
- *Vegetative propagation* by stem includes both underground stems such as *tubers*, *rhizomes*, and *corms* or sub-aerial stems like *stolons*, *runners* and *suckers*.

- A flower is the part of the plant that makes the seeds. A flower has four specialized parts; *sepals*, *petals*, *stamens*, and *carpels*.
- Pollination is the process of the transfer of pollen grains from the male part (anther) to the female part (stigma).
- The two types of pollination in flowering plants are *self-pollination* and *cross-pollination*.
- The major pollinating agents for land plants are wind and animals.
- When pollen grain lands on the right stigma it germinates and develops pollen tubes. The pollen tube carries the sperm cells to the ovule, where fertilization occurs.

REVIEW EXERCISE FOR UNIT 4

Part I: ***Choose the best answer for each of the following questions***

1 One of the following is not a flowering plant.

A A barely plant
B A papaya plant
C A pumpkin plant
D A fern

2 Which one of the following does not form the internal tissues of stems and roots?

A Epidermis
B Cortex
C Vascular bundles
D None of the above

3 One of the following is not part of the shoot system.

A Stem
B Flowers
C Leaves
D None of the above

4 In one of the following structure and function is wrongly associated.

A Epidermis – protection
B Mesophyll tissue – gas exchange.
C Root cap – protection.
D Vascular bundles – transport.

5 One of the following is not used as a means of artificial vegetative propagation method

A Stem cutting
B Grafting
C Layering
D Seed sowing

Part II: ***Match correct terms/meaning given in column 'B' with their items given in column 'A'.***

Column A		Column B	
6	Mosses	A	Tid plant
7	Ferns	B	Fruit forming plants
8	Gymnosperms	C	Dry area
9	Flowering plant	D	Underground stem
10	Succulent	E	Moist place

Part III: ***Fill in the blank spaces with correct answers.***

11 _____ is the process of food making in plants.

12 The vegetative body parts of a higher plant is made up of _____, _____ and _____.

13 _____ and _____ are sex organs of a flower.

14 The two types of pollination of flowering plants are _____ and _____.

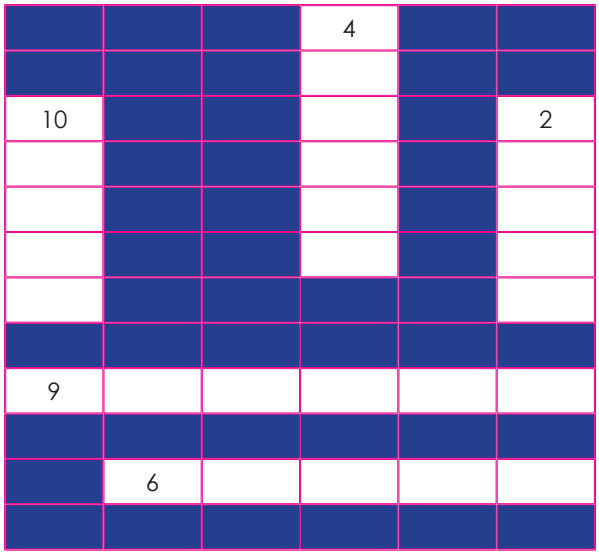
15 Endosperm is formed by the union of _____ and _____.

Part IV: ***Give short answer to the following questions.***

16 List down the major groups of plants that do not posses flower.

17 Write down the major body parts of a flowing plant and give one function for each.

Part V: ***Copy the crossword puzzle below and use the numbered clues to complete and solve the puzzle.***



The numbers in the brackets show the number of letters in each word.

Across

6 The neck of a pistil (5)

9 Part of a stamen that contains pollen grains (6)

Downward

2 Part of a pistil that contain an egg (5)

4 The swollen lower part of a pistil (6)

10 Brightly coloured part of a flower (5)

Unit 5

ANIMALS

Unit Outcomes

By the end of this unit, you will be able to:

- *tell that animals are diverse in size, type and distribution, demonstrate love and respect to them and explain why insects are the most diverse group of animals;*
- *define metamorphosis, explain complete and incomplete metamorphosis and give examples of insects that reproduce by complete and incomplete metamorphosis;*
- *describe how tsetse flies, army worm and maize borer affect humans and explain the methods of controlling them;*
- *explain the characteristics specific to social insects and give examples of social insects;*
- *explain the roles of queen, drones and workers in bees, explain methods of bee keeping and management of beehive, demonstrate the techniques of harvesting honey and compare a modern beehive with a traditional one; and*
- *construct a model of modern beehive, appreciate the behaviour of social insects and express an interest to investigate more about social insects.*

Main Contents

5.1 Diversity of Animals
5.2 Life Histories of Some Insects
5.3 Some Economically Important Insects
5.4 Social Insects
Unit Review

Introduction

The word "*animal*" comes from the Latin word *animale*, meaning vital breath or soul. In everyday usage, the word refers to non-human animals. The biological definition of the word refers to all members of the Kingdom Animalia including humans.

Animals can be grouped into two main groups: *Vertebrates* and *invertebrates*. The main difference between vertebrates and invertebrates is that invertebrates do not have a backbone or a spinal column. Examples of vertebrates include humans, birds and snakes while examples of invertebrates include insects and flatworms.

There are several types of animals living under different conditions. Some animals live in the wild, some live with humans, some are very large and others are very small. In this unit, you will study the diversity of animals, and insects as the most diverse group of animals, including their life history. Some economically important insects (*tsetse fly*, *dark moth – armyworm*, and *maize borer moth*) and social insects including the honeybee are discussed.

5.1 Diversity of Animals

By the end of this section, you will be able to:

- tell that animals are diverse in size, type and distribution;
- demonstrate love and respect to animals;
- explain why insects are the most diverse group of animals.

Diversity of Animals

How diverse are animals?

Animals are diverse in size, type, and distribution. There are many types of animals. The two main groups are vertebrates and invertebrates (see Table 5.1). See Figure 5.1, 5.2 and 5.3 for different sizes and types of animals.

Table 5.1: Comparison chart of vertebrates and invertebrates

Features	Invertebrate animals	Vertebrate animals
Characteristics	Animals without backbone	Animals with back bone
Numbers	98% of the animal species	2% of the animal species
Size	Small	Big
Examples	Insects, flatworms, round worms, snails etc.	Humans, snakes, fish, birds etc

How are animals different in size?

Animals show differences in size from very large to very small. An elephant is a large animal while a rat is a small animal, and a housefly is smaller than both.


Centipede


Termites


Mite


Honeybee


Snail


Bug

Figure 5.1: Invertebrate animals

Key Terms

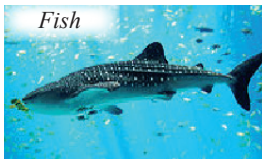
- **Vertebrates:** Animals which have backbone or spinal column.
- **Invertebrates:** Animals which do not have backbone or spinal column.
- **Terrestrial animals:** Animals living on land.
- **Arboreal animals:** Animals living on the branch of trees in the forest.
- **Aquatic animals:** Animals which live in water.
- **Aerial animals:** Animals living in air.

How are animals distributed?

Animals live in various environments such as land, sea, air, forests, soil etc. Animals such as cattle and lions live on land and use limbs to walk. Land animals have toes that produce claws and hooves for walking, climbing, and running. Animals living on land are called *terrestrial animals*.

Animals such as monkey and apes live on trees. They use their limbs to climb. Some animals travel slowly along branches of trees. Animals living on the branch of trees in the forest are called *arboreal.*


Birds


Fish


Bat (mammal)


Monkey (mammal)


Reptile


Frog (amphibian)


Goat (mammal)

Figure 5.2: Some vertebrate animals

Key Terms

- **Amphibian:** Animals living in water and on land.
- **Reptile:** Animals living on land moved by crawling and with horny scale covered body.
- **Mammals:** Animals which the female gives birth to live young and can feed them with their own milk.

Animals such as fish and whale live in water. They use their fins to swim. Animals, which live in water environment are called *aquatic animals*. Whales, which live in water, are the largest known animals.

Some animals such as birds and bats live mostly in the air. They use their limbs to fly. Animals living in air are called *aerial animals.*

Activity 5.1

Observe and Group Animals

☑ Look at Figure 5.3 and fill in the table.

Wild animals	Domestic animals

☑ Which animals in Figure 5.3 is the largest, and which is the smallest? Are they Vertebrates or invertebrates?

☑ Make a visit of your school compound and record the type of animals you see. Look into every surface including the soil.

☑ What type of organisms are found in large numbers and variety in your locality?

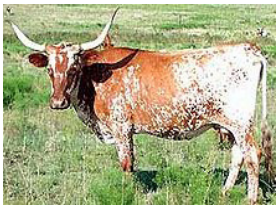
☑ Name some animals which live in Ethiopia.

An elephant

Lion

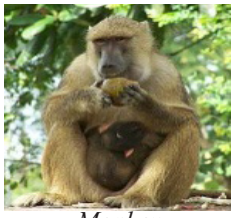
Zebras

Giraffe



Cow

Hyena



Monkey

Donkey

Figure 5.3: Some large Mammals

Activity 5.2

1. What are the uses of animals - wild and domestic animals.
2. Name types of wild animals found only in Ethiopia and reason why we should take care of them.
3. How do you show your love and respect for animals.

Why are insects the most diverse group of animals?

Insects are among the most diverse groups of animals on the planet. They include more than a million described species and represent more than half of all known living organisms.

Insects may be found in nearly all environments, although only a small number of species occur in the oceans.

Insects are the most diverse group of animals because:

- ☑ they are able to live in different habitats,
- ☑ they are able to adapt to the different physical conditions in which they are found,
- ☑ they are able to adapt to changing conditions,
- ☑ they are able to reproduce rapidly.

Show love and respect to animals as they are useful for humans and they have the right to live.

Exercise 5.1

I ***Choose the most exact answers for the following questions.***

1 Which of the following animals live in holes of a ground?

A Termites C Honey bees

B Birds D Snails

2 Which of the following animals live on trees?

A Zebras C Lions

B Monkeys D Hyenas

3 The habitat of a fish can be a

A lake C forest

B mountain D land

4 Insects are found in many places because of their

A ability to adapt C ability to fly

B body size D abdomen

5 Which of the following is the largest animal?

A Lion C Elephant

B Whale D Donkey

5.2 Life Histories of Some Insects

By the end of this section, you will be able to:

- define metamorphosis as a change of form of an animal involving several distinct stages;
- explain complete and incomplete metamorphosis; and
- give examples of insects that reproduce by complete and incomplete metamorphosis.

Word Roots and Origins

Insects from Latin insectum meaning cut into sections.

Insects

What are Insects?

Insects are a class of living creatures that have segmented bodies supported by an exoskeleton, a hard outer covering made mostly of *chitin* (*chitinous exoskeleton*).

The segments of the body are organized into three distinctive but interconnected units: *a head*, *a thorax*, and *an abdomen* (see Figure 5.4).

