BIOLOGY

A Textbook for Grade 10

B10TB

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Foreword

Liberia, having gone through a period of utmost turmoil till 2003, due to the civil wars, is still reeling under its effect and the added trauma of Ebola in 2014 and effects of the COVID-19 outbreak in 2020. The Liberian government, in the past decade, has made valiant efforts to bring order to the lives of its people. In one such effort, the Ministry of Education (MoE) brought changes to the National Curriculum Framework which are relevant to the present generation, and which would prepare them to meet the challenges of the changing trends of the world. The National Curriculum Framework (NCF) 2018 recommends a change in basic assumptions in the teaching learning process from behaviorist to constructivist approach — moving from hardcore print material to the digital world. Keeping in consideration the sociocultural context and varied experiences of learners as laid down in the Framework, our Teaching Learning Materials are expected to be competent to use multiple methods and techniques like e-learning resources, energized textbooks, and readily available reference material to engage the learners.

As a first initiative, the MoE, through its World Bank-funded Improving Results in Secondary Education (IRISE) project, has adapted textbooks for Grades 10 to 12 in five subjects — English Language and Literature, Mathematics, Biology, Physics and Chemistry.

The National Curriculum Framework, 2018, recommends that children's learning at school is a reflection of their life outside the school and shows them the path to become a responsible citizen who makes knowledge-based choices.This principle marks a departure from the legacy of teacher centered learning to student centered learning. The syllabi and textbooks developed on the basis of the NCF indicate a serious attempt to implement the idea of Activity Base Learning (ABL). We hope these

measures will take us ahead in the direction of building a system of education as outlined in the NCF.

Combined with the efforts by the school principals and teachers this will encourage children to reflect on their own learning and to pursue imaginative activities and questions.With this in mind, perhaps for the first time in our country, we are able to provide separate subject specific textbooks accompanied with guides for teachers for 10–12 grades. Not only have these been developed, adapted and modified to the Liberian context, each of the eight Minimum Learning Competencies (MLCs) have been included in each textbook. So as to reach every high school student, for the first time in the country's history we have included the digitized form of the textbook accessible by a Quick Response (QR) code given in each book. Not only does it have the digitized textbook, but it provides additional learning materials for use by students, teachers and interested persons. The links to these e-resources and digitized material is being made available on the MoE's website.

The Textbooks and Teacher Guides have reached the hands of the students after a rigorous quality evaluation by carefully handpicked subject specialists by the MoE, to whom the Ministry expresses gratitude. For the success of this project, I acknowledge the contributions of the IRISE Project Team in the World Bank, and in particular, the Task-Team Leaders; the Project Implementation Team in Liberia headed by its Coordinator Abraham A. Kiazolu II, supported by the Executive Director of the Center of Excellence for Curriculum Development and Textbooks Research, Mrs. Julia K. Sandiman-Gbeyai and her technical working group (TWG), and the International Textbook Consultant and Advisor, Dr Shveta Uppal engaged by the MoE. These notwithstanding would not have been possible without the guidance of the Senior Management Team (SMT) of the Ministry of Education, and in particular, the Deputy Ministers for Instructions, Administration, and Planning, Research and Development, respectively.

Professor Dao Ansu Sonii, Sr.
Minister of Education
Republic of Liberia

Monrovia, Republic of Liberia
January 24, 2023

Acknowledgments

The development of textbooks contributes to the quality of teaching and learning that go on in the classroom.

The Ministry of Education (MoE) has aligned its Curriculum for Grades 10–12 to the National Curriculum Framework (NCF) of 2018. To ensure the provision of Teaching Learning Materials (TLMs) that support the revised curriculum, the Ministry has sought, reviewed and adapted a new set of textbooks and teacher guides along with digitized contents and e-learning resources for the five core subjects taught at the Senior Secondary education level, namely English Language and Literature, Mathematics, Biology, Chemistry and Physics, through an internationally competitive bidding process from the market supported by the World Bank funded Improving Results in Secondary Education (IRISE) Project.

With profound gratitude and honor, we recognize the Senior Management Team of the Ministry, headed by the Coach, Professor D. Ansu Sonii, Sr., for the strategic decision to make teaching learning materials available and accessible to all in the Liberian Senior Secondary School System, and for providing directions through the process of securing these textbooks and other teaching learning materials for our students and teachers. Our special thanks and appreciation to the World Bank for the financial support towards this policy intervention, and its education task-team including Alonso Sanchez, Oni Lusk-Stover and Binta B. Massaquoi for all their technical inputs offered throughout the process to ensure the kind of quality TLMs the Liberian students deserve are made available for improved learning outcomes.

We would like to specifically recognize the invaluable contributions of the 15 subject experts selected by the MoE from across the various education systems and the West African Examinations Council (WAEC) to evaluate, review and sign off on these teaching learning materials. They didn't just deliver according to our expectations, but also ensured

the contextual relevance of the materials to the Liberian Secondary Education Curriculum and its minimum learning competencies (MLCs). These subject experts include Professor Isaac Saye-Lakpoh Zawolo – *Superintendent* of the Monrovia Consolidated School System (MCSS), Mr. Matthew V.Z. Darblo, Sr. – *Mathematics Instructor* at the University of Liberia (UL), Mr. Charles Tieh Bropleh – *Mathematics Specialist* (MoE), Mrs. Linda Y. Dean – *English Specialist*, Mr. Hassan M. Bangura – *English Language and Literature Expert*, Mr. J. Emmanuel Milton – *English Specialist* (MoE), Mr. Moses K.M. Togbah – *Physics Specialist*, Mr. Prince A. Dossen – *Physics Specialist*, Mr. Benjamin Koryah – *Physics Instructor* at the University of Liberia (UL), Mr. Dominic Dugbe Doe – *Chemistry Specialist*, Mr. Patrick A. Anderson, Sr. – *Director of* the Division of Technical and Vocational Education (MoE), Mr. Kandakai Massaquoi – *Chemistry Specialist*, Ms. Patricia N. Doe – *Head* of Biology Department, African Methodist Episcopal University (AMEU), Mr. Job Carpenter – *Biology Specialist* and Mr. Prince Philip K.A. Aderibigbe – *Biology Specialist*.

The MoE is sincerely grateful to Dr Shveta Uppal, the *International Textbook Consultant* engaged by the IRISE Project to provide technical guidance and quality assurance support to the revising of the Textbooks Management Guidelines (TMG) and the procurement process leading to the provision of textbooks, teacher guides, digital contents and e-learning resources for the Senior Secondary School System in Liberia in accordance with the revised TMG. Heartfelt thanks and appreciations also to the *Executive Director* for the Center of Excellence for Curriculum Development and Textbooks Research, Mrs. Julia K. Sandiman-Gbeyai, and members of her Technical Working Group (TWG) for taking up the responsibility to lead the process of making textbooks and other TLMs available to Liberian students and teachers.

Lastly, we acknowledge the IRISE Project Delivery Team led by Mr. Abraham A. Kiazolu, II – *Project Coordinator*, Mr. Fuseini A. Abu – *International Procurement Specialist* and Mr. Lawrence S. Taylor – *Project Control Specialist* who coordinated the entire process.

We remain grateful to you all!

Hon. Alexander N. Duopu, Sr.,
Deputy Minister for Instruction
Ministry of Education, Republic of Liberia
#The Teacher

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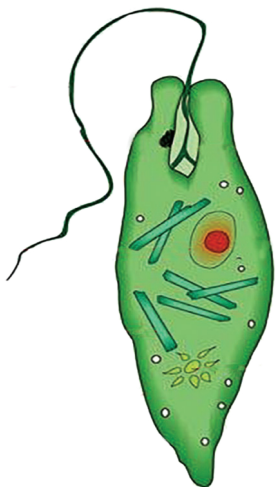
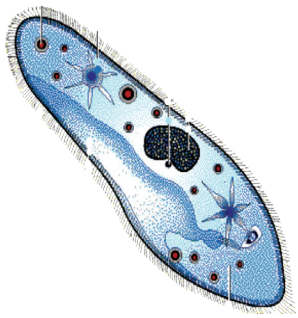
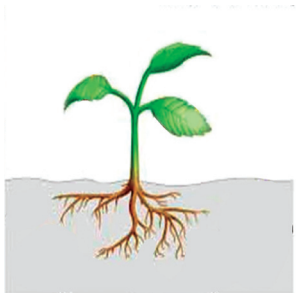




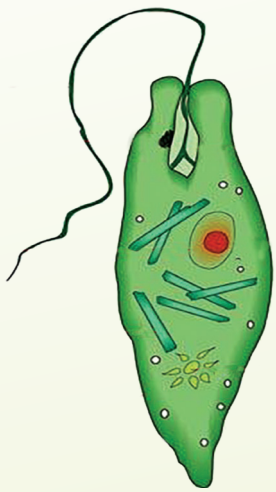


B10CH01

CHAPTER 1

INTRODUCTION TO BIOLOGY AND ITS BRANCHES; THE STUDY OF CELL AS THE BASIC UNIT OF LIFE: MOVEMENT OF SUBSTANCES ACROSS CELL MEMBRANE

Chapter Contents



Chapter Outcomes

At the end of this chapter the learners should be able to:

- define biology and discuss some of its branches;
- discover major contributors to the development of biology;
- compare the characteristics of living things and non-living things;
- relate the structures and composition of the cell in relations to their functions;
- compare the basic functions of tissues, organs and systems;
- demonstrate the use of microscope in studying biology;
- differentiate between Prokaryotic, Eukaryotic and Akaryotic cells;
- explain the main differences between the plant and animal cells;
- define the mechanisms by which substances move into and out of the cell;
- appreciate that all living organisms are made up of cells and that the cell is the building block of life.

Introduction

This chapter deals with the different branches of biology, the cell as the unit of life and the development of cell theory. Living things, although they are made of similar basic units (cells), exist in a vast range of different types, size and structural complexity. Biologists aims to provide understanding of the structure and function of organisms and how they interact with one another. For biologists life is identified as a combination of characteristics common to all living organisms.

The technical improvements made by the early microscope has led to the accumulation of knowledge about the cell in the early 1800s.

Diffusion is the process, by which molecules of solid, liquids and gases move from an area of high concentration to an area of low concentration. This movement, down the concentration gradient, continues until molecules are evenly distributed. Osmosis is the movement of water molecules from a solution of lower concentration of solutes to a solution of higher concentration of solutes through a semipermeable membrane or osmosis is the movement of water molecules from a region of higher concentration to a region of lower concentration.

1.1 Definition of Biology

The word Biology comes from two Greek words-Bios, which means "life"; and logos, which means "study of". Biology, therefore, means the study of life and living organisms. It is the branch of natural science which investigates the structure, function, distribution and origin of life.

Branches of Biology

Biology is divided into a number of branches or subdivisions. The main branches are:

(a) Botany : The study of plants
(b) Zoology : The study of animals
(c) Microbiology : The study of microscopic organisms

The above branches are further subdivided into the following sub-branches.

- Morphology: Morphology is the branch of biology that deals with the form of living organisms and with the relationship between their parts.

- Anatomy: Anatomy is the branch of biology concerned with the study of the body structures of living organisms.
- Physiology: Physiology is the study of the normal functions of living organisms and their parts.
- Taxonomy: The study of the classification of living organisms.
- Histology: The study of tissue structures.
- Ecology: The study of interaction of organisms among themselves and with their nonliving environment.
- Evolution: The change in the characteristics of a species over several generations.
- Genetics: The study of heredity or inheritance of biological characters.
- Entomology: The study of insects.
- Parasitology: The study of the relationships between parasites and their hosts.
- Embryology: The study of the development of embryos.
- Cytology: The study of cell structure and function.
- Bacteriology: The study of bacteria.
- Mycology: The study of fungi.
- Virology: The study of viruses.

Activity 1

Group discussion

Make peer groups in your class. Discuss the different branches of biology within your peer groups and then Present to your class.

Exercise

1. Which of the following is **not** the concern of Biology?
   (a) Structures of living things
   (b) Functions of living things
   (c) Interaction among living things
   (d) Composition of elements
2. The branch of Biology that deals with the naming of living things is:
   (a) Ecology
   (b) Cytology

(c) Evolution
(d) Taxonomy

1.2 Contributors to the field of Biology

(a) Aristotle (384-322 B.C) proposed that the origin of life is spontaneous generation. Spontaneous is the concept that living things arise from non-living material.
(b) Carl Linnaeus (1707-1778), a Swedish doctor and Botanist, who is also called the Father of Taxonomy. Proposed the development of hierarchical system of classification of nature. The Linnaean system is important because it has led to the use of binomial nomenclature to identify organisms.
(c) Louis Pasteur (1822-1895), a French Chemist and Microbiologist, known from his discoveries of the principles of vaccination, microbial fermentation and pasteurization.
(d) Robert Koch (1843-1910) was the German Bacteriologist who discovered the bacteria that causes anthrax, septicemia, tuberculosis and cholera.
(e) Gregor Mendel (1822-1884) was Austrian Botanist, teacher and Augustinian prelate, became regarded as the Father of genetics. He discovered the basic principles of heredity and laid the mathematical foundation of the science of genetics.

Activity 2

Work in groups for this activity

Form a group and prepare a well organized presentation about Scientists who have made a major contribution to our modern understanding of the cell: Robert Hooke, Anton van Leeuwenhoek, Rene Dutrochet, Matthias Schleiden, Theodor Schwann and Rudolf Virchow. Refer this textbook, other books and the internet if available.

Activity 3

Discussing the branch of Biology related to Sexualy transmitted disease

- Work on with mixed groups for this activity describing the branches of Biology and those related to STIs.
- Use this textbook and other books as well as internets for your discussion.
- Present your findings to the class.

1. Who was the Scientist that contributed to the study of microorganisms?
   (a) Carlos Linnaeus
   (b) Aristotle
   (c) Gregor Mendel
   (d) Louis Pastuer
2. Who is the Scientist that contributed to the method of identifying and culturing pathogens?
   (a) Robert Hooke
   (b) Robert Koch
   (c) Robert Brown
   (d) Charles Darwin

1.3 Characteristics that distinguish living things from non living things

Respiration, nutrition, excretion, locomotion, reproduction and growth are the characteristic features of all living things.

Respiration : is the process by which living things, use oxygen to break down sugar to obtain energy.

Nutrition : the biochemical and physiological process by which living things use food to support their life.

Plants are autotrophs, obtain food by the process of photosynthesis using sunlight,water and carbon dioxide.

Animals are heterotrophs, obtain food by eating plants and other animals.

Metabolism : is the sum of all chemical reactions that takes place inside the cell.

Excretion : The process by which living things eliminate waste products of metabolism out of the cell.

Example, Urea is an excretory product of liver cells removed by kidney cells.

Irritability : is the reaction of an organism to changes in the external environment.

Movement : is the mobility of an organism from place to place. It is the characteristic feature of animals.

Reproduction : is the process by which living things produce offsprings for the survivial of their species.

Growth : is the process by which living things increase in size.

Exercise

1. Which of the following characteristics of living things is important for species survival?
   (a) Irritability
   (b) Excretion
   (c) Metabolism
   (d) Reproduction
2. One of the following is an important process by which living things obtain energy
   (a) Growth
   (b) Respiration
   (c) Excretion
   (d) Movement

Activity 4

Characteristics that distinguish living things from non Living things

Form a group and prepare a well organized presentation about the basic characteristics that distinguishes living things from non Living things. Refer this text book other books and the internet if available.

1.4 Characteristics and examples of *Euglena*

Euglena is an oval-shaped unicellular flagellate. The cell exhibits the features of both plants and animals.

The cell of *Euglena* is enclosed by a tough protein layer called the Pellicle. It also consists of cell membrane, nucleus, contractile vacuole, eye spot (stigma), chloroplast and flagellum.

Habitat: *Euglena* inhabit in fresh water rich in organic matter and mineral ions.

Locomotion: *Euglena* moves by means of a flagellum a whip like structure.

Nutrition: *Euglena* is normally autotorphic, however, in the absence of light it can feed saprophyticallu.

Reproduction: Sexual reproduction is absent in *Euglena*, the organism reproduces asexually by binary fission.

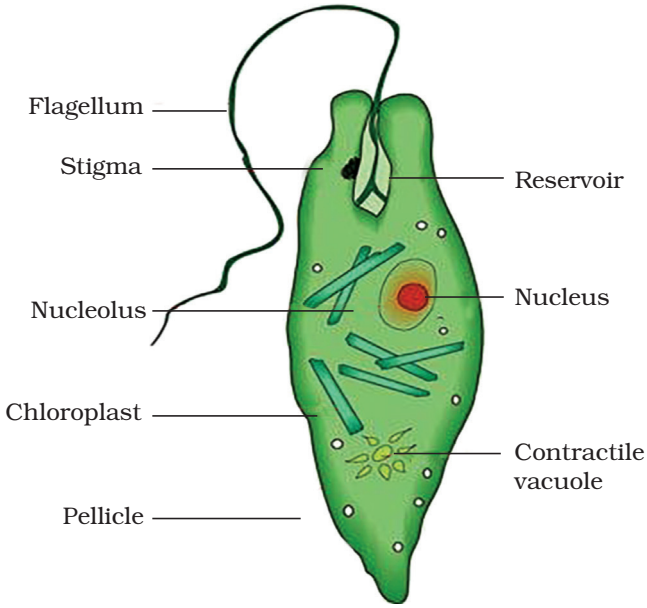


Figure 1. Structure of Euglena

ACTIVITY 5

Characteristics and examples of *Euglena*

Form small groups of students.

Discuss on the characteristics of *Euglena* by using examples.

Refer this textbook, other books and internet if available. Then present it to class.

1.5 BIOLOGICAL TOOL

Light Microscope

Microscope is an instrument used to study or examine objects that cannot be seen by the naked eyes.

A microscope can magnify and resolve image of objects. The most commomly used microscope are light and electron microscopes. The invention of these two kinds of microscopes contributed a lot for the understanding of biological structures and functions.

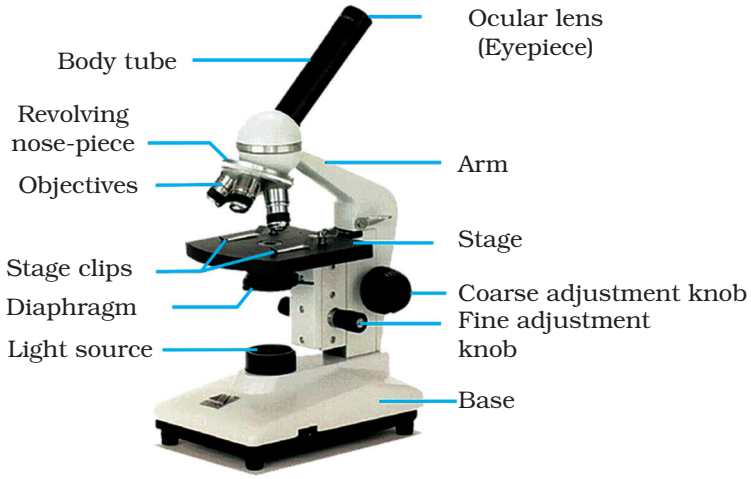


Figure 2. Parts of a Microscope

Activity 6

You need

A Compound microscope

Method

1. Find a Compound microscope in the laboratory.
2. Stand close enough so that you can look into it comfortably
3. Identify the parts of compound microscope.
4. Describe the function of each parts.

Exercise

1. Part of a Compound microscope through which a specimen is viewed is called _____ .
   (a) Base
   (b) Ocular
   (c) Nose piece
   (d) Body tube
2. Which part of a compound microscope is used to adjust the focus of a specimen placed under the higher objective?
   (a) Coarse adjustment
   (b) Fine adjustment
   (c) Diaphragm
   (d) Mirror

1.6 Cell and cell theory

The making of advanced types of microscopes helped humans to observe cells better. An important discovery was made by Robert Brown in 1831, showed the presence of a little sphere-like body in the cells of a plant root. This rounded body was later called a nucleus. A further improvement of microscopes and the application of microscopic techniques, biologists were able to study different kinds of cells from plants and animals.

In 1839, the German botanist Matthias Schleiden made a careful study of plant bodies and stated that all plants are made up of cells. In 1839, another German Zoologist Theodor Schwann reported that all animal bodies also consist of individual cells. These two Germans combined their findings and developed the idea that all organisms are composed of cells. The cell theory formulated by Schleiden and Schwann, did not explain how new cells are formed. It was Rudolf Virchow (1855) who, for the first time, explained how the cells divide. He stated that all new cells must come from pre-existing cells. The cell-theory in its modern form is a set of statements which can be stated as follows:

- All living things are composed of cells and their products.
- All cells are basically alike in chemical composition and life activities.
- Cells are the smallest structural and functional unit of every living thing.
- Cells arise only by division of the previously existing cells.

Prokaryotic and Eukaryotic Cells

Based on their structure, cells are fundamentaly classified as prokaryotic and eukaryotic.

Prokaryotic cells are cells without membrane bounded nucleus and other organelles. Such cells are smaller in size and do not exhibit compartment of cellular structures. The best example is bacteria and bluegreen algae.

Eukaryotic cells are cells with membrane bounded nucleus and other organelles. They are bigger in size and exhibit compartment of cellular structures. Examples are plant and animal cells.

A brief discussion of all the parts of a ‘generalized’ or ‘typical’ cell is shown in Figure 3 below.