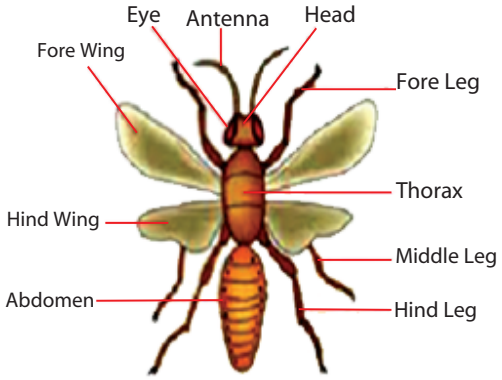


Figure 5.4: External structure of insects

The head consists of a pair of sensory antennae, a pair of compound eyes, and, if present, one to three simple eyes and mouthparts.

The thorax has three segments and six segmented legs. One pair of legs on each segment of the thorax. If wing's are present in the species, there are two or four wings.

The abdomen consists of eleven segments, though in a few species of insects these segments may be fused together or reduced in size. The abdomen also contains most of the digestive, respiratory, excretory and reproductive internal structures.

Metamorphosis

What is metamorphosis?

A fundamental difference between insects and other animals is that as insects grow, their bodies completely change their form. This process is called *metamorphosis*.

There are two types of metamorphosis in insects: *Complete* and *Incomplete metamorphosis*.

- ***Complete metamorphosis*** involves a complete change of form involving four main stages: egg, larva, pupa and adult.
- ***Incomplete metamorphosis*** involves a gradual development involving only three stages: egg, nymph and adult. The nymph closely resembles the adult except it is smaller and wingless.

Key Terms

- **Instar:** each stage between moults in incomplete metamorphosis in insect life cycle.
- **Moult:** removal of outer body cover.
- **Nymph:** wingless stage hatching out from egg in some insects which looks like adult except it is small.
- **Metamorphosis:** complete change of body.
- **Hatch:** keeping warm until young break out of egg.
- **Larvae:** an active feeding worm like stage of life coming out of egg in insects.
- **Caterpillar:** the larvae of butterfly, moths, etc.
- **Pupa:** the inactive, non-feeding stage of life after larval stage in insects.

Incomplete Metamorphosis

What processes take place in the life cycle of grasshoper?

The following processes take place in the life cycle of grass hoppers.

- ☑ The desert locust is a species of grasshopper. It develops by incomplete metamorphosis, i.e., there is no larval stage (see Figure 5.5).
- ☑ The eggs hatch into wingless *nymphs*, which resemble miniature, incomplete adults.
- ☑ In order to grow, the nymph needs to shed its hard outer skin (*cuticle*) and expand its body before the new cuticle hardens.
- ☑ Each stage between molts is called an *instar*. At each moult, the nymph develops more adult features until after the fifth moult when it is a fully formed adult with wings.
- ☑ For the first five instars, the nymphs are called '*hoppers*' and move by crawling or hopping along the ground. They feed on the natural vegetation by cutting off pieces with their jaws.
- ☑ When they develop wings, they fly to a new area where they feed, mate and reproduce.
- ☑ The female extends her abdomen to about 5 cm below the surface of damp sandy soil to lay the eggs. The eggs hatch in 10 – 20 days, depending on the temperature.

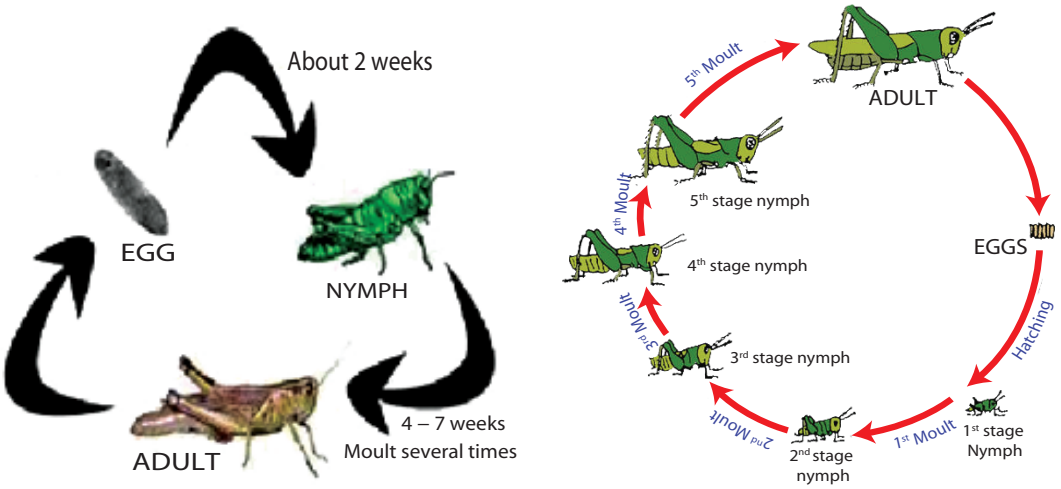


Figure 5.5: Incomplete metamorphosis in Grasshopper

Complete Metamorphosis

What processes take place in the life cycle of butterfly?

The following processes takes place in the life of butterflies.

- ☑ The butterfly lays its eggs on the underside of leaves. For example, cabbage (see Figure 5.6).
- ☑ The eggs hatch into larvae (*caterpillars*) which feed on leaves and grow rapidly, moulting the outer layer of their '*skin*' (*cuticle*) as they do so.

- ☑ Just before its final moult, the caterpillar attaches itself to a wall or tree by means of its clasper and a girdle of silk. Rhythmic contractions split the cuticle, which is then shed.
- ☑ The caterpillar has now become a pupa. Its organs have taken on a form that will later become a butterfly. The cuticle begins to darken and hardened outline of the butterfly's external structures can be seen in the pupa. The pupa will stay dormant over winter; then the cuticle will split and the butterfly will emerge.

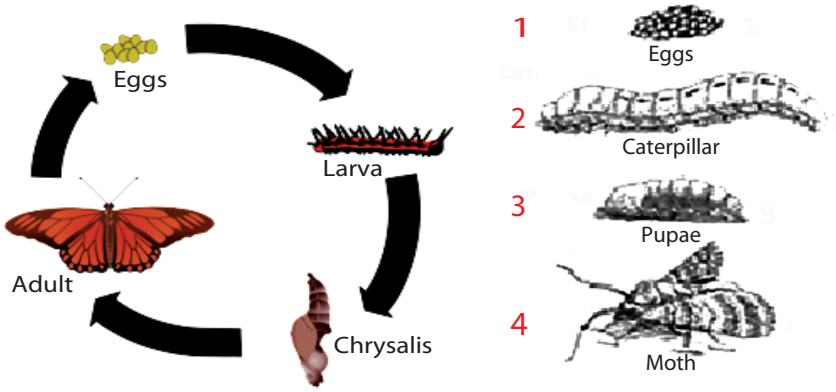


Figure 5.6: Stages of complete metamorphosis of butterflies

Activity 5.3

Examining Insect Life Cycles

You need to collect houseflies and mosquitoes including the various stages in their life cycles.

1. Examine the stages in the life cycle of the housefly and identify the following life stages. An egg, A caterpillar, A pupa and A housefly; what kind of metamorphosis is it?
2. Draw the life cycle of a mosquito?

Exercise 5.2

I ***Choose the correct answers for each of the following questions.***

1. Incomplete metamorphosis does not include
   - A egg stage
   - B larval stage
   - C nymph stage
   - D adult stage
2. During complete metamorphosis larval stage is followed by,
   - A egg
   - B adult
   - C pupa
   - D nymph
3. Which one of the following insects do not shows complete metamorphosis?
   - A housefly
   - B butter fly
   - C honey bee
   - D locust

4 Moulting is:

A shedding of exoskeleton
B shedding of leg
C harmful to insects
D used to lay egg

5 Both nymph and larva

A look like the adults
B are able to reproduce
C hatch from eggs
D all of the above

5.3 Some Economically Important Insects

By the end of this section, you will be able to:

- describe how tsetse flies affect humans and animals;
- explain the methods of control of tsetse flies;
- describe how armyworm damages crops;
- explain the methods of control of armyworms;
- describe how maize borers damage maize; and
- explain the methods of control of maize borers.

Key Terms

- **Vector:** a carrier of disease causing organisms.
- **Anaemia:** disease of the blood.
- **Sleeping sickness:** name given for the disease caused by trypanosomite in humans.
- **Pest:** harmful insects and other small animals.
- **Insecticides:** chemical substances used to kill insects.

Some Economically Important Insects

What are Economically important insects?

Some insects are of great economic importance; some are harmful while others are beneficial to human beings. Insects such as tsetse fly, dark moth and maize stock borer moth are economically harmful.

Tsetse fly

How are tsetse flies economically harmful?

The tsetse fly is a harmful pest that affects both cattle and people. Tsetse flies are vectors of the diseases known as *Trypanosomiasis* or *Tryps* (*sleeping sickness in humans and Gendi in cattle*) with common symptoms such as intermittent fever, progressive anaemia and loss of weight. Tsetse flies are commonly found along the edges of lakes and banks of rivers. Vector control consists of two practical interventions, trapping and spraying the Tsetse fly (see Figure 5.7).

What are the methods of controlling tsetse fly?

The following are some of the methods used to control tesetse flies.

- ☑ Removing bushes and undergrowth along streams to reduce tsetse fly populations.
- ☑ Spraying areas known to shelter the tsetse flies with insecticides.
- ☑ Spraying livestock with insect repellent.
- ☑ Trapping tsetse flies by traps.


Figure 5.7: A tsetse fly and a trapping apparatus

Activity 5.4

Reading and Evaluation

Controlling trypanosomiasis can be achieved by the release of large numbers of sterile male tsetse flies into an area. These sterile males mate with females but no offspring are produced hence the population falls. Read about this method and discuss how it is used. Evaluate this method when compared with other traditional methods of control and discuss in class.

Army Worm

What is the Dark moth (Armyworm)?

The African armyworm is not a worm at all but it is the larval stage of the night flying moth (see Figure 5.8). The larval stages of moths and butterflies are called *caterpillars*.

- ☑ Caterpillars can be hairy, spiny and have unusual shapes.
- ☑ They have large powerful jaws adapted to cut and chew leaves.
- ☑ Caterpillars are very greedy eaters. If they become too numerous they can soon finish the leaves a tree. It is these larval forms or caterpillars that cause much damage to agricultural crops.
- ☑ Most adult butterflies and moths feed on nectar.
- ☑ The larvae have biting mouthparts and the adults have sucking mouthparts.

Figure 5.8: Adult Butterfly, Caterpillar and Armyworms moving in mass

The term armyworm is given to the armyworm because it advances in a mass across a field consuming the grass as they go. Armyworms attack maize, sorghum, wheat, barley, millet, teff, rice, sugarcane and rangeland grasses. They do not attack vegetables, tea and coffee.

Within a few days, all plants in a field may be covered with black caterpillars. Larvae first eat the upper and lower surface tissue of leaves. This results in windowing of the leaves with big swarms, the entire leaves are eaten. This results in severe crop loss.

What are the methods used to control armyworms?

The following traditional methods can be used to control armyworms.