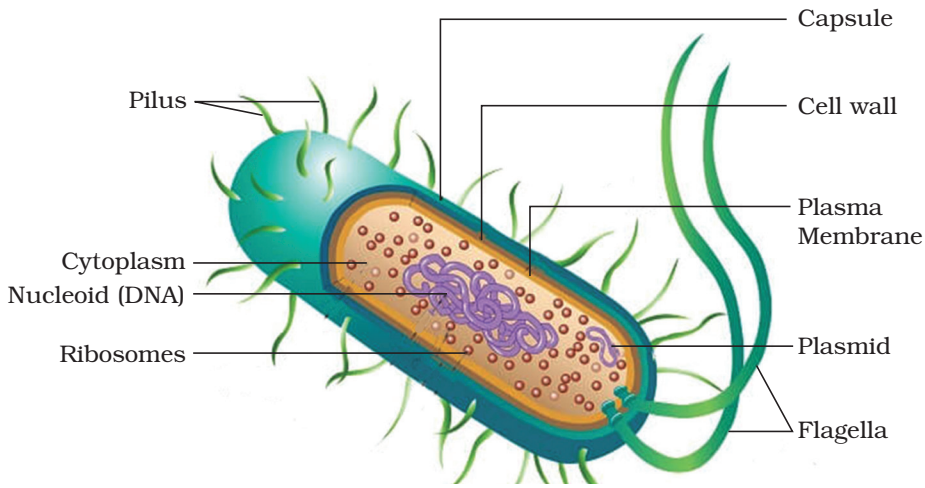


Figure 3. The structures of a typical bacterial cell

The cell membrane : The cell membrane is a thin, outer layer that encloses the contents of the cell. It is also known as plasma membrane. The cell membrane allows certain substances to pass into and out of the cell, but prevents the passage of other substances. Hence, the cell membrane is semi-permeable or selectively permeable. It also separates one cell from other cells in multi-cellular organisms. Membranes are also found around certain organelles within the cell. Each cell can perform all the required functions of life. The cell is, therefore, said to be the basic unit of all organisms. But, how does a cell perform all functions of life? Every eukaryotic cell, regardless of its size and shape has parts that are responsible for the basic structure and function of the cell. The main parts are the cell membrane, the cytoplasm and the nucleus. These three main components constitute the protoplasm and visible under light microscope. Protoplasm is the living material of the cell and forms the physical basis of the cell. It performs life activities such as metabolism, feeding, reproduction, and response to environmental changes etc.

Although protoplasm is common to both plants and animals, plant cells have additional structures such as cell - wall, large central vacuole.

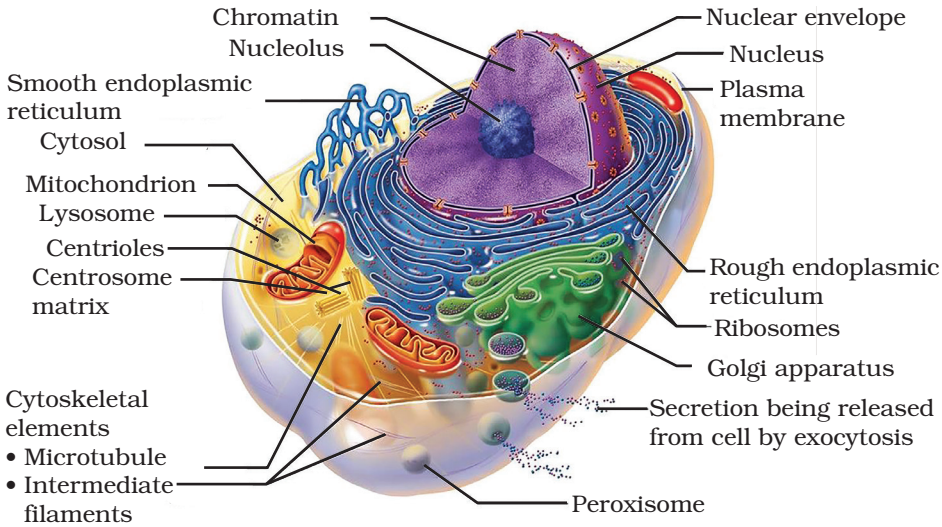


Figure 4. A generalized cell structure.

The Nucleus

The nucleus is the 'control' center of a cell. It directs and organizes the functions of a cell in which it is found. It also controls the division (reproduction) of a cell. The nucleus floats within the cytoplasm of a cell and is surrounded by a double membrane called the nuclear membrane (envelope). There are holes in the nuclear membrane. These are known as nuclear pore. They permit substances to pass in and out of the nucleus.

Nuclear fluid or nucleoplasm is a liquid found within the nuclear membrane. Chromosomes are found in nucleoplasm. Chromosomes are made up of protein and DNA (Deoxyribo Nucleic Acid). DNA gives information for making proteins in cells. DNA is passed to new cells, during cell division. When sex cells are produced, copies of the parents DNA are contained in the chromosomes, in the nucleus of egg cells and sperm cells. Mature red blood cells do not have nucleus. Some unicellular organisms such as *Paramecium* contain two nuclei.

The nucleus also contains one or more nucleoli (singular; nucleolus). They are round but have no membrane around them. They contain ribosome and RNA. RNA (ribonucleic acid) is another kind of nucleic acid used for protein synthesis.

The Cytoplasm

The cytoplasm is a semi-fluid substance outside the nucleus. It contains fluid, enzymes, organelles, structures and organic and inorganic substances. Within the cytoplasm, several chemical reactions of the cell occur. It is like a factory. It receives materials; break them down to form useful substances. It manufactures new substances to be given to other cells, and excrete waste materials. The higher magnification of the electron microscope shows that the cytoplasm contains many organelles which do specific jobs inside the cell.

Mitochondria (power houses of the cell)

The mitochondrion (plural; mitochondria) is an organelle where ATP (Adenosine Tri-phosphate) produced. ATP is an immediate source of cellular energy. The release of energy in cells from foods molecules using oxygen is called aerobic respiration. So mitochondria are sites of aerobic respiration. The structure of mitochondiron is shown in the Figure 5 below.

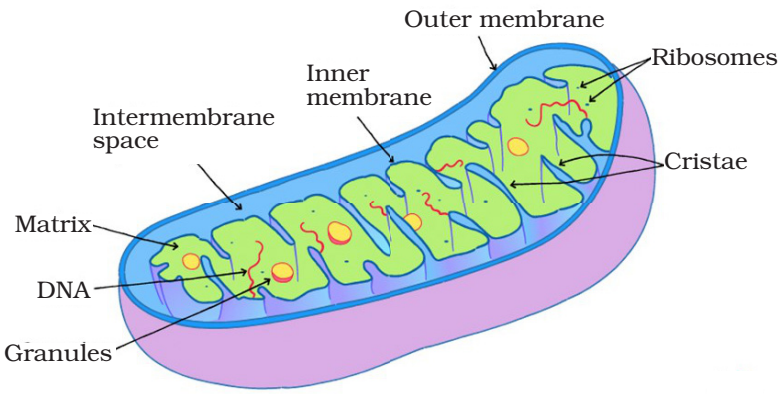


Figure 5. Structure of mitochondrion

The number of mitochondria in each cell depends upon the amount of energy the cell needs. For instance, a muscle cell needs more energy than a fat cell so a muscle cell will have more mitochondria than a fat cell.

Plastids

Plastids are organelles that are found only in plants. Like the mitochondria, plastids are also surrounded by a double membrane.

There are three kinds of plastids called chloroplasts, chromoplasts and leucoplasts:

- Chloroplasts contain the green pigment chlorophyll. Chlorophyll enables a green plant, to convert the energy of sunlight into chemical energy of food. Cells containing chloroplasts carry out the process of photosynthesis. Young plant stems and leaves of plants also contain chloroplasts. Within the chloroplasts are stacks of membranes that look like piles of coins. Chlorophyll molecules are found in these stacks of membranes known as grana.
- Chromoplasts contain carotenoid pigments which are responsible for coloring of flowers and fruits.
- Leucoplasts are colorless plastids found in storage organs such as bulbs (in onions), tubers (in potatoes).

Vacuoles

Vacuoles are organelles found in the cytoplasm of cells. They are surrounded by a membrane known as tonoplast. They are filled with watery fluid containing pigments, salts, sugars and wastes. They are permanently found in plant cells and are very large. They are usually small in animal cells forming small vesicles such as contractile vacuole and food vacuole. In plant cell the watery fluid within vacuoles is called cell - sap. When filled with water they push the cytoplasm against the cell membrane. This stretches the cell membrane against the cell wall making the cell rigid. This gives support and shape to plant cells. Contractile vacuoles in unicellular organisms (amoeba for example) serve as excretory structures.

Ribosomes

These are small, dot-like particles with no membrane around them. They are found throughout the cytoplasm. They are also found attached to some of the surfaces of the endoplasmic reticulum (ER). At the ribosomes, proteins such as enzymes are produced. So they are called sites or worktables of proteins synthesis.

Endoplasmic Reticulum (ER)

The word ‘endoplasmic’ means ‘within the cytoplasm’ and ‘reticulum’ means ‘little net’. So, endoplasmic reticulum is a network of channels or canals formed between the nuclear membrane and the cell membrane.

It also forms a series of channels within the cell dividing the cell into small compartments. There are two types of endoplasmic reticula (plural) known as rough endoplasmic reticulum and smooth endoplasmic reticulum.

Rough endoplasmic reticulum (RER) - a system of internal membranes containing ribosomes attached to it. This is concerned with protein synthesis since it contains ribosomes.

Smooth endoplasmic reticulum (SER) - does not have ribosomes on its surfaces. It is concerned with the synthesis of lipids such as cholesterol.

Endoplasmic reticulum also serves in transporting of materials, within the different regions of the cell and is known as the transport system of the cell.

Lysosomes

Lysosomes are membrane-bounded vesicles containing hydrolytic enzymes.

The proteins (enzymes) contained in lysosomes are so powerful that they breakdown big molecules and other worn out (old) cell components. Lysosomes also digest and eliminate any external body entering the cell by doing so. Main function of lysosome is to defend the cell. They also destroy the cell itself when it gets old so they are called "suicidal bags" of the cell.

Golgi Bodies or Golgi complex

These are stacks of sacs lying over each other. Golgi bodies collect materials synthesized in the cell, pack and store them. They distribute synthesized products to cells so they are known as the delivery system of the cell.

Centrosomes

They are paired organelles found mainly in animal cells near the nucleus. They are also found in protists. Higher plant cells and fungi do not have centrioles. They help cells during cell division.

Flagella and Cilia

Flagella and cilia are important structures made of threads or tubes. Cilia (singular; cilium) are usually short in length. They can be found in the lining of the windpipe (trachea). They help to clear off particles that

enter the trachea along with air. The flagellum (plural, flagella) is long, whip-like structure and help in the movement of cells such as sperm cells, *Euglena* etc.,

Activity 7

Generalized structure of animal cell.

Form group of 4 – 5 students, draw and label the structures of the generalized animal cell.

Describe the functions of each organelle in the cell.