- ☑ Use of moth traps to protect *infestations*.
- ☑ Using cut branches from trees to 'brush' the caterpillars off the plants.
- ☑ Driving herd of cattle, sheep, and/or goats back and forth across affected areas .
- ☑ Dragging thorn bushes or beating the infested areas with sticks and branches.
- ☑ Collecting larvae by hand.
- ☑ Letting chickens feed on larvae.

Traditional control measures are only effective for small areas. In large areas with heavy infestation, the pests have to be sprayed with *pesticides* from the air. The disadvantage of this method is that useful insects are also destroyed.

Key Terms

☑ **Armyworms:** are caterpillars that move in mass as armies and consume grasses on their way.

Maize Stalk Borer Moth

What is maize stalk borer moth and its importance?

Maize stock borer is a species of moth that is also known as the maize stalk borer. It is known as "*Ageda Korkur*" in Amharic. Adults are pale brown and the wingspan is 35 – 40 mm. The larvae feed on various grasses, as well as sorghum and sugar cane (see Figure 5.9).

Eggs are laid in a long column stretching up the stem, under a leaf sheath. They hatch after about 10 days.

The larvae are called caterpillars and they crawl up the plant into the funnel and feed on the leaves. This results in characteristic lines of holes and "*windows*". The shoot may turn yellow and die. If the plant dies, the caterpillars will move to another plant.

Adult

Hole made on stalk by larvae

Larva in stalk

Figure 5.9: Maize stalk borer moth

The mature caterpillar cuts a hole in the stem before pupating within the tunnel. Eventually the moth will use this hole to emerge.

The leaves of young plants have holes and "*windows*". When the attack is severe, the central leaves die. In older plants, the caterpillars of the first generation bore in the main stem. Some caterpillars *bore* in the cobs. Damage to sorghum is usually less serious than damage to maize.

Activity 5.5

Group Work and Discussion

1. Ask people to tell you some economically harmful insects, which damage crops in your community. Ask their name, how they harm, and the method of control people use.
2. Visit the health facility and ask what kinds of insects are involved in the transmission of disease in your community. Ask the name of the insect, the disease transmitted, how it is transmitted and the method of control.
3. Write a report of your investigation in groups. In the report, write what you can do to control the harmful insects in your community. Discuss about the methods of control in class.

Exercise 5.3

I ***Choose the best answer for each of the following questions***

1. Which one of the following is a vector?
   - A Dark moth
   - B Grasshopper
   - C Tsetse fly
   - D Butterfly
2. Which of the following form a swarm that attacks crops?
   - A tsetse fly larvae
   - B moth larvae
   - C honeybee larvae
   - D housefly larvae

3 Sleeping sickness is

A a disease of cattle
B a disease of crops
C a disease of people
D a disease of insects

4 Caterpillars are _____ stage of insects

A adult
B larvae
C pupa
D nymph

5 Larval stages of insects moving in mass is called

A Caterpillar
B Instar
C Armyworm
D Swarm

5.4 SOCIAL INSECTS

By the end of this section, you will be able to:

- explain the characteristics specific to social insects;
- give examples of social insects;
- explain the roles of queen, drones and workers in bees;
- explain methods of bee keeping and management of beehive;
- demonstrate the techniques of harvesting honey;
- compare a modern beehive with a traditional one;
- construct a model of modern beehive;
- appreciate the behavior of social insects; and
- express an interest to investigate more about social insects.

Social Insects

What are social insects and their characteristics?

Insects that live together in communities or colonies are called social insects. The main groups of social insects are bees, ants and termites.

Social insects live together in large groups or colonies and share out the work needed to sustain the colony between them. Different casts of the insect carry out different duties within the colony.

All social insects possess the following common characteristics.

- ☑ Large populations (colonies)
- ☑ Elaborate nests
- ☑ Parental care,
- ☑ Protective devices
- ☑ Swarming
- ☑ Communication and
- ☑ Division of work.

Activity 5.6

Individual Library Assignment

1. Give examples of social insects.
2. What are the advantages of living in a large social group to the insects?
3. Why are honeybees considered as social insects?

The Honeybee

What are the castes of honeybee?

Honey bee is a social insect which produce honey. A colony of bees consists of three castes of bee (see Figure 5.10). They are queen, drone, and worker castes.

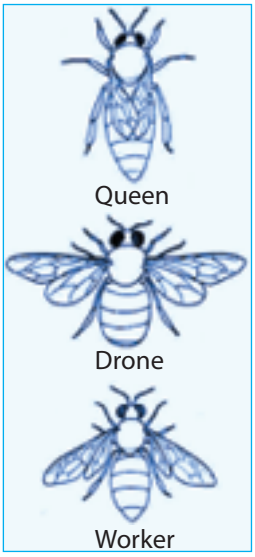


Figure 5.10: Castes of honeybee

What is a Queen Bee?

- ☑ There is only one queen bee per hive.
- ☑ The queen is the only bee with fully developed ovaries.
- ☑ A queen bee can live for 3 – 5 years.
- ☑ The queen mates with several male bees (*drones*), and will remain fertile for life.
- ☑ She lays up to 2000 eggs per day.
- ☑ Fertilized eggs become female (*worker bees*) and unfertilized eggs become male (*drone bees*) (See Figure 5.11).
- ☑ When she dies or becomes unproductive, the other bees will "make" a new queen by selecting a young larva and feeding it a diet of "*royal jelly*".
- ☑ For queen bees, it takes 16 days from egg to emergence.

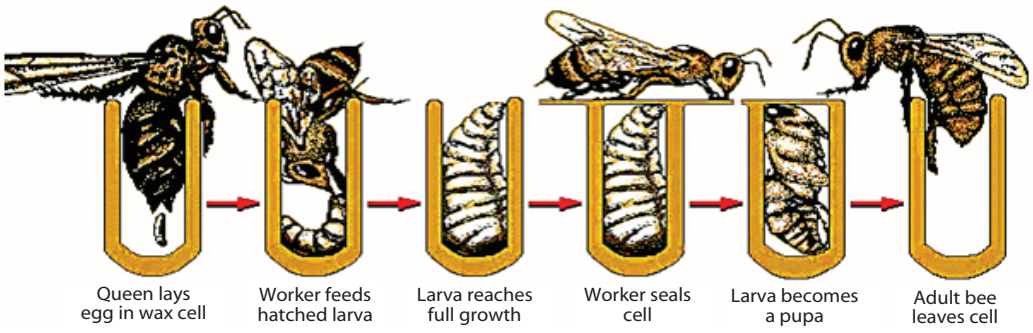


Figure 5.11: The process of honeybee hatching

What is a Worker Bee?

- ☑ All worker bees are female, but they are not able to reproduce.
- ☑ Worker bees live for 4 – 9 months during the winter season, but only 6 weeks during the busy summer months (*they literally work themselves to death*).
- ☑ Nearly all of the bees in a hive are worker bees.
- ☑ A hive consists of 20,000 – 30,000 bees in the winter, and over 60,000 – 80,000 bees in the summer.
- ☑ The worker bees sequentially take on a series of specific tasks during their lifetime (see Table 5.2).

Table 5.2: Periods of work activity of worker bees

Period	Work activity
Days 1 – 3	Cleaning cells and incubation
Day 3 – 6	Feeding older larvae
Day 6 – 10	Feeding younger larvae
Day 8 – 16	Receiving honey and pollen from field bees
Day 12 – 18	Wax making and cell building
Day 14 onwards	Entrance guards; nectar and pollen foraging

- ☑ For worker bees, it takes 21 days from egg to emergence. The worker bee has a barbed stinger that results in her death following stinging, therefore, she can only sting once.

What is a Drone Bee?

- ☑ A drone bee is a male which mates with the queen.
- ☑ These male bees are kept on standby during the summer for mating with a virgin queen.
- ☑ Because the drone has a barbed sex organ, mating is followed by death of the drone.
- ☑ There are only 300-3000 drones in a hive.
- ☑ The drone does not have a stinger. Because they are of no use in the winter, drones are expelled from the hive in the autumn.

How do honeybees communicate?

A honeybee that discovers a new food source will tell other honeybees about its location through the honeybee dance. When a worker bee returns from an abundant food source, she will dance inside their nest in a circle. The dancer wiggles her abdomen while crossing the circle made by round dance.

Waggle dance is a term used for a particular number 8 – like dance of the honeybee.

Key Terms

- **Waggle dance:** a term used for a particular figure-eight dance of the honeybee.
- **Round dance:** circular dance pattern by honey bee.
- **Nectar:** Sweet fluid produced by flowers is 60% water and 40% solids. This is collected by the bees and converted into honey at 17 – 18% moisture content.
- **Super:** the supplementary wooden boxes placed on top of the hive body to expand the size of the colony, and to provide for storage of surplus honey.

Methods of Beekeeping

What is beekeeping?

Beekeeping is the maintenance of honey bee colonies, commonly in hives, by humans. A beekeeper keeps bees in order to collect honey and beewax, to pollinate crops, or to produce bees for sale to other beekeepers.

What are beehives?

A beehive is an enclosed structure in which honeybees live and raise their young. Natural beehives are naturally occurring structures occupied by honeybee colonies, while domesticated honeybees live in manufactured beehives, often in an apiary (Figure 5.13). These manufactured structures are typically referred to as "*beehives*".

Figure 5.12: Natural beehive on tree

The beehive is internal structure with a densely packed matrix of hexagonal cells made of beeswax, called *a honeycomb*. The bees use the cells to store food (*honey and pollen*) and to house the "*brood*" (*eggs, larvae, and pupae*).

***Traditional (Fixed comb) hive*:** is a hollow structure made of cheap materials like clay, straw, bamboo, false banana leaves, logs, barks of tree, and animal dung. The bees fill all the available space with honeycombs from the top downwards. The honeycombs cannot be removed since they are attached to the top and the sides of the hive. The honey can be removed only by removing one wall of the hive and breaking or cutting out the honeycomb (see Figure 5.13).

Key Terms

- **Beehive:** it is an enclosed structure in which honeybees live and raise their young.

Hive made of mud

Hive made of bamboo

Hives made of wood

Hives made of mud and grass

Figure 5.13: Different types of traditional hives in Ethiopia

Modern Hive (Hive with Frames) is a brood (*offspring*) chamber (*box*) with a fixed bottom board and flight board. In the bottom board, there is a ventilation hole (15 cm × 30 cm), which can be covered with fine wire mesh or other suitable materials. The brood chamber holds ten frames, which are kept separately at the right distance by means of a side bar, or nails. Queen excluder (*not necessary*) placed horizontally on top of the brood chamber.

Figure 5.14: A man made modern hive

Activity 5.7

Talk to a beekeeper about bee keeping and demonstrate some of the techniques used.

What is the importance of beekeeping?

Honeybees are important for humans.

People keep honeybee for their economic importance. Honeybees are important pollinating agents of crops and give various products such as:

- ☑ Honey
- ☑ Pollen
- ☑ Propolis
- ☑ Beeswax
- ☑ Queen jelly

These products can be sold to get money or used for various purposes.

Pollen

Pollen is the male germ cells produced by all flowering plants for fertilization and plant embryo formation. The Honeybee uses pollen as a food. Pollen is one of the richest and purest natural foods, consisting of up to 35% protein, 10% sugars, carbohydrates, enzymes, minerals, and vitamins.

Honey

The bees use honey for food all year round. There are many types, colors and flavors of honey, depending upon its nectar source. The bees make honey from the nectar they collect from flowering trees and plants. Honey is an easily digestible, pure food. Honey is hydroscopic and has antibacterial qualities.

Beeswax

Secreted from glands, beeswax is used by the honeybee to build honey comb. It is used by humans in drugs, cosmetics, artists' materials, furniture polish and candles.

Propolis

Collected by honeybees from trees, the sticky resin is mixed with wax to make a sticky glue. The bees use this to seal cracks and repair their hives. It is used by humans as a health aid, and as the basis for fine wood varnishes.

Royal Jelly

Royal jelly is the powerful, milky substance that turns an ordinary bee into a Queen Bee. It is made of digested pollen and honey or nectar mixed with a chemical secreted from a gland in a nursing bee's head. It commands higher prices, and is used by some as a dietary supplement and fertility stimulant. It is loaded with all of the B vitamins.

Management of Beehives

How should a beehive be managed?

Management of beehives includes:

- ☑ Preparing modern hives
- ☑ Selecting proper place for the hive where water and flowers are available
- ☑ Protection of a hive from disturbance and enemies
- ☑ Knowledge of proper method of honey harvesting
- ☑ It is possible to harvest some of the honey made by bees but the beekeeper should leave sufficient for the needs of the colony of bees.
- ☑ Knowledge of forming new colonies
- ☑ Monitoring colonies carefully for the appearance of queen cells, which are a signal that the colony is determined to swarm and for signs of disease.

Techniques of Harvesting Honey

What is the technique of harvesting honey?

Honey is harvested from the super of the hive following careful procedures (see Figure 5.15 'a' and 'b').

- ☑ protection methods of bee sting during harvest.
- ☑ knowledge of the bees is the first line of defense.
- ☑ wearing protective clothing is the second line of defense. The protective clothing is generally light coloured (*but not colourful*) and of a smooth material.
- ☑ smoke is the beekeeper's third line of defense. Smoke calms bees.

Did You Know?

Honeybees are not aggressive by nature, and will not sting unless protecting their hive from an intruder or are unduly provoked.

Activity 5.8

I Library Assignment

1. Why is it advisable to leave some of the honey in the colony when harvesting honey?
2. What is the economic importance of beekeeping, both in terms of pollinating crops, and obtaining products from the hive?
3. What is the use of the following? Honey, Beeswax, Pollen, and Queen Jelly.
4. What is the advantage of using a modern beehive?

Figure 5.15: Harvesting honey with protective clothing and using smoke

Most beekeepers use a "*smoker*" – a device designed to generate smoke from the incomplete combustion of various fuels.

Comparing a Traditional and a Modern Beehive

Traditional hive	Modern hive
Frames not removable and difficult to inspect.	Removable frames which allow the apiarist to inspect for diseases and parasites.
Not easy to form new colony.	Movable frames also allow a beekeeper to more easily split the hive to make new colonies.
No re-using of comb thus decrease the productivity.	Re-using comb can thus increase the productivity of a beekeeping enterprise.
Bee are damaged during honey harvest yields more beeswax but less honey.	Safe to bee during harvest only extra honey is harvested. Yields more honey but less beeswax

Activity 5.9

Work in small groups and write a group report

1. Discuss how bees are able to communicate with each other through various dances, to indicate the source of food.
2. Discuss the ability of honeybees to live together in a hive and how that increases the chances of their survival.

Construction of a Model Beehive

How is model modern beehive constructed from locally available materials?

For bees to give us their products they need to be kept in hives and provided with necessary services. Providing the proper hives with enough space together with enough food supply (*flowers*) are considered to be very important in bee farming. Construction of suitable hives is very crucial in beekeeping practice in order to harvest the yield, inspect and manage the hives without disturbing, annoying and killing bees.

In our country almost all beekeeping practices by the rural farmers are done in a very traditional way, with traditional hives (Figure 5.16). The traditional hollow log hives are hanged in long trees. These hives make the activities of inspection, management and harvesting very difficult.

Figure 5.16: The traditional cylindrical hives

Traditional hives which are made from clay pots, barrels and most containers can easily be modified into modern top-bars hives. The important thing in modern hives is to maintain the proper, equal distance between the combs. In Ethiopia it is possible to construct an alternative, easy, economical and productive top bar like hives from locally available materials at the farmer level.

Activity 5.10

Constructing a model top bar modern beehive from local material.

Materials you require

- ☑ Hard paper or cardboard
- ☑ Measuring tape
- ☑ A pair of scissor
- ☑ Glue

Procedure

1 In groups observe Figure 5.17 very carefully and the box should have a height of 30 cm and width of 40 cm at the top and 22 cm of at the bottom.

2 Cut the hard paper and prepare two pieces of 1 m X 40 cm for the top cover and 1 m X 22 cm for the bottom covers.

3 Cut the hard paper and prepare again two pieces of 1 m X 30 cm for the side covers.

4 Prepare two pieces of 40 cm X 30 cm and 22 cm X 30 cm for the front and rear side covers.

5 Cut 2 cm X 10 cm on the 40 cm X 30 cm (front side cover you have already prepared) and set an entrance for bees

6 Measure and cut appropriate partition board at the middle.

7 Stick all sides with a glue together.

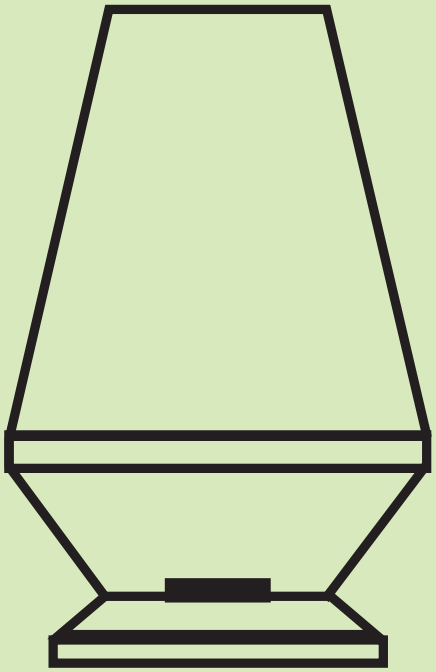


Figure 5.17: Model top bar hive

Activity 5.11

Work in small groups and write a group report

Research into how the life of solitary wood bees differs from that of the honeybee and another social insect such as the termite and make comparisons with the honeybee.

Key Terms

☑ **Termite mound:** large nest made from clay, sand and their saliva by termites with the nest chamber above ground level.

Did you know?

* Termite colonies eat non-stop, 24 hours a day, seven days a week.
* Termites have wings that they shed once they have found a good place to build a nest.

What are termites?

Termites are social insects and raise their young as a group. They are organized into colonies similar to those of bees and ants but they are unrelated to these insects (see Figure 5.17).

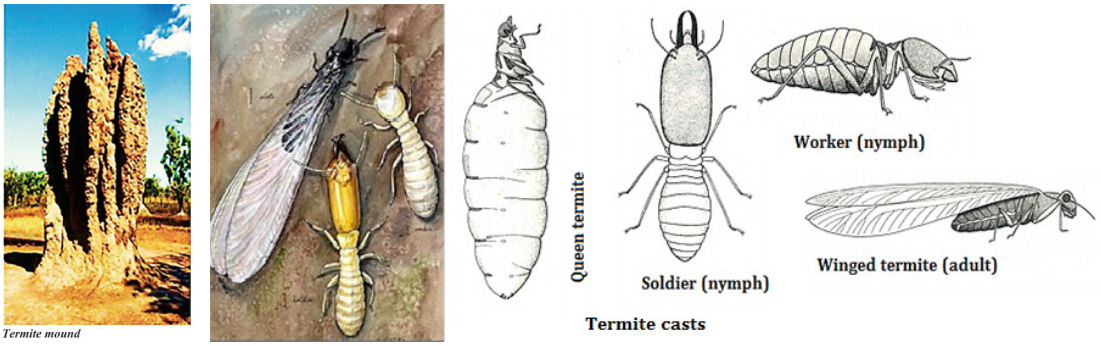


Figure 5.18: Termite mound and termite casts

Activity 5.12

I Library Assignment

1 Why is it advisable to leave some of the honey in the colony when harvesting honey?

2 What is the economic importance of beekeeping, both in terms of pollinating crops, and obtaining products from the hive?

3 What is the use of the following? Honey, Beeswax, Pollen, and Queen Jelly.

4 What is the advantage of using a modern beehive?

5 Try to appreciate the behavior of social insects and show interest to investigate the similarity between honey bee and termites.

II Constructing a Model Beehive

Visit a beekeeper and ask how a beehive is prepared, read books in the library and construct a model beehive in groups, make a drawing of your beehive and label the parts.

Exercise 5.4

Choose the best answers for each of the following questions

1 From the castes of bees, sterile females which cannot reproduce are called

A Drones
B Workers
C Queen
D Queen and workers

2 A small six sided chamber made from wax by workers bee is called

A Royal jelly
B Honey comb
C Honey
D Frame

3 Which of the following is not true about useful insects?

A They spread disease
B They kill harmful pests
C They pollinate plants
D Some decrease crop production

4 The insect that causes a huge damage to crops is

A Mosquito
B Dark moth
C Housefly
D Bee

5 An insect which can build a mound is

A Termite
B Housefly
C Mosquito
D Locust

Unit Summary

- Animals show differences in a number of ways including size, type and distribution.
- Insects are the most diverse group of animals.
- The fundamental difference between some insects and other animals is that as insects grow, their bodies completely change their form. This process is called metamorphosis. Metamorphosis may be said to be incomplete or complete.
- Complete metamorphosis involves a complete change of form involving four main stages: egg, larva, pupa and adult.
- Incomplete metamorphosis involves a gradual development involving only three stages: egg, nymph and adult. The nymph closely resembles the adult except it is smaller in size and wingless.
- Some insects are of great economic importance; some are harmful while others are beneficial.
- Tsetse fly is a harmful pest that affects both cattle and people. They are vectors of disease. The term vector means a carrier of disease. They are commonly found along the edges of lakes and banks of rivers.
- The tsetse fly carries a parasite called trypanosome, which causes a disease called nagana in cattle and sleeping sickness in people.
- Suitable methods of controlling the tsetse fly include removing bushes and undergrowth along streams to reduce tsetse fly populations, spraying areas known to harbour the infection with insecticides, and Spraying livestock with insect repellent.