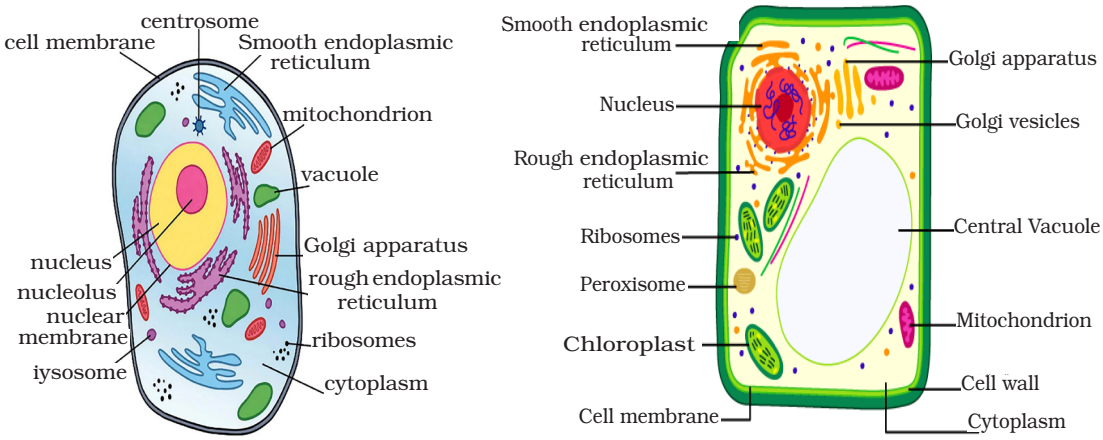
Write a report.

Table 1 Eukaryotic cell structures and their functions

Structure	Description	Function
Plasma membrane	Thin sheet of layer	Regulates what passes into and out of cell, holds content of the cell
Nucleus	Spherical structure bounded by double membrane contains chromosomes and nucleoli	Control center of the cell, directs protein synthesis and cell division
Nucleolus	Site for ribosome synthesis	Assembles ribosomes
Endoplasmic reticulum	Network of internal membranes	Forms compartments and vesicles
Golgi complex	Stacks of flattened sacs or vesicles	Modifies and packages proteins for export from the cell.
Lysosomes	Vesicles that contain hydrolytic digestive enzymes	Digest worn out organelles and foreign bodies, play role in cell death.
Mitochondria	Sausage shaped double layered structures	Power houses of the cell, sites of cell respiration
Chloroplasts	Double membranous organelles in plants and algae	Sites of photosynthesis Mitochondria and chloroplasts are referred to as energy producing organelles.
Ribosomes	Small assembles of protein and RNA	Sites of protein synthesis

Comparison of Plant and Animal Cells

Plant and animal cells show some differences in appearance when observed under a microscope. When examined under high power of a compound microscope, a cheek cell (animal cell) from the inside lining of the cheek of a human and a thin section of leaf cell (plant cell) look like those of figures 6 (a) and (b).



(a) Typical animal cell

(b) Typical plant cell

Figure 6.

From Figure 6 one can see that both plant and animal cells contain a spherical body called the nucleus, a small volume of semi-fluid substance called the cytoplasm and a thin, sheet of outer covering named cell - membrane or plasma membrane. In plant cells an additional external hard covering called the cell - wall is visible. The cell-wall can be seen microscopically better than the cell membrane under light microscope. The cell wall is a non - living material made from a substance called cellulose. The cell wall is permeable and allows substances to move freely from one cell to another cell. It makes plant cells rigid and provides support and shape. In the cytoplasm of plant cells there are also spaces or cavities called vacuoles. Vacuoles are large and contain solutions. Small structures which usually contain coloring substances called plastids are also be observed in plant cells.

Activity 8

Comparison between and Animal and Plant cells.

Form group of 4-5 students, draw and label the parts of the Plant and Animal cells.

Distinguish the differences between and Animal and Plant cells

Highlight the Comparison of the internal structures of these cells to the class.

Comparisons between plant and animal cells.

Plant Cells

- Possess cellulose, cell wall.
- Contain plastids that contain pigments such as chlorophyll.
- Have, large central vacuole with cell sap that contain solutions of sugar, salts, etc.
- Have tonoplast around vacuoles are regular in shape.
- Have no centrioles except in cells of lower forms of plants such as mosses.

Animal Cells

- Possess no cell-wall.
- Contain no plastid.
- Do not have large vacuoles but they have smaller ones such as contractile and food vacuoles.
- Have no tonoplast.
- Have no definite shape.
- Have centrioles.

ACTIVITY 9

Biological tools (identifying laboratory materials and apparatus)
Go to your school Biology laboratory.
Consult your laboratory technician about the laboratory set up.
Identify some laboratory materials and apparatus.
Discuss functions of the laboratory materials.
Write a report about your visit.

ACTIVITY 10

Observing Onion epidermal cells under the microscope
You need

- Peeled Onion to a single layer
- Specimen stain with iodine.
- A set of blank microscope slides to mount on the specimen
- Cover slips
- An eye dropper or pipette to create a wet mount
- Laboratory sheet take down notes and observation
- Simple light microscope.

Method

1. Cut the onion them peel the epidermal layers.
2. Alternatively, peel the onion into one super thin layer.
3. Carefully mount the onion peel on top of the microscope slide.
4. Using the pipette or dropper, apply one or two drops of iodine over the onion sample. Then, carefully place the cover slip over the stained sample.
5. Alternatively, you may use methylene blue, first cover the onion peel with cover slip then apply methylene blue. Then allow it to diffuse in between the slide and the cover slip to stain the onion peel.
6. Write down your observation on a data sheet.
7. Draw and label all the parts you observed.

Activity 11

Observing scraped cheek cells from the mouth under the microscope

You need

- Toothpick
- Specimen stained with methylene blue
- Simple light microscope
- Slides
- Cover slip
- Eye dropper
- Laboratory sheet

Method

1. Cells of the inner linings of cheek were gently scraped using toothpick, transferred and spread in the water on the glass slide.
2. Cheek cells stained with methylene blue for 2 minutes and mounted with glycerol
3. Observe under the microscope objective lens (low power & high power).

Write down your observation on the data sheet

Draw and label the parts you observed.

Distinguish between the onion and cheek cells.

Exercise

Part I: True or False

1. Cells are similar in their size and shape.
2. Cells are structural and functional units of life.
3. Cells are coming from pre-existing cells.
4. Cell wall is found in both plants and animal cells.

5. Endoplasmic reticulum is found only in plant cells.
6. Chromosomes are found within a nucleus.

Part II: Choose the best answers for the following questions

1. Which of the following cellular structures is not found in Prokaryotic cells?
   (a) Chromosomes
   (b) Mitochondria
   (c) Cell wall
   (d) Ribosome
2. Which of the following structure is present in all Eukaryotic cells?
   (a) Chloroplast
   (b) Cell membrane
   (c) Cell wall
   (d) Lysosomes
3. Protein synthesis in cells takes place:
   (a) In the nucleus
   (b) In the vacuoles
   (c) In the Golgi bodies
   (d) In the ribosomes
4. Material exchange between the cell and its environment occurs through:
   (a) Mitochondria
   (b) Cell membrane
   (c) Nucleus
   (d) Reticulum
5. According to the cell theory:
   (a) All cells are similar in shape
   (b) All cells are equal in size
   (c) All cells are structural and functional units
   (d) All cells come spontaneously
6. The center for cell energy production is:
   (a) Nucleus
   (b) Mitochondrion
   (c) Golgi body
   (d) Cell wall

Movement of substances into and out of the cell

Membranes regulate or control the movement of materials into and out. Passive transport is the movement of substances from a region of high

concentration to a region of low concentration, without the expenditure of energy.

Passive Transport Allows

- Metabolites such as O_2, salts and nutrients to get into the cell.
- Waste products such as CO_2 and other metabolites must pass out of the cell.
- There are three processes to transport materials across the cell passively.

In case of a gas, each gas diffuses from the side of high partial pressure to that of lower partial pressure, i.e. down the pressure gradient. This takes place during diffusion of gases in cellular respiration. The oxygen moves from extracellular fluid to the cells. The carbon dioxide moves from cells to extracellular fluid.

The rate of diffusion is affected by three important factors. These are:

- The steepness of the diffusion gradient or the difference in concentration between two points. The steeper the concentration gradient, the faster the rate of diffusion.
- The surface area of a membrane through which diffusion takes place, the greater the rate of diffusion. Greater the area, greater will be the rate of diffusion.
- Rate of diffusion decreases rapidly with distance. Diffusion is therefore, only effective for very short distance.

(i) Facilitated diffusion : The particles must be helped to diffuse across the membrane by a carrier proton or a channel protein with an ion pore.

- Materials are transported from high concentration to lower concentration.
- Kinetic energy facilitates the transport.
- Needs carrier molecules which are proteins.
- The carrier molecule transports those molecules which are not soluble and those can't pass through the pores.
- The carrier molecule combines with the substrate and changes the shape of the molecule.

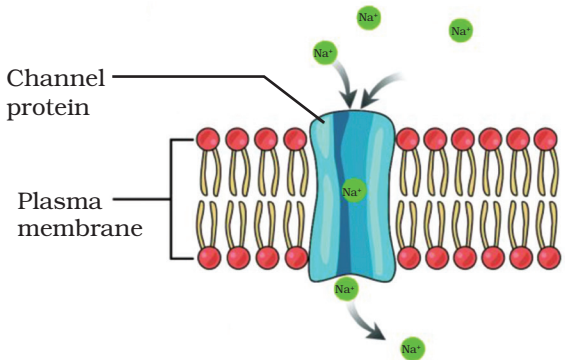


Figure 7. The effect of ionophore.

- Ions simply move straight through ion pore of a channel protein.

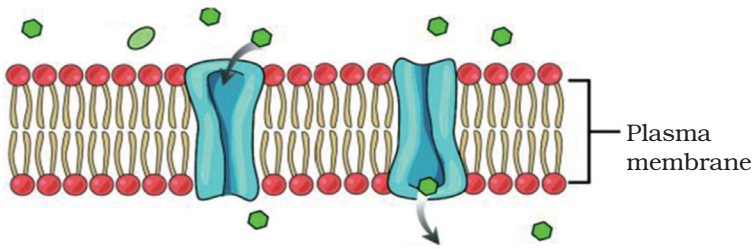


Figure 8. Facilitated diffusion consisting a special protein.

- The carrier protein must undergo a conformational change to move particles through the membrane
- Energy from ATP not needed.
- Specific molecules diffuse faster than others in special pores.
- Diffusion faster in one direction.
- Equilibrium reached when concentrations are equal.

Since diffusion wouldn't be possible without the protein, the process is known as facilitated diffusion. The rate of facilitated diffusion is affected by the same factor that affects simple diffusion but the number of carrier proteins present determines the rate.

(ii) Osmosis : Is the net movement of water molecules through a selectively permeable membrane. In another words it is the movement of water molecules (solvent) from a region of high (less negative) water potential to one with a lower (more negative) water potential, across a partially permeable membrane.

The tendency of water molecules to move from one place to another is measured as the water potential represented by the symbol Y (Greek letter psi).

(a) Water potential is expressed in units of pressure - pascals (Pa), kilopascals (KPa) or megapascals (MPa).

(b) Pure, liquid water has a highest water potential than solution.