- Some insects live together in large groups or colonies and share out the work needed to sustain the colony between them.
- Different castes of the insect carry out different duties within the colony. The ability of social insects to live together in a hive increases the chances of their survival. Examples of social insects include ants, termites, and honeybees.
- Honeybees are a social insect which are beneficial to people. They live in a hive in which there are three castes, Queen (lays eggs), Drones (mates with the queen) and Workers (gather nectar, build honeycomb, protect the hive).
- It is possible to harvest some of the honey made by bees but leaving the colony of bees sufficient for its needs.
- A beehive should be managed carefully and the honey is harvested with protective clothing.
- The economic importance of beekeeping is great. Bee are pollinators of crops and produce useful substances. The useful products obtained from honeybee include honey, beeswax, pollen, and queen jelly.
- Bees communicate with each other through various dances, to indicate the source of food.

Review Exercise for Unit 5

Part I: ***Choose the best answer for each of the following questions.***

1 Which one of the following is the largest animal?

A Elephant C Whale

B Mule D Zebra

2 Animals living in water are called

A Aquatic C Terrestrial

B Arboreal D Aerial

3 Which one of the following is not true about insects

A Their body is divided into three main parts

B They are the most diverse animals

C All of them have an abdomen

D All of them have complete metamorphosis life cycle

4 The head of insects support

A Wings C Thorax

B Abdomen D Antenna

5 Each stage between moults of incomplete metamorphosis is called

A Pupa C Larva

B Instar D Caterpillar

6 Which of the following shows incomplete metamorphosis

A Butterfly
B Moth
C Grass hopper
D House fly

7 The larval stage of moths and butterflies is called

A Nymph
B Pupa
C Caterpillar
D Moult

8 The correct sequence of complete metamorphosis is

A Egg → Pupa → Larva → Adult
B Egg → Larva → Pupa → Adult
C Egg → Larva → Caterpillar → Adult
D Egg → Larva → Instar → Caterpillar

9 Army worm is the larval stage of

A Dark moth
B Locust
C Butterfly
D Tsetse fly

10 In a modern hive of honey bee, honey is harvested from

A Brood box
B The super
C Top cover
D The hive stand

PART II: ***Match items given in Column A to the appropriate description given in Column B.***

Column A		Column B	
11	Caterpillar	A	Removal of outer body cover
12	Pupa	B	Young stages of honeybee
13	Moulting	C	Female honeybee
14	Brood	D	Male honeybee
15	Drone	E	Animals having back bone
16	Invertebrate	F	Animals living on land
17	Vertebrate	G	Animals living in water
18	Terrestrial	H	Animals with no backbone
19	Aquatic	I	The 3rd life stage in butterflies
20	Vector	J	The larval stage of butterflies
		K	Animals living on tree branches
		L	Disease carrying insects

Part III: *Fill in the blanks with the appropriate terms.*

21 The most diverse group of animals are _____ .

22 Complete metamorphosis involves _____ distract stages.

23 The larval stage of the night flying moth is _____ .

24 Social insects live in _____ .

25 Honey bees perform _____ to locate a new food source.

Part IV: *Give short answers for each of the following questions.*

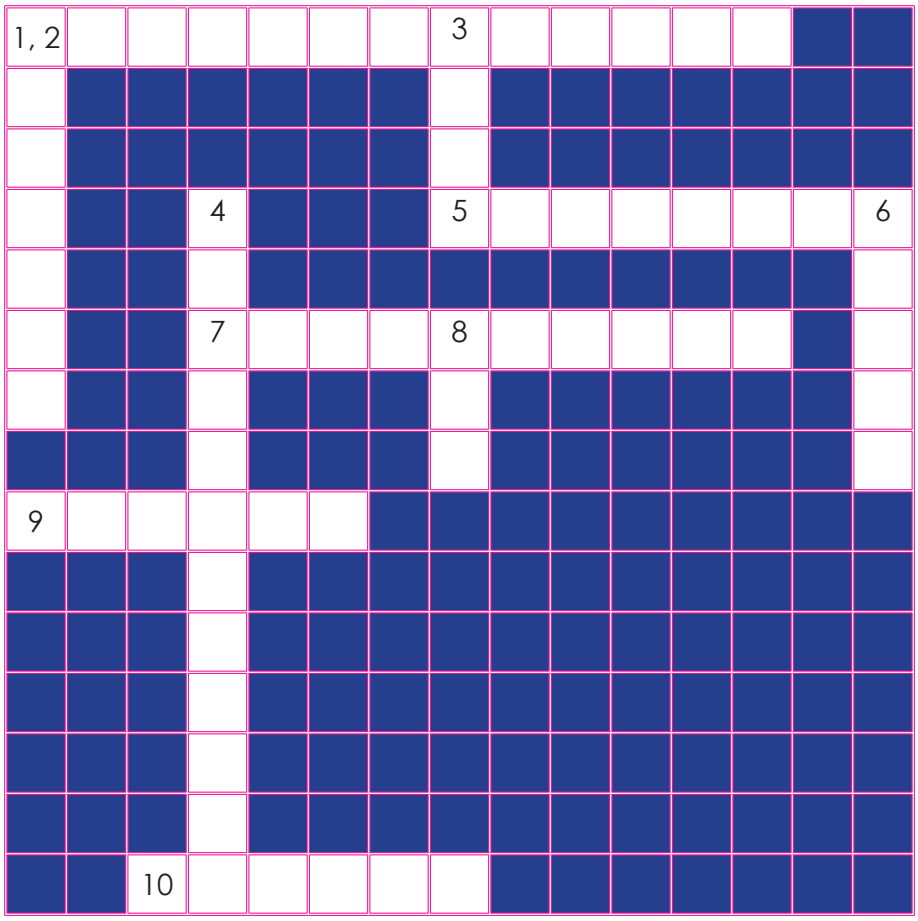
26 What are social insects?

27 What is the role of the queen in a honeybee colony?

28 What are the advantages of a modern beehive?

29 How can the sting of bee be protected when harvesting honey?

Part V: *Copy the crossword puzzle below and use the numbered clues to complete and solve the puzzle.*



The numbers in the bracket indicate the number of letters in each word.

Across

1 Change of body structure in insects (13)

5 Animals living on tree (8)

7 Animal group with back bone (5)

9 Stage between molts in incomplete metamorphosis (6)

10 Animals living in air (6)

Downward

2 Vertebrate group (7)

3 3rd life stage in complete metamorphosis (4)

4 Animal group without back bone (12)

6 2nd life stage in complete metamorphosis (5)

8 1st life stage of all insects (3)

Unit 6

ENVIRONMENT

Unit Outcomes

By the end of this unit, you will be able to:

- *define habitat, classify habitats into terrestrial and aquatic and give example for each;*
- *define population and community and give examples for each;*
- *identify smaller habitats in your surroundings, examine organisms that dwell in them and write a report on your findings;*
- *use quadrats to estimate distribution of organisms in a given habitat, demonstrate methods of collecting and preserving plant and animal specimens and collect and preserve plant and animal specimens,*
- *describe food chain and food web with practical examples and construct a simple food chain by observing food relationship of organisms in your surroundings; and*
- *explain the different trophic levels of a food chain; describe the pyramid of numbers using a diagram and indicate the trophic levels on the diagram of the pyramid of numbers.*

Main Contents

6.1 Habitat
6.2 Studying a Habitat
6.3 Food Relationships
Unit Review

Introduction

Why is it so important to know about our Environment?

We should question about the environmental change that is happening in our day to day life. Natural and Man-made contribution and its consequences brought the attention of leaders and other people to the environment. Unexpected climate change, such as global warming, poor productivity of harvest due to poor care for the soil, air pollution, erosion and deforestation are some among many others.

Look around your environment, what are the natural and man-made environmental disasters? What should be done to make the environment more suitable for living organisms?

Did You Know?

* Ethiopia is known for its natural resources, however, less than 3% of the forest cover is left, 81 billion M^3 (74% of 110 billion M^3) of water leaves the country with soil and nutrients; 95% (Urban + Rural) and 99.9% (Rural) of energy demand is met from biomass energy; drought and desertification is spreading; temperature is rising even in high lands; and land productivity is declining.

Good understanding about environment is the basis to care for the natural system. As a result of awareness about the environment, people might care and maintain the proper natural system in a better way. In this unit you are going to explore habitats and their characteristics. The second subunit focuses on how to study a habitat through various tools and techniques that help us collect information on the types, distribution and numbers of living organisms within. The last subunit deals about food relationship among living organisms and how energy is transferred from one form of living thing to another within an environment.

6.1 Habitats

By the end of this unit, you will be able to:

- define habitat as a place where living things live;
- classify habitats into terrestrial and aquatic;
- give examples of terrestrial and aquatic habitats;
- define population as a group of organisms of same species;
- give example of populations;
- define community as a group of populations of different species; and
- give examples of communities.

What is a Habitat?

A habitat is a place where an organism lives and reproduces in its environment. It is the natural home or address, where an organism can be found, such as under a stone or at the bottom of the pond. It might be also a clean stream, river edge or a forest. For example, the habitat for a tadpole can be a pond, where its environment consists of water, temperature and oxygen that will influence the tadpole's rate of growth and activity. The watery environment contains plants and animals on which the tadpole will feed, but it also contains fish and insects which may eat the tadpole. Thus, the water, the oxygen, the temperature, the food and the predators are all part of the tadpole's environment (see Figure 6.1).

Key Terms

- **Environment:** everything in the surrounding of an organism that could possibly influence it.
- **A habitat:** is an ecological or environmental area that is occupied by a particular species of animal, plant or other type of organism.
- **Aquatic habitat:** a watery environment in which living things dwell.
- **Terrestrial habitat:** a land environment in which living things live.

Figure 6.1: Example of a Habitat

Aquatic and Terrestrial Habitats

Since there are various ways of life observed in living things, there has to be wide range of habitats suitable for the different types of living things. These habitats are generally classified into *aquatic* and *terrestrial* habitats.

What is an aquatic habitat?

Aquatic Habitat is an environment, which is characterized by living organisms that live in water. It includes ponds, streams, rivers, seas and oceans. Such habitats are suitable for harbouring fishes, algae, tadpole, ducks, tortoises and others (see Figure 6.2a and Figure 6.3a). *Can you add some more?*

What is a terrestrial habitat?

Terrestrial Habitat is an environment, which is characterized by living organisms that live on land. It includes forests, mountains, hills, rocks and soils. Such habitats are suitable for birds, insects, worms, trees and wild animals (see Figure 6.2b and Figure 6.3b). Can you add some more?

a) *Lake*

b) *Forest*

Figure 6.2: An example of aquatic and terrestrial habitat

a) *Whale*

b) *Rhino*

Figure 6.3: Animals living in aquatic and on terrestrial habitats

Activity 6.1

Discuss on habitats

Materials you will Require:

A log, a stone (rock), a tree, a river, or a pond.

Procedures:

- ☑ In groups, look for a habitat in your school compound and village.
- ☑ Discuss on the habitats you may have observed and classify them into aquatic and terrestrial.

Did You Know?

* Whale is the biggest animal living in aquatic habitat and an elephant is the biggest mammal that lives on a terrestrial habitat.

Population and Community

In a given habitat every living organism is adapted or suited to its environment. Moreover, living organisms do not exist separately but interact with their living and nonliving environment. For example, fishes live only in aquatic habitat because they are adapted to interact with the aquatic environment.

Did You Know?

* Ethiopian human population is estimated to be 73,918,505 (CSA 2008) and the population of one of the endemic wild animals of Ethiopia, Walia Ibex, is approximately 745.

What is population?

A group of living organisms of the same species that lives in a particular area is called a *population*. Within any habitat there are a number of organisms of the same species living together as members of a population. For example, there will be a population of each type of algae, fish, bird and insects. On the other hand on land, you can find a population of human beings, domestic animals such as cats, dogs and so on.

Key Terms

- ☑ **Population** is a group of living organisms of the same species that live in a particular area.
- ☑ **Community** is all the different population that are found in a particular area.

Each population has its own requirements to live within a given habitat such as temperature, humidity, types of food and other factors that can determine its existence and reproduction. In addition, places where there are predators, competitors or parasites may not be suitable and can prevent a population from occupying the area. Therefore, living organisms interact within the environment as a population.

Population of a certain species can be characterized in a way they are distributed in a given area. They may be found distributed randomly, uniformly or in a group form. Therefore, in some populations, individuals can be observed living in groups, in some others they are dispersed here and there, evenly or unevenly (see Figure 6.4).

Figure 6.4: Population of Walia Ibex

What is community?

A community is all the various living things or populations living and interacting in a particular area. A community is made up of all the plants and animals living in a habitat. Within a habitat, there likely are populations of different species. A group of populations that live together in a given habitat are called a community (see Figure 6.5).

Figure 6.5: Community of domestic animals and men

Exercise 6.1

I *Choose the best answer for each of the following questions*

1 Which of the following is the best habitat for a fish

A a lake B a stone C a log D a tree

2 Which of the following is the best habitat for a tape worm?

A a lake
B a forest
C a human intestine
D a grass

3 A community includes all

A the plant species only
B the animal species only
C the different species
D all the single species

4 A population consists of

A all different species within a given habitat
B a group of the same species with in a given area
C plants and animals only
D none of the above

II *Try to sort out, the following as aquatic and terrestrial habitats from the biggest container to the smallest ones.*

Habitat	Aquatic	Terrestrial
Ditch, farmland, park, pond, stream, river, savannah, lake, rock pool, ocean, rain forest, mountain, field, desert, sea, ocean.		

6.2 Studying a Habitat

At the end of this section, you will be able to:

- identify smaller habitats in your surroundings;
- examine organisms that dwell in the smaller habitats;
- write a report on the small habitats and the organisms dwelling in them;
- use quadrats to estimate distribution of organisms in a given habitat;
- demonstrate methods of collecting and preserving plant and animal specimen;
- collect plant and animal specimens; and
- preserve plant and animal specimens.

Key Terms

- **Sampling:** is the technique used to estimate the population of a species that are found in a given habitat.
- **Quadrats:** are a series of square (1 m^2) frames that are placed in a habitat used for sampling.

What is the importance of studying a habitat? How is it possible to determine or estimate the number of a population within a habitat?

Observing Habitats in Our Surroundings

If you observe your surroundings, you can find habitats in which there are various populations and communities. It might be possible to count all the trees in your school or all the insects under a stone, or all the worms in the moist soil sample. However, it would be difficult or impossible to identify and count all the different kinds of fish in a lake or all the trees in a forest.

Observing habitats and identifying different species, population or community requires a systematic approach. Scientific approach uses various tools and techniques. Sampling is one of the techniques that is commonly used in identifying a population of a species. By sampling we mean we take a portion or sample of the area to estimate the population of a species that is found in a given habitat.

The sampling technique enables a biologist to estimate the total number of organisms in the habitat under study. Since the organisms may not be evenly distributed, it will be good to take several samples from different parts of the habitat randomly. The samples will also need to be taken at regular interval throughout the year as there are seasonal fluctuations in the environment.

What are quadrats?

Quadrat is a square or rectangular frame made of metal, wood or is pegged out with string on the ground. It is shown in Figure 6.6. It can be made up to an area of 0.25 m^2 or (0.5 m X 0.5 m), you can make quadrats using locally available materials such as bamboo, or sticks, wire or strings.

Figure 6.6: A quadrat

Quadrats are best suited to sampling vegetation. The quadrats must be placed at random throughout a habitat so that they are not deliberately placed towards vegetation which looks interesting, you can use the quadrat land depending on the type of information you require.

Activity 6.2

Mapping a habitat

In this activity you will examine your surrounding and map it so that you can better describe it.

Procedures:

- ☑ Make a group and identify a habitat to be visited.
- ☑ Draw a map of the habitat and then look for living organisms and mark where you find them on the map.
- ☑ Did you find similar types of living organisms in one spot?
- ☑ What are the most common types of living organisms in the area?
- ☑ Does the habitat have enough food, water and shelter for the living organisms?
- ☑ Write a brief habitat survey report and present it in the class. Your report should include:
  - ✓ the size of the habitat.
  - ✓ the nature of the habitat.
  - ✓ sizes of the various populations of organisms found and identified.
  - ✓ comments on any particular interesting features. For example, particular plants found only where the ground is damp.

Using Quadrats

How is it possible to determine the population of a certain species within a habitat?

Quadrats are samples used to identify and estimate the number of plant communities in a given habitat. In using quadrats first map the area and know the total coverage of the habitat. The quadrats must be placed randomly throughout a habitat of interest. The quadrats can be used to have quantitative information such as density, frequency and percentage cover of the plant species (see Figure 6.7).

Figure 6.7: Using a quadrat

There are factors that need to be considered in relation to the use of quadrats. These are

- ☑ distribution of various species,
- ☑ shape and size of the quadrat (square, circle or rectangle), and
- ☑ number of observations needed to obtain an adequate estimate of density (sample size).

To obtain the density of organisms per unit area of habitat

- ☑ first count the number of a plant species present within a quadrat each time it is placed,
- ☑ repeat counting until the quadrat has reached and placed all the randomly selected area of the habitat, and
- ☑ finally calculate the average number of this plant species per unit area.

Activity 6.3

Identification and examining of a small habitat

Procedures:

Divide yourself into groups and look for a small habitat in your surrounding probably on a playing field, a pool or a small wood.

- ☑ Form a quadrat tool using locally made bamboo or stick, the quadrat should be arranged in the order of a square metre for simplicity.
- ☑ Divide the habitat into locations and select locations randomly by picking numbers in some random way.
- ☑ Examine and identify the organisms found.
- ☑ Write a brief report on your findings following the format below.
  - ✓ The size of the habitat in square meters.
  - ✓ The nature of the habitat either aquatic or terrestrial (draw the picture of the habitat or use camera or mobile phone, if possible).
  - ✓ Sizes of the various populations of organisms found and identified.
  - ✓ Comment on any particular interesting features, example, particular plants found only where the ground is damp.

- ✓ Estimate the whole population of the habitat.
- ✓ Comment on how reliable the estimates are.
- ✓ Is there any other better way to sample the organisms in a habitat besides using a quadrat? (as line transects)

Collecting and Preserving Plant and Animal Specimens

Why do we collect and preserve specimens of plants and animals?

Plants and animals are collected to obtain specimens for demonstration and studies. In fact many plants and animals can be studied where they live and they don't have to be collected. Only collect specimens which must be taken back to the school laboratory for display or study or specimens which cannot be studied at once because they live in places such as water or under soil. Then, collected specimens can be preserved to keep the dead sample remain unspoiled and can be used for future learning by displaying in a laboratory or museum of the school.

How can you collect and preserve animal specimens?

There are various methods of collecting and preserving plant and animal specimens depending on their nature (*size*, *strength*). This can be done using collecting tools such as pitfall trap, pooter, sweep net, butter fly net and the like. Chemicals such as chloroform, alcohol, formalin are used to kill and preserve animal specimens.

Note: We should treat all animals with respect. If the animals are simply to be examined and drawn they should be returned to the wild unharmed as soon as possible. If the animals are to be retained as specimens, they should be killed in a humane way, using chemicals such as chloroform, and immediately placed in a preservative solution such as formalin.

Description of Various Tools used in Collecting Animal Specimens

***Pitfall Trap*:** is a container that is sunk into the ground so that its rim is flush with the soil surface. Insects and other arthropods are captured when they fall into the trap. To prevent insects from escaping or preying on each other, pitfall traps usually contain a killing/preserving agent such as pet safe anti-freeze, soapy water, or ethyl alcohol (see Figure 6.8).

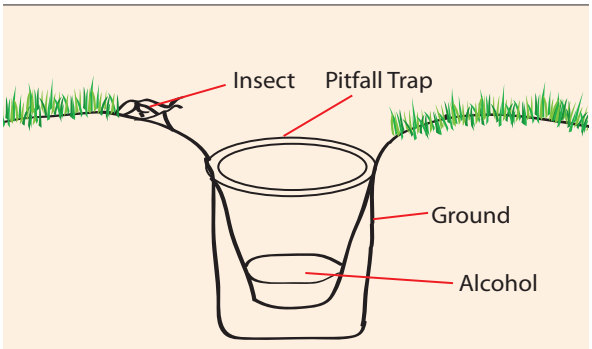


Figure 6.8: A Model of Pitfall trap

***Sweep nets*:** are study nets, often with a canvas bag that are used to collect insects and other invertebrates from long grasses (see Figure 6.9).

Figure 6.9: Sweep net on use to collect insects

***Tullgren Funnel*:** This is to extract insects from soil. A soil sample is placed on wire gauze which is over a funnel which leads into a beaker with a mixture of alcohol and water. There is a strong light held over the soil for the necessary amount of time. The light gradually dries out the soil, driving the insects within it to go downward until eventually reaching the beaker of liquids (see Figure 6.10).

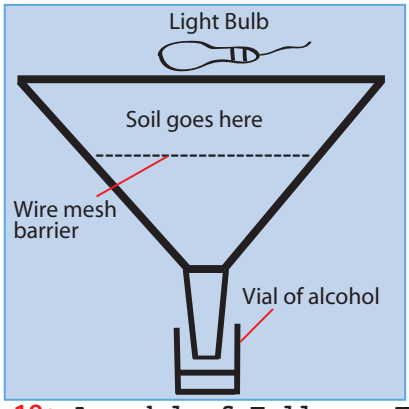


Figure 6.10: A model of Tullgren Funnel

***Pooter*:** A small jar with two separate tubes leading out. One tube is covered with wire gauze on the inside of the beaker. Inhale through this tube while placing the other end over small insect to suck the insect into the beaker (see Figure 6.11).

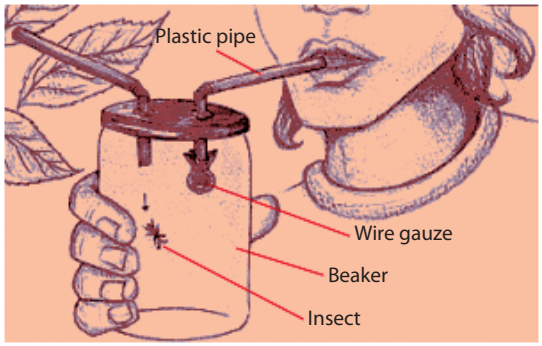


Figure 6.11: A model of pooter, to trap insect using inhale in to beaker.