(c) The water potential of a pure water is zero.

(d) All other systems (cells, solutions and suspensions) have water potential that is lower than that of pure water. Their water potential value must be negative.

(e) The rate at which Osmosis proceeds is influenced by the same factors as simple diffusion. These are:

- surface area of the membrane.
- difference in water potential
- distance the water molecules must travel.

Isotonic : When the external water potential is the same as that of the cell, there is no net movement of water out of the cell.

Hypotonic : When external cell solution have less amount of solute than that of the Cell solution there is net water movement into the cell. The cytoplasm becomes distended by water uptake; if this distension causes pressure against cell wall (plant cell) the cell is described as turgid. A pressure potential develops. Plant cells, surrounded by a cellulose cell wall, are protected by their wall from rupture. Animal cells such as red blood cells, have no external wall to protect them from rupture. Their plasma membrane is unable to resist the pressure potential that develops; the cell may swell until they burst: this is called **hemolysis**.

Hypertonic : When external solution is stronger than that of the cell inside there is net movement of water out of the cell solution.

In plant cells, the cytoplasm loses water by osmosis and shrinks. As a result, there is no pressure from the cytoplasm on the cell wall and the cell becomes flaccid. If the water loss by osmosis has become severe, the cytoplasm and plasma membrane pull away from the cell wall and the cells become plasmolyzed. When a red blood cell loses water by osmosis there is shrinking of the cell. This phenomenon is called Crenation. Active transport is the movement of particles or ions from their lower concentration to substances across a membrane by the expenditure of energy. it is always against a concentration gradient.

Active transport is the movement of ions against electrochemical gradient. Some membrane proteins act as carrier molecules (Figure 9) and transport the substrate to the other side of the membrane.

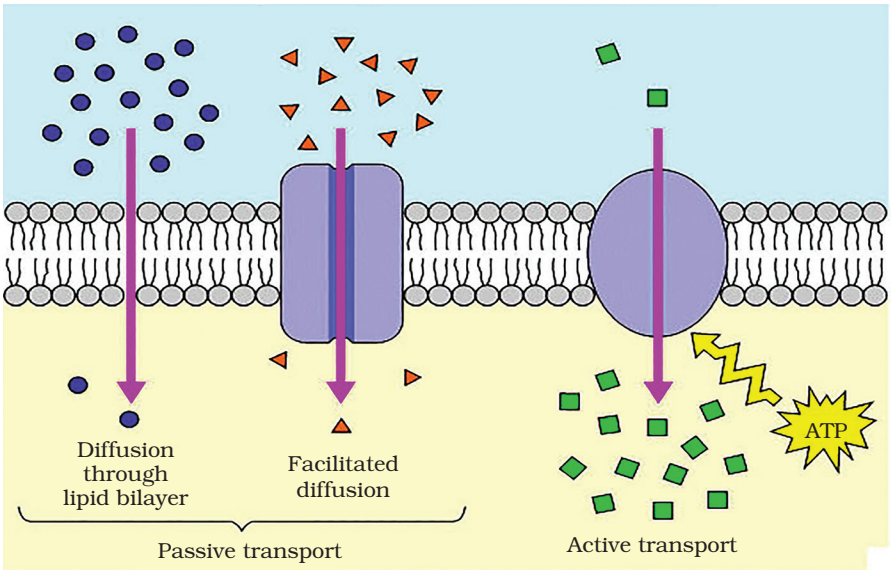


Figure 9. Role of a carrier molecule in active transport

Almost all the cells maintain a difference in ionic concentration on the inside and outside of the cell membrane. The most common is a sodium–potassium pump. In this pump energy is derived from ATP (Figure 10).

Three Na+ – Pumped out of the cell
Two K+– Pumped in the cell
} By one ATP

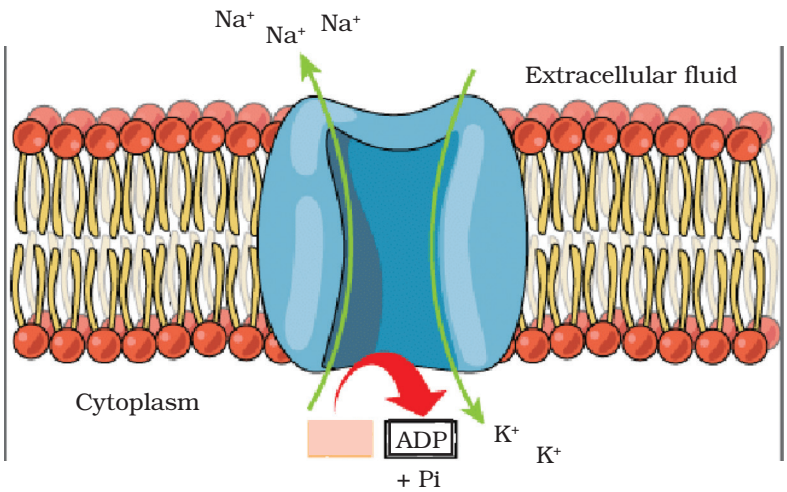


Figure 10. Sodium – potassium pump

As seen in the above figure, the pump is a carrier protein that span across the membrane from one side to the other. On the inner side it accepts sodium and ATP, while on the outer side it accepts potassium. The transfer of sodium and potassium across the membrane is brought about by the changes in the shape of the protein. Note that, for every $2k^+$ ions taken into the cell, $3Na^+$ ions are removed.

Thus, a potential difference is built up across the membrane, with the inner side of the cell being negative. This tends to restrict the entry of negatively charged ions (anions) such as chloride and favouring diffusion of cations (positively charged ions) into the cell.

The exchange of three Na^+ ions for two K^+ ions creates an electrical gradient across the cell membrane. That is, the outside of the membrane becomes positively charged and the inside of the membrane becomes negatively charged. In this way, the two sides of the cell membrane are like the positive and negative terminals of a battery. This difference in charge is important for the condition of electrical impulses along nerve cells. The sodium – potassium pump is only one example of a cell membrane pump. Other pumps work in similar ways to transport important metabolic materials across cell membranes.

ACTIVITY 12

Comparison between passive and active transport.

Form group of 4 – 5 students, describe passive transport and active transport with examples.

Then compare and contrast passive transport and active transport

Refer this textbook, other books and the internet if available. Then write a report.

Endocytosis and Exocytosis

Endocytosis

It is a process by which cells ingest external fluid, macromolecules, and large particles, including other cells. In endocytosis the external materials are enclosed by a portion of the cell surface membrane, which folds into itself and forms a pouch. The pouch then pinches off from the cell membrane and becomes a membrane – bound organelle called a vesicle. Some of the vesicles fuse with lysosomes, and their contents are digested by lysosomal enzymes.

Biologists distinguish three types of **endocytosis**, based on the kind of material that is taken into the cell.

(i) Pinocytosis involves the transport of suspensions of finaly divided solidsor fluids;

(ii) Phagocytosis is the movement of large particles or whole cells. Many unicellular organisms feed by phagocytosis. In addition, certain cells in animals use phagocytosis to ingest bacteria and viruses that invade the body. These cells, known as phagocytes, allow lysosomes to fuse with the vesicles that contain the ingested bacteria and viruses. Lysosomal enzymes then destroy the bacteria and viruses before they can harm the animal.

(iii) Receptor - mediated endocytosis : The membrane includes to form vesicles only in regions where particles have bound to specific receptors. The binding stimulates the infoldings.

Exocytosis

Exocytosis is essentially the reverse to endocytosis. During exocytosis, waste materials such as solid and undigested remains from phagocytic vacuoles may be removed from cells or useful materials may be secreted. Secretion of enzymes form the pancreas is achieved in this way. Plant cells use exocytosis to export the materials needed to form cell walls.

Activity 13

Differences between Endocytosis and Exocytosis.
Form student groups, describe Endocytosis and Exocytosis.
Describe Pinocytosis and Phagocytosis;
Tabulate the basic differences between Endocytosis and Phagocytosis.
Then present it to your class

Key terms

- Metabolism
- Prokaryotic Cell
- Eukaryotic Cell
- Diffusion
- Osmosis
- Water potential

- Osmotic pressure
- Osmotic potential
- Active transport
- Endocytosis
- Exocytosis

SUMMARY

- Biology is the study of living things.
- Zoology studies about animals.
- Botany studies about plants.
- Microbiology deals with microorganisms.
- Ecology deals with the interactions among living organims and with their environment.
- Genetics is the study of heredity.
- Cytology is the study of cell.
- Linnaeus contributed in the classification of living things.
- Pasteur contributed in the study of microorganisms.
- Koch contributed in isolating and culturing diseases causing organisms.
- Mendel contributed in the study of heredity.
- Living things exhibit reproduction, growth, feeding, respiration, excretion, metabolism and irritability.
- *Euglena* is a unicellular organism showing both the features of plant and animal cells.
- Microscope is an important tool in biology to study living things that cannot be seen by naked eyes.
- Cell theory states that cells are the structural and functional units of life.
- Prokaryotic cells without membrane bounded nucleus and other organelles.
- Eukaryotic cells membrane bound nucleus and organelles.
- Cells are basically composed of cell membrane, cytoplasm and nucleus.
- Cells allow material exchange in and out of a cell passively or actively.
- Passive transport occurs along a concentration gradient without the expenditure of energy by the cell.
- Diffusion is material transport form lower to higher concentration,
- Osmosis is the diffusion of water from low concentration to high concentration across a semi-permeable membrane.

- Facilitated diffusion is the diffusion of certain substances by the help of carrier and channel proteins.
- Active transport is material movement form low concentration to higher concentration by expenditure of energy.
- Endocytosis is the entry of materials in bulk.
- Phagocytosis is the uptake of materials through a cell membrane.
- Pinocytosis is the uptake of liquid materials in bulks through a cell membrane.
- Exocytosis is the exit of materials in bulk from the cell.

Exercise

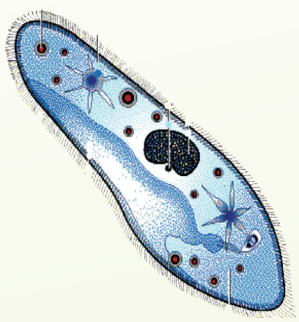
1. Which of the following is **true** about the Cell Thoery?
   (a) Cells are structural units
   (b) Cells are functional units
   (c) Come from pre-exising cells
   (d) All of the above
2. Which of the following cellular structures is **not** common for Prokaryotic and Eukaryotic cells?
   (a) Ribosome
   (b) Mitochotndrin
   (c) Cytoplasm
   (d) Cell membrane
3. Which of the following material transport involves cell energy?
   (a) Diffusion
   (b) Osmosis
   (c) Endocytosis
   (d) Facilitated diffusion
4. In which of the following solution a cell loses water?
   (a) Hypertonic
   (b) Isotonic
   (c) Hypotonic
   (d) Distilled water

B10CH02

CHAPTER 2

THE HIERARCHY AND DIVERSITY OF LIVING THINGS: UNICELLULAR ORGANISMS

Chapter Contents



Chapter Outcomes

At the end of this chapter the learners should be able to:

- outline the diversity of living things;
- discuss the basis of taxonomy (classification);
- explain the characterstic features of viruses;
- identify the major characteristics of the kingdoms Monera (bacteria), Protista (protists), Fungi (fungi), Plantae (Plants) and Animalia (animals);
- classify organisms into kingdom, phylum, class, order, family, genus and species;
- explain the basic characteristics of unicellular organisms;
- name unicellular organisms that are causative agents of diseases and the diseases they cause.