How can you collect and preserve plant specimens?

Collecting plant specimens is different from animal specimens both in technique and procedure because of their nature. Plant specimens are collected and preserved using various techniques, such as pressing and drying, storing the seeds in a gene bank and others.

Procedures followed in collecting and preserving plant specimens:

1 ***Collecting various types of plants leaves and flowers:*** Plant specimens are usually collected using a plastic bag. In collecting a plant specimen first you have to devise a method of removing plants whole from the ground, taking care that the root system is not damaged. Any soil should be washed off and the plant is left in the sun to dry out.

2 ***Pressing and drying:*** The best specimens are plants that are pressed as soon as possible after collection, before wilting and shrivelling. Specimens are pressed flat and dried between sheets of absorbent blotters or semi-absorbent paper such as newspaper. The plant should be carefully laid out between the drying sheets, as their form at this stage largely determines their ultimate appearance. The flowers should be spread out with the petals carefully arranged, wilted leaves should be straightened and unnecessary shoots of excessively twiggy shrubs may be cut away.

3 ***Mounting*** is a process of posting or putting specimens on a card or other materials to minimize damage and to sustain for long period of time. Well-mounted herbarium specimens can last for many centuries. We can use various four methods to secure a specimen to a mounting card:

- ☑ spot glue paper strip with gummed paper.
- ☑ sew with needle and thread, securing knots with linen tape.
- ☑ float specimens on to card (*in the case of macroalgae*), and others.

4 ***Labelling:*** In order to identify the plant specimens and where it was collected, labelling is important. Plant specimens should be stored in a dry room. Museums, gene banks and laboratories are the common places to preserve various types of plants and animal species for visit and study (see Figure 6.12).

Figure 6.12: Preserved plant specimen

Activity 6.4

Collection and preservation of animal and plant specimens

Procedures:

- ☑ In your group, discuss the various techniques that could be used to collect animals and insects within a habitat.

1 Collect and preserve some animals and plants from your village using the above mentioned techniques.

2 Display them in your class.

Exercise 6.2

Choose the best answers for the following questions

1 Quadrat is more suitable for sampling of

A animals
B plants
C microorganisms
D all of the above

2 During studying habitats,

A quadrats are placed randomly
B quadrats are placed all over the place
C mapping is needed
D A and C

3 Which of the following is used to preserve animal specimens for laboratory study?

A formalin
B water
C salt
D gasoline

4 Preservation of plant specimen involves

A drying
B mounting
C labelling
D all of the above

5 Sweep net is used to trap

A spider
B butterflies
C monkey
D ants

6.3 FOOD RELATIONSHIPS

By the end of this section, you will be able to:

- describe food chain with a practical example;
- construct a simple food chain by observing food relationship of organisms in your surrounding;
- describe food web with a practical example;
- explain the different trophic levels of a food chain;
- describe the pyramid of numbers using a diagram;
- describe the pyramid of energy using a diagram;
- indicate the trophic levels on the diagram of the pyramid of numbers.

Key Terms

- **A food chain** is a single path as organisms of a single habitat eat each other.
- **Food webs** show how plants and animals are interconnected by different paths.

Food Chain and Food Web

Living organisms in a habitat interact with each other for food, space and other resources. From your Unit 4 lesson, you remember that green plants are able to convert sunlight energy into chemical energy. This chemical energy in the form of food is transferred through the various organisms. The transfer of energy contained in food can be well explained in terms of food chain and food web.

Food Chain

What is a food chain?

A food chain is a simplified food relationship showing food transfer from green plants to the different organisms. It is a single path of food transfer. A food chain always begins with a producer, or an organism that makes its own food through photosynthesis, and consists of organisms that feed on the other. For example, green plants (*producers*) produce food by photosynthesis. The grass (*produce*) is eaten by a grasshopper (*consumer*), the grasshopper is eaten by a frog, the frog is eaten by a snake, and the snake is eaten by a hawk (*bird*). A plant or an animal can be in more than one food chain.

Food chains are not always limited to three consumers; they may contain more than three consumers.

Key Terms

- **Consumers:** can be classified into three groups depending on the way they feed.
- **Herbivores:** are animals that feed on plants or primary consumers.
- **Carnivores:** are animals that feed on herbivores or secondary consumers.
- **Omnivores:** are animals that feed on both plants and animals.

Example:

Grass (*Autotrophs/Producer*) → Grasshopper (*Primary Consumer*) → Frog (*Secondary Consumer*) → Snake (*Tertiary Consumer*)

Green plants, which are the producers, have a critical position in the thread of life because they form the energy linkage between the sun and non-photosynthetic organisms.

Food Web

What is food web?

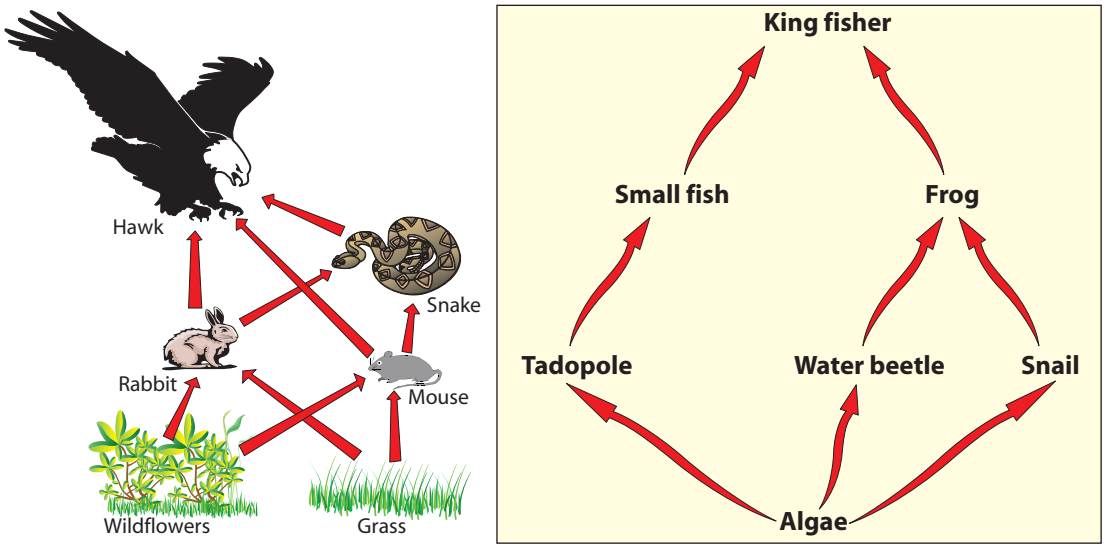
In nature, organisms in a habitat are involved in more than one food chain, therefore, in actual situation, natural food chains are interlocked to form a food web. A food web is a complex feeding relationship showing actual food transfer in nature from producers to consumers. A food web may begin with grass (producers), which would be eaten by insects, mice or rabbits, which would be eaten by different predators. More species are included in a food web, which uses a series of arrows to describe relationships (see Figure 6.13).

Activity 6.5

Identification of examples of food chain

Procedures:

- ☑ Be in groups of four and consider the above example or your surrounding.
- ☑ Give similar examples of food chains that show two level consumers (secondary consumers) and three level consumers (tertiary consumers).
- ☑ Share your examples in your class.
- ☑ What are the general patterns of relationship in a food chain?



a) *Terrestrial* b) *Aquatic*

Figure 6.13: Food web in terrestrial and aquatic habitats

In general, food chain and food web are means of describing feeding relationship within the environment. In both cases, the feeding relationship starts from a producer, green plants which make their food by the process of photosynthesis.

The sun is the source of energy for living organisms. Those that make their own food are known as *producers* and those that feed on either plants or animals are called *consumers*.

Can you give examples for each type of consumers?

Activity 6.6

Identification of food chain and food web

Be in groups of four and look at the following living organisms in a habitat: (*trees, sun flower, dog, elephants, monkey, rat, cat, sheep, donkey, algae, cow, mice, frog, grasshopper, hawk, fish, lion, tigers, grass, fruits, hyena, earthworm, birds, beetles, snake, butterfly….*)

1 Then sort them out into the following groups or categories.
   A Producers _____.
   B Primary consumers _____.
   C Secondary consumers _____.
   D Tertiary consumers _____.
2 Draw second level food chain.
3 Draw third level food chain.
4 Construct a food web using these organisms.

Trophic Levels

What are trophic levels?

Trophic level is the feeding level of an organism in a food chain. Each stage of a food chain is called a *trophic level*. The producers occupy the lowest (first) trophic level of any ecosystem. At the second trophic level are herbivores. They are primary consumers. The third trophic level constitutes animals that eat herbivores, called carnivores, and are secondary consumers. Some food chains may contain a four trophic level composed of carnivores and are called tertiary consumers or top carnivores.

Key Terms

☑ **Trophic Level:** is each level in a food chain. Matter is always 'lost' as heat energy at each trophic level.

Trophic level: As we go from the lower to the upper trophic level, the amount of initial energy decreases. This is because of the loss of much energy by consumers for their daily activity. As a result more energy is available at the lower trophic level than the upper.

All the trophic levels occupied by the consumers use small proportion of the energy to build their body. In consumers most of the energy in foods is lost for different activities such as body heat regulation, movement of body and to expel their waste. The amount of energy flowing through the food chain usually drops with each step up the chain, thus giving the characteristic 'pyramid' shape. This is why a trophic level is represented as a pyramid. The base of the trophic level represents the producer trophic level and the apex (tip) is the highest level of consumers called *the top predators* (see Figure 6.14).

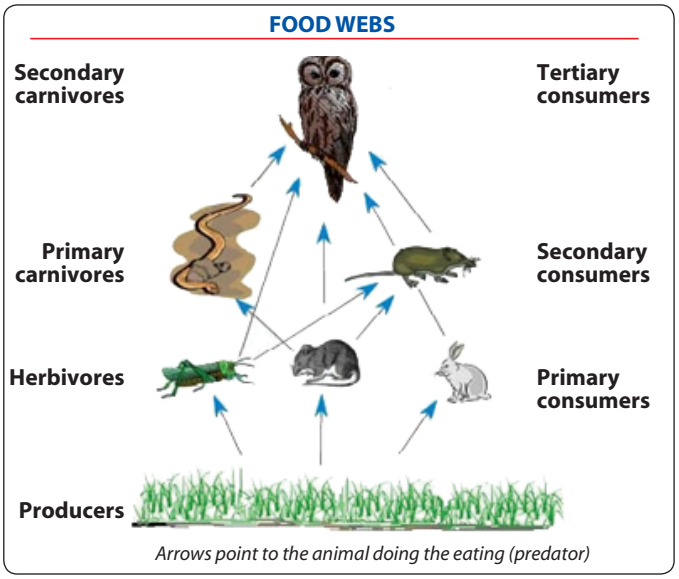


Figure 6.14: Diagram of a Trophic level

The initial energy that comes from the sun flows through the producers and converted into chemical energy. The producers use some of the chemical energy for their own life processes and pass only a portion of the trapped chemical energy to the consumers.