Introduction

Since the time of Linnaeus, about 1.5 million species have been named. However the actual number of species of organisms in the world is much greater, judging from the very large numbers that are still being discovered. Today, it is estimated that at least 10 million species exist on earth. Organisms are not only enormous in number; they vary greatly in size, structure, habits and modes of life and are highly diversified.

2.1 Classification and the Importance of Living Things

Since early times, biologists have made attempts to classify organisms. The first attempt was made more than 2,000 years ago by the Greek philosopher and biologist Aristotle (322 B.C. i.e., 4th century B.C). He classified few hundred different kinds of plants and animals. Aristotle classified plants, based on stem differences, as herbs, shrubs and trees. Similarly, he grouped animals into three kinds according to where they live i.e., as either land, water or air dwellers. This classification scheme was accepted for years yet it is confusing. For example, according to Aristotle's scheme, bats and mosquitoes could be placed in the same group since both live on land. But you would see that a bat is more related to a mouse than to a mosquito when you read and understand the modern classification scheme. Example *Triticum aestivum* (wheat).

During the 1700s, the Swedish botanist, Carolus Linnaeus classified all then known organisms into two large groups; the kingdoms plantea and animalia. According to Carlolus Linnaeus every living organism has a genus and species names. This called Binomial system of naming or Nomenclature. In this scientific names the genus name begins in capital letter but the species name in small letter. Both should be written in italics.

For instance, *Homo sapiens* refers to all human beings, Canis familaries and Felis domestica for dog and cat respectively.

It also works for plants. For example *Zea mays* and *Triticum aestivum* for maize and wheat respectively.

Due to the discovery of the microscope this simple classification system was expanded in the later part of the 18th century. The invention of the microscope allowed biologists to learn about microorganisms and

other organisms such as protists. Thus, the German scientist, Haeckel produced a three kingdom scheme which includes protists as the 3rd kingdom. This scheme has plant kingdom, animal kingdom and protist kingdom. Because bacteria were included with plants in the plant kingdom, biologists could not agree on Haeckel's classification. Some biologists claim that bacteria are unicellular while others considered them to be multi-cellular. Finally, they agreed to put the bacteria and blue-green algae in a separate kingdom called kingdom monera. This produced 4 classification schemes. Robert Whittaker in 1969 an American biologist, proposed a five kingdom system that soon became widely accepted. Whittaker's five kingdoms are monera; protista, fungi, plantae and animalia. Today, most biologists employ five-kingdom scheme of Whittaker.

The Species Concept

Living things are divided for convenience, into smaller groups. Such division separates living things into kingdoms. Thus, an organism in the animal kingdom could be expected to have more in common with another organism belonging to the same group than the ones from the plant kingdom. Among animals, some share a number of traits in common and these may be placed together into a phylum. For instance, those animals that have rod like structures called notochord are placed in one phylum called chordate. As smaller and smaller divisions are made among plants and animals, one finally arrives at a group of organisms that have so features in common, they normally inter breed. They are said to be of the same species. A species is a group of individuals that have common ancestor, closely resemble each other, can interbreed and produce fertile offspring.

The smallest natural group of organisms are called species. A part from small variations (difference) members of a species are almost identical in their anatomy, physiology and behavior. All dogs belong to the same species, however, there are wide variations of different breeds.

Figure 1. Classification of a single species of animal

2.2 Classification of Organisms–Kingdoms

In this system, four kingdoms consist of Eukaryotic organisms. The two most familiar kingdoms are Animalia and plantae, contain only organisms that are multi-cellular during most of their life cycle. The kingdom fungi contain multi-cellular forms and single celled yeasts. The large number of unicellular eukaryotes are arbitrarily grouped into a single kingdom called Protista. This kingdom includes the algae all of which are unicellular during important parts of their life cycle, and the protoza. The other kingdom, kingdom monera consists of prokaryotic organisms.

The five-kingdoms scheme of classification is based on the following criteria:

- The complexity of cell structure Prokaryote or Eukaryote
- The complexity of organism's body..... Unicellular or multicellular
- The mode of nutrition ..... Autotrophic or heterotrophic

The four classification schemes are:

1. Two kingdom system – Plantae and Animalia
2. Three kigdom system – Protista, Plantae and Animalia
3. Four kingdom system – Monera, Protista, Plantae and Animalia
4. Five kingdom system – Monera, Protista, Fungi, Plantae and Animalia

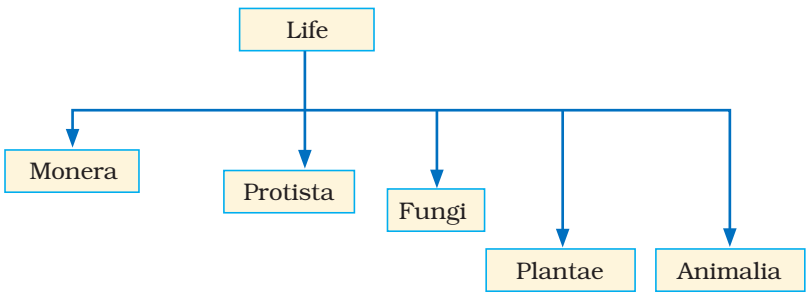


Figure 2. Five kingdom classification based on some criteria

ACTIVITY 1

Discussion on the characteristics of each kingdom

From groups of 4-5 students list out the general characteristics of each kingdom and present to the class.

The concept of classification is to identify who is related to whom. Such grouping is based on the basis of similarity of traits. The more traits that two organisms have in common they are thought to be the more closely related. Two closely related organisms often show many physical (structural) similarities. Developmental and biochemical (chemical composition in the living organisms) traits may also be used to determine relationship among organisms.

As discussed earlier, traits such as size, presence or absence of nucleus, autotrophism and heterotrophism and mobility, are some of the characterstics used in the five - kingdom scheme of classification and are presented in the following section.

Kingdom Monera

The important characteristics of Monera are mentioned below:

1. The Monerans are unicellular organisms.
2. They contain 70s ribosomes.
3. The DNA is naked and is not bound by a nuclear membrane.
4. They lacks organelles like Mitochondria, Lysosomes, Plastids, Golgi bodies, Endoplasmic reticulum, Centrosome, etc.
5. They reproduce asexually by binary fission or budding.
6. The cell wall is rigid and made up of peptidoglycan.
7. Flagellum serves as a locomotory organelle.
8. They show different modes of nutrition such as autotrophic, parasitic, heterotrophic, or saprophytic.

Kingdom Protista

Of the five kingdoms of organisms, the kingdom protista is the most diverse. Kingdom Protista is a link between the Prokaryotic kingdom, Monera and the complex, Eukaryotic, multi-cellular kingdoms fungi, plantae and animalia.

Before the introduction of the five-kingdom system of classification by Whittaker in 1969, the green photosynthetic protophyta were considered as plants; and those protists that ingest their food like animals such as protozoa were considered very small and simple animals. Some protists are decomposer fungi - like protists such as slime moulds.

General characteristics

- Most protists are microscopic, but some are very large.
- Many are unicellular; in fact, all single celled Eukaryotes (except yeasts) are protists.
- Have many specialized cellular parts or organelles that carry specific functions of living.
- Traditionally, protists have been grouped into photo-synthesizers (algae), heterotrophic (protozoa) and absorbers (fungi).
- Some may have flagella or cilia for locomotion.
- Photosynthetic forms have cell wall and pigments primarily chlorophyll molecules.

- Some protists (protozoans) holozoic nutrition and have organelles for ingestion, digestion and egestion.
- Almost all the protists live in water, because they have no protective structures against drying out.

Kingdom protista consists of prtozoa and algae.

Kingdom Fungi (Heterotrophic Decomposers)

The fungi are a large group of organisms that range in size from one - celled (yeasts) to multi-cellular forms (toad stools and puff balls).

The so called multicellular forms are multinucleated cells enclosed in cells with cell-walls. They obtain their energy by decomposing dead and dying organisms and absorbing the nutrients from these organisms.

Some fungi also cause diseases on both humans, animals and plants (athlete's foot in humans, rusts and smuts in plants). Others are useful in baking, brewing, as foods, drugs and sources of antibiotics.

Characteristic of Fungi

- They are Eukaryotes and have heterotrophic nutrition.
- They have no chlorophyll.
- They feed by absorbing nutrients from dead or living materials of others.
- They have parasitic, saprobic or symbiotic modes of nutrition.
- They have a rigid cell wall generally made up of chitin. Chitin contains nitrogen and polysaccharide.
- Their body is in the form of thread - like structures called mycelia (singular-mycelium). Each thread - like fine filament is called hyphae (mass of hyphae produce mycelium).
- They are non - motile. They reproduce by both sexual and asexual means. Asexually by spore formation and budding and sexually by conjugation.

Kingdom Plantae

The green plants are multicellular Eukaryotes. They are adapted to life on land by developing ways to absorb minerals in partnership with fungi (mycorrhizae), to conserve water with water tight cuticle, reproduce by spores and seeds.

Members of the kingdom plantae have many things in common.

- They are all multicellular Eukaryotes
- They cannot move about
- They all have cell wall made of cellulose
- They all have two stages in their life cycle a haploid gametophyte generation and a diploid sporophyte generation undergoing alternation of generation
- They are mostly autotrophic and have coloured photosynthetic pigments

Kingdom Animalia

Nearly 2 million different kinds of animal species have been described, but millions more are awaiting to be identified. Some scientists believe that the total number of animals species may be as high as 30 million. Scientists (taxonomists) group or classify animals based on features they have in common.

Feature of Animals

- Animals have bodies made up of many cells (multi-cellular).
- Animals ingest food (consumers/heterotrophs).
- Animals have nerves and muscles for responding to the environment.
- Animals can move all or part of their bodies. At some point during their lives, animals are capable of movement. In most animals, this stage is the adult. But some animals (*e.g.* Corals) have sessile (non - mobile) adult phases and mobile juvenile forms.
- Animals developed external or internal skeletons to provide support, skin to prevent or lessen water loss, muscles that allowed them to move in search of food; brains and nervous systems for integration of stimuli and internal digestive systems.
- Kingdom Animalia includes all invertebrate animals such as sponges, coelentrates, worms, molluscks, echinoderms, arthropods and vertebrate animals fishes, amhibians, reptiles, birds and mammals.

Activity 2

Observing representative organism from each kingdom

Observe one organism from each of the 5 Kingdoms

Draw and label the parts of each organism you have observed

2.3 Unicellular Organisms

Unicellular organisms such as *Amoeba, Paramecium, Euglena, Yeast,* and *Bacteria* are studied using microscope because they cannot be seen with naked eye.