Activity 6.7

Based on Figure 6.14 discuss on the number of organisms in trophic levels

- ☑ In groups, observe the number of organisms from bottom to top of each trophic level.
- ☑ Discuss what happens to the number of the organisms as you go up or down the pyramid. What is the reason?

Biological Pyramids

Ecologists classify the relationship among living organisms in pyramid model. Basically there are three types of ecological pyramids. These are pyramid of number, pyramid of biomass and pyramid of energy.

Pyramid of Numbers

What is a pyramid of numbers?

As the name suggests, pyramid of numbers represents the number of individuals at each trophic level. A graphical representation in the form of a pyramid showing the feeding relationship and the number of organisms at each trophic level is known as *pyramid of numbers*.

The number of individuals generally decreases passing along a food chain. We can show the relative number of organisms at each trophic level as a pyramid of numbers. Accordingly, if the upper trophic level contains more numbers of individuals than the lower, there will not be enough food for the upper. As a result both organisms perish. However, this is not always the case, in some food chain the lower trophic level may contain individuals than the upper and the pyramid becomes inverted. This happens in parasitic food relationship because on a host we can find large number of parasites (see Figure 6.15).

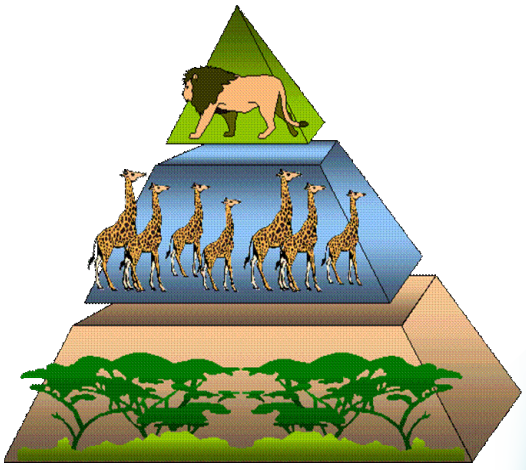


Figure 6.15: Pyramid of numbers

Pyramid of Energy

Shows the amount of energy lost and transferred in each trophic level. It describes that less energy is found in each next trophic level because of a small portion of the food becomes part of the organisms' body. Much of the rest of the food is used for various activities of the organism (see Figure 6.16). The pyramid of energy gives the clearest general picture of the relation ships within a particular community.

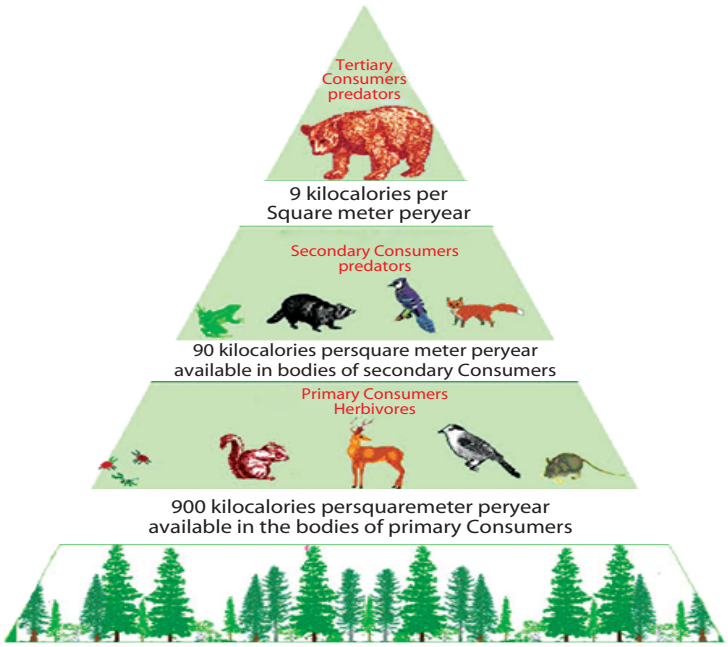


Figure 6.16: Pyramid of Energy

Pyramid of Biomass

A measure of the total mass of dry organic matter produced in a given community. The pyramid of biomass is more useful than the pyramid of numbers because it indicates the quantity of living things present in each trophic level.

Activity 6.8

Discussion on the shape of pyramid of numbers

In Groups:

1 discuss how the shape of a pyramid of numbers may be different for different food webs. For example, a single large tree may provide food for a large number of caterpillars. So, in this case, the base of the pyramid of numbers would be very small.

2 explain how an inverted pyramid of numbers might arise. For example, a single rose bush may support many aphids, and each aphid may support a large number of bacteria.

Exercise 6.3

Choose the best answers for the following questions

1 Food Chain is

A a simple type of feeding relationship only among animals

B a simple type of feeding relationship among living organisms

C not always limited to three consumer levels

D A and C

2 Which one of the following is true about food web and food chain?

A Plants are not involved in case of food web

B Food web is more complex type of food relationship

C Both are limited to explain similar types of organisms

D None of the above

3 Plants

A are producers of food for consumers

B are the first to convert light energy into chemical energy

C form the base of the pyramid of number

D all of the above

4 One of the following consumers is characterized by eating only meat

A herbivores

B carnivores

C omnivores

D producers

5 One of the following describes correctly about pyramid of energy

A it is the number of consumers at each level

B it is the amount of energy lost and transferred at each trophic level

C energy flow increases as we go up to the pyramid

D none of the above

Unit Summary

- In this unit we have discussed the following main points
- A habitat: is an ecological or environmental area that is occupied by a particular species of animal, plant or other type of organism.
- Population: A group of living organisms of the same species within a habitat.
- Community: A group of populations within a habitat.
- Sampling is a technique used to estimate the population of a species that are found in a given habitat. Quadrats are a series of square (1 m^2) frames that are placed in a habitat used for sampling.
- There are various ways of methods of collecting and preserving plant and animal specimens depending on their nature (size, strength). This can be done using collecting tools such as pitfall trap, pooter, sweep net, butterfly net and the like. Chemicals such as chloroform, alcohol, and formalin are used to kill and preserve animal specimens.
- Food relationship among living organisms is classified into two categories. These are food chain and food web. A food chain is a single path as organisms of a single habitat eat each other. Food webs show how plants and animals are interconnected by different paths.

- Trophic level: These are defined as steps of food chains which are differentiated on the basis of their method to obtain the food.
- A graphical representation in the form of a pyramid showing the feeding relationship and the number of organisms at each trophic level is known as pyramid of numbers.
- Pyramid of energy shows the amount of energy lost and transferred in each trophic level.

Review Exercise for Unit 6

Part I: ***Choose the best answers for the following questions.***

1 Populations of different organisms living together in an area is called:

A habitat
B community
C ecosystem
D species
E all

2 Terrestrial habitats are:

A fresh-water
B ponds and streams
C lakes
D land
E sea

3 The amount of earth covered with water is:

A 1/2
B 2/4
C 3/4
D 1/4
E 4/4

4 Which of the following comes first?

A Mounting the plant
B Pressing the plant
C Collecting the plant
D Drying the plant
E All are done at once

5 The origin of energy for all living organisms is

A water
B chlorophyll
C plants
D sun-light
E oxygen

6 Which one of the following feeds on primary consumers?

A Producer
B Tertiary consumer
C Secondary consumers
D Primary consumers
E All of the above

7 At the base of any ecological pyramid will be:

A decomposers
B consumers
C producers
D herbivores
E all of the above

8 The transfer of food energy from the source in plants through a series of organisms with repeated stages of eating and being eaten is known as:

A food-chain
B food web
C succession
D energy flow
E all of the above

9 Which of the following is not the same to the others?

A Herbivores
B First order consumers
C Second order consumers
D Cow
E None

10 Fungi, moss and ferns grow on a dead decaying log. The log is

A producer
B consumer
C habitat
D population
E all of the above

PART II: *Match items given in column 'B' with items given in column 'A'.*

	Column A		Column B
11	Pit fall traps	A	surrounding of an organism
12	Food web	B	natural home for living organisms
13	Food chain	C	water dwellers
14	Quadrat	D	land dwellers
15	Community	E	a group of organisms of the same species in a given area
16	Population	F	a group of different species in a given area
17	Terrestrial	G	sampling technique
18	Aquatic	H	simple food relationship
19	Habitat	I	complex food relationship
20	Environment	J	a tool to collect insects for study and preservation purpose

PART III: *Fill in the blank spaces with correct answers.*

21 A food chain begins with _____ .

22 Dead animals can be preserved using chemicals such as _____ and _____ .

23 As one goes from the lower tropic level to the upper the initial energy _____ in amount.

PART IV: *Give short answers.*

24 Distinguish the difference between aquatic and terrestrial habitat.

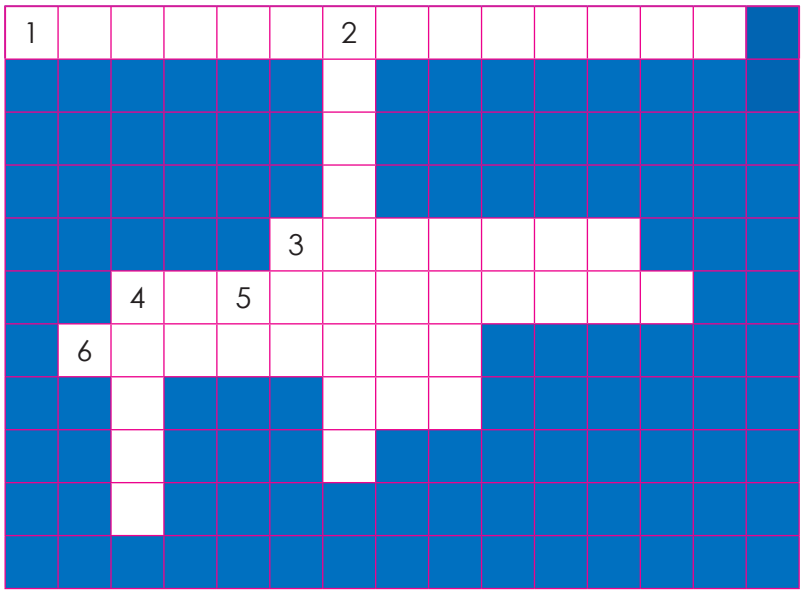
25 What is the difference between environment and habitat?

26 What is the difference between population and community?

27 How do you determine the population within a habitat?

28 What is the difference between food web and food chain?

PART V: ***Word Puzzle. Copy the crossword puzzle below into your exercise book and solve the numbered clues to complete.***



The numbers in brackets indicate the numbers of letters in each word to be inserted in a box

Across

1 A watery environment in which living things live. (4)

3 A series of square frames for habitat study. (7)

5 All animals that depend on producers (green plants). (9)

6 The techniques used to estimate the population of a species in a given habitat. (8)

Downward

2 All the different population that are found in a particular area. (9)

4 A habitat that covers $(3/4)^{th}$ of the earth surface. (5)