Every unicellular organism has specific structures, habitat, mode of locomotion, modes of nutrition, reproduction and importance. Some structures used for movement in unicellular organisms are cilia, flagella and pseudopodia (Figure 3).

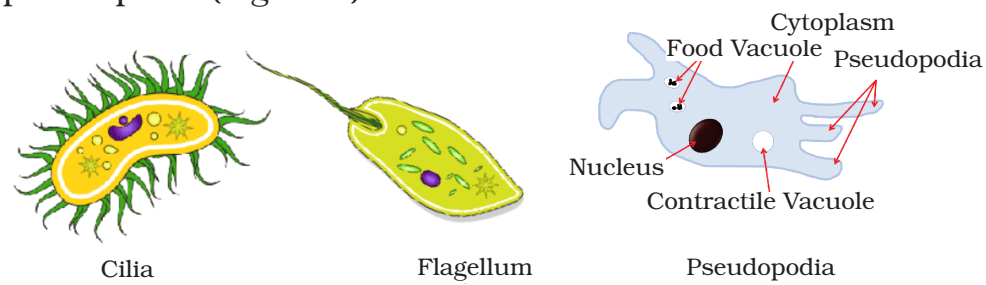


Figure 3. Structures used for movement in unicellular organisms

Activity 3

Draw the structures of unicellular organism

Draw and label the structures of:-

1. Amoeba

2. Paramecium

3. Euglena

Present the highlight to your class.

Amoeba

Amoeba is a single celled organism found in mud at the bottom of ditches, ponds and as intestinal parasites of animals and humans.

The body parts of amoeba include nucleus, cytoplasm, contractile vacuoles, and food granules.

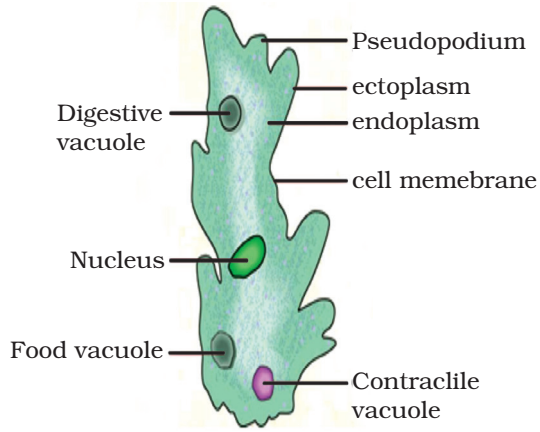


Figure 4. Structure of Amoeba

Amoeba is able to move by forming pseudopodia, because of the flow of cytoplasm.

Amoeba feeds on bacteria and microscopic algae, which are engulfed by pseudopodia and form a vacuole in the cytoplasm. Enzymes are released into the vacuole.

Amoeba reproduces asexually by binary fission and sporulation.

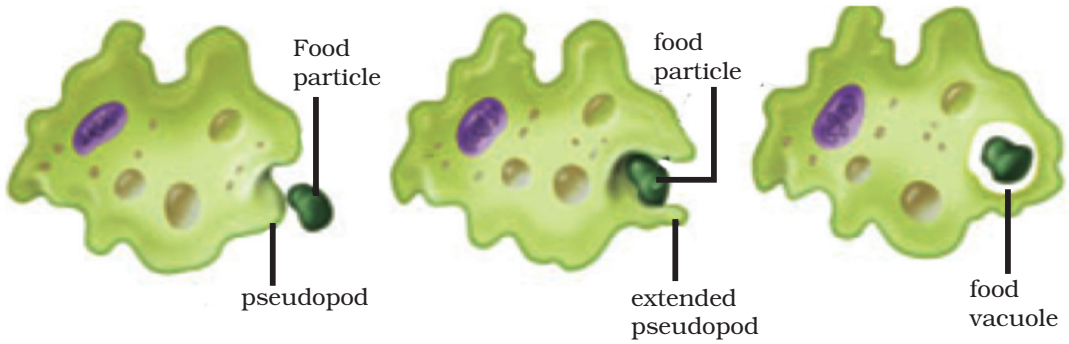


Figure 5. The feeding of Amoeba using its pseudopodia

The mechanism for binary fission involves:

- Occurs everyday when conditions are favourable
- Amoeba stops moving and becomes rounded
- The nucleus divides in two and each part takes some cytoplasm with it forming two daughter cells Figure 6.

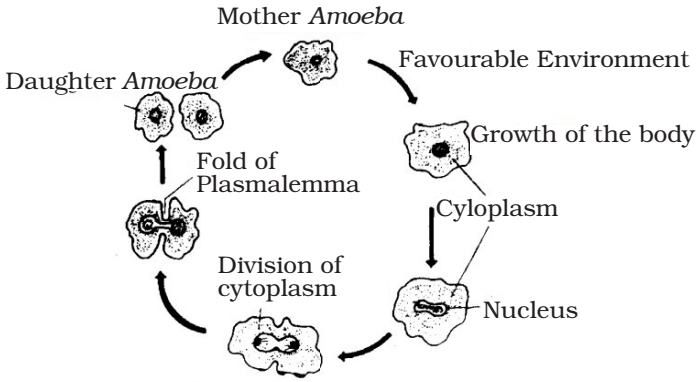


Figure 6. Binary fission in Amoeba

The mechanism for sporulation involves:

- Occurs when conditions are unfavourable e.g. drought
- A thick covering or cyst surrounds the amoeba
- Whilst in the cyst it may divide many times
- When conditions become favourable the cyst ruptures and the amoeba will be released Figure 7.

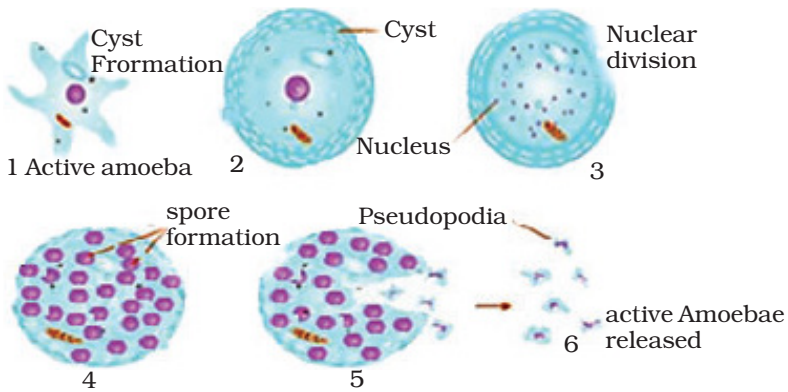


Figure 7. Spore formation of Amoeba.

Amoeba is a colorless protozoon, microscopic in size; irregular in shape and composed of the following structures.

Cell Membrane: Boundary of the cell that changes its shape, which is flexible to aid movement.

Nucleus: Have one or more nuclei for reproduction and controlling cellular activities.

Food vacuole: Found in the cytoplasm and contains food for digestion.

Contractile vacuole: Present in the cytoplasm and removes excess water.

Habitat: In water, soil, mud, ponds, rivers and lakes. Some amoebas are parasites, living inside other organisms.

Nutrition: Heterotrophic, feeding on organic matter. *Amoeba* get food by the process of engulfing using pseudopodia (false foot). The engulfed food particle is taken into a food vacuole and digested.

Reproduction: There is no sexual reproduction in Amoeba. Amoeba reproduces asexually by binary fission. During unfavorable conditions, amoeba reproduces asexually by spores and cyst formation sporulation.

Locomotion (movement): Amoeba moves by means of pseudopodia. Pseudopodia mean 'false feet'.

Importance: It is an intestinal parasite of animals and humans causing amoebic dysentery.

Paramecium

Paramecium is a single celled organism, shaped like a shoe print, which is found in fresh water ditches and ponds.

The body parts of *Paramecium* include nucleus, cytoplasm, contractile vacuoles, and oral groove.

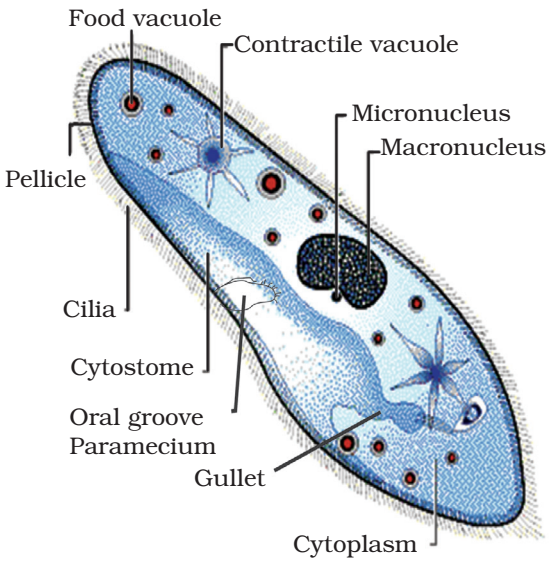


Figure 8. The Structure of Paramecium Cell

Paramecium is able to move by spinning around its long axis due to the rhythmic movement of cilia. It feeds on bacteria, which are drawn into the oral groove and carried to the cytosome by the action of cilia. The food is digested by enzymes as it passes around the cytoplasm.

Paramecium reproduces both asexually and sexually. Asexual reproduction by binary fission is more common. The nucleus of the paramecium divides in two and each part takes some cytoplasm, while forming two new individuals

Sexual reproduction by conjugation involves the following sequence of events:

- Two *Paramecium* come together and are joined at the oral surfaces by cytoplasm.
- The mega nuclei break up and disappear.
- The micronucleus in each organism divides into four.
- Three of these disappear and the remaining one divides into two.
- One micronucleus from each organism migrates into the other organism and unites with the remaining micronucleus forming a zygotic nucleus in each organism.
- The organisms separate and the nucleus in each divides into eight.
- Each organism undergoes binary fission twice to form four new individuals (Figure 9).

Paramecium is a single celled colorless slipper shaped organism.

Cilia short hair like structures covering the body, that are used for movement in water by beating and also used for feeding.

Cell membrane: The boundary with cilia.

Nucleus: Have two nuclei - Macro (mega) nucleus, which is large, and micronucleus, which is smaller. Micronucleus is used for reproduction while macronucleus serves as nucleolus.

Food vacuoles: Used for digestion of food.

Cytostome and cytopharynx for entrance of food into the food vacuole.

Contractile vacuoles: Used to remove wastes.

- Oral groove is used to collect food.
- Gullet forms food vacuole.

- Anal pore removes digestive food.

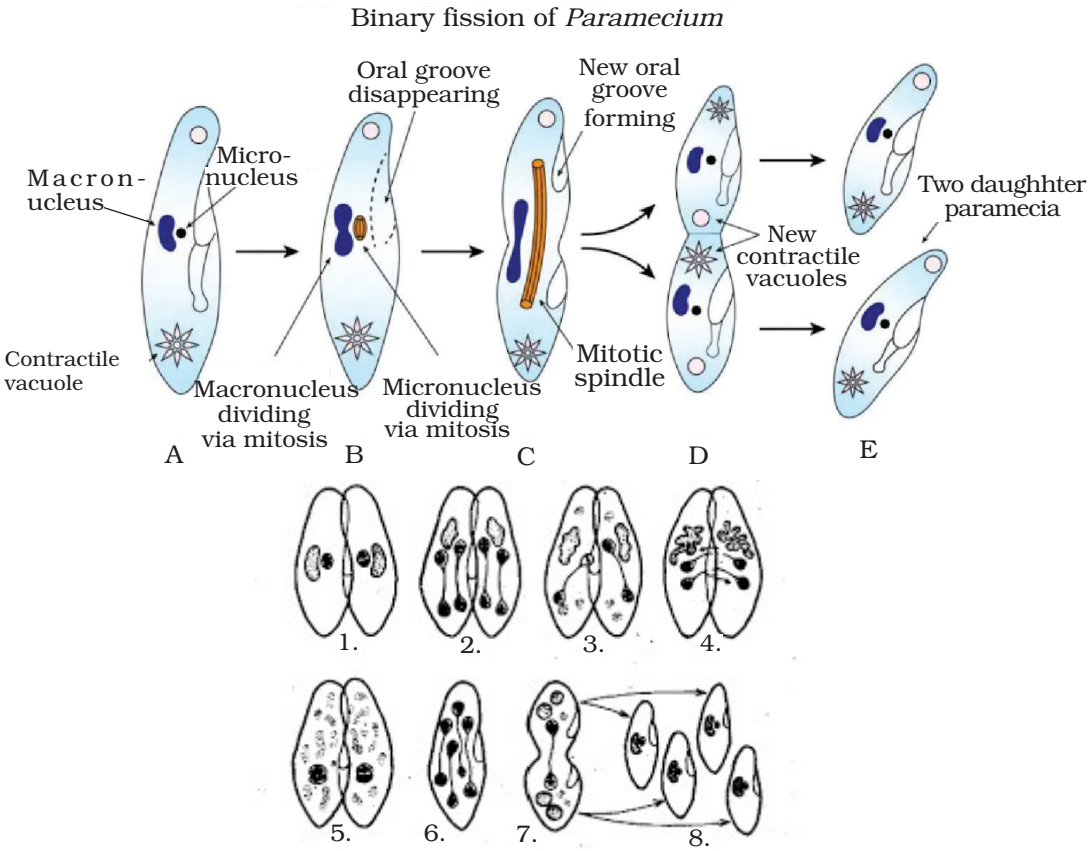


Figure 9. Life cycle of Paramecium with fission and conjugation phases

Habitat: Lives in fresh water ditches, ponds, rivers, and lakes.

Nutrition: Feeds on solid food including bacteria and other small cells. It uses cilia that create currents in water to sweep food into oral groove.

Locomotion: Cilia are used for movement in water by beating to allow moving with a synchronous motion (like a caterpillar).

Reproduction: *Paramecium* reproduces both asexually and sexually.

Asexual reproductions by binary fission involve the division of the micronucleus that forms to daughter *Paramecia*.

Sexual reproduction is by conjugation. Conjugation is the process by which two *Paramecia* come together and are joined at the oral surface by the cytoplasm.

Importance: *Paramecium* decomposes waste materials and help in recycling of nutrients in the environment.

Euglena

Euglena is a single celled organism, which is oval, shaped and has a single flagellum. It is found in fresh water ditches and ponds, particularly those contaminated by urine and faeces.

The body parts of *Euglena* include nucleus, cytoplasm, contractile vacuoles, chloroplast, and flagellum (Fig 10).

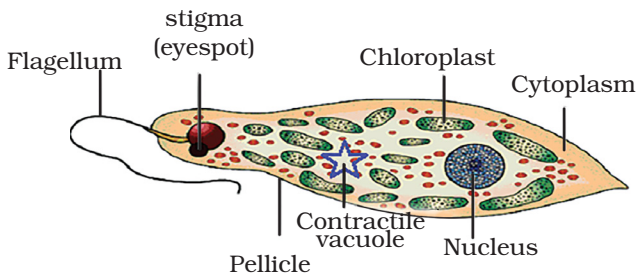


Figure 10. The Structure of Euglena cell

Euglena is able to move in a wave-like motion as it spins around its long axis due to the lashing of the flagellum against the water.

Euglena has a chloroplast and produces its own food by photosynthesis.

It reproduces asexually by binary fission. Asexual reproduction involves the following processes:

- The *Euglena* stops moving
- The nucleus divides into two and a second flagellum will be formed.
- The cytoplasm divides along the length of the organism, with a nucleus and flagellum on each side.
- Two new organisms are formed.

The movement of *Euglena* is by the whipping of the flagellum. *Euglena* is an oval shaped single celled organism. It shows both plant and animal like characteristics. It is plant like because it has chlorophyll and can make its own food by the process of photosynthesis. It is animal like also because, it has no cell wall and can feed on organic matter.

Cell membrane, cytoplasm, and nucleus are present.

Chloroplasts contains chlorophyll

Flagellum: a whip like structure at one end and used for movement and with an eyespot sensitive to light at the base. Contractile vacuole used for water balance.

Habitat: Found in contaminated freshwaters.

Nutrition: Produces its own food by photosynthesis during the presence of light and feeds on organic matter during dark time.

Locomotion: move in a wave-like motion by lashing of the flagellum against the water.

Reproduction: Reproduces only asexually by binary fission.

Importance: Serve as food for other microorganisms.

ACTIVITY 4

Observing unicellular organism from pond water

You need

- Microscope glass slides
- Cover slips
- A compound microscope
- A dropper

Method

1. Collect some pond weed
2. Place a few pond weeds in a jar and add water
3. Place the jar in a dark room for a few days.

Observe and study them

Draw and label the parts of your observations.

Bacteria

Bacteria : There are many different kinds of bacteria, but they have certain generalised features. Some bacteria exist as individuals while others in group.

Bacteria are found in a variety of habitats both outside and inside of other organisms.

The parts of a bacterium include nuclear material, cell wall, cytoplasm, slime envelope, and flagellum.

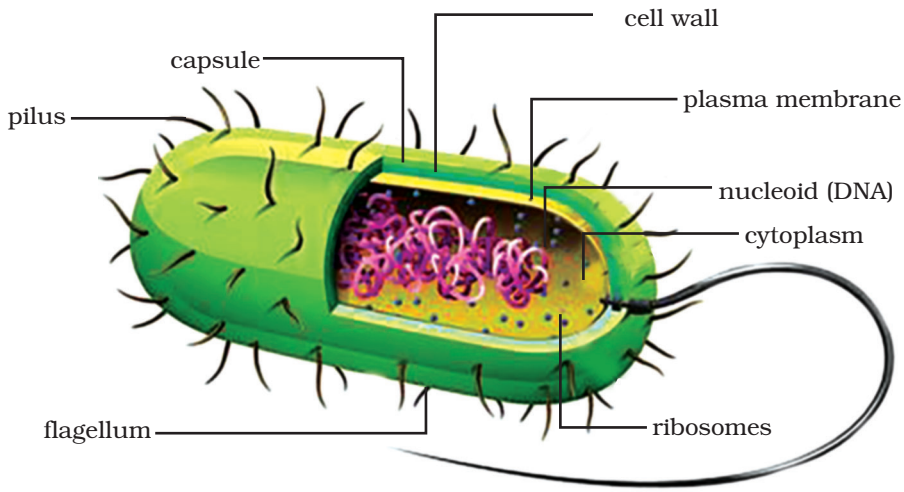


Figure 11. Generalized bacterial cell

Bacteria have no nucleus but a knot of nuclear material.

They move by flagella.

Bacteria reproduce asexually by binary fission which involves the following processes:

- The bacterium stops moving.
- The nuclear material divides into two.
- The cytoplasm divides along the length of the organism, with nuclear material on each side.
- Two new bacteria are formed.

The different bacterial forms include cocci, bacilli, vibrios, and spirilla.

Some bacteria can cause diseases in humans including Cholera, Pneumonia, Typhoid, and Syphilis.

Bacteria are single celled prokaryatic organisms and they do not have most organelles found in plant and animal cells.

Bacteria have rigid cell wall and flagellum. They have dense cytoplasm and there is no vacuole.

Bacteria have no nucleus but a knot of nuclear material. Their internal structures are seen only by electron microscope.

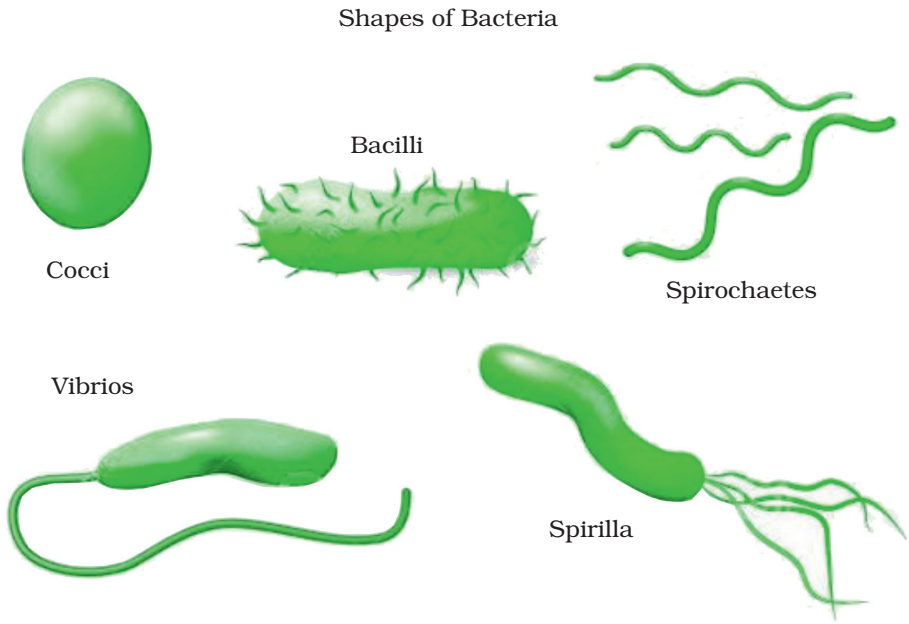


Figure 12. Different shapes of Bacteria

Habitat: Bacteria are found everywhere, on land, air, and water, on and inside other organisms.

Nutrition: Some Bacteria make their own food (Autotrophs) others feed on organic matter (Heterotrophs), and on dead organic matter (Decomposers).

Locomotion: Bacteria are able to move due to the motion of flagella.

ACTIVITY 5

Drawing of a Prokaryotic bacterial cell.

Draw and label the Prokaryotic bacterial cell.

State the functions of each labelled parts.

Refer this textbook, other books and the internet if available. Then present it to your class.

Reproduction

Bacteria reproduce asexually by binary fission. It takes 20 to 30 minutes for one division. To give rise to 1.2×10^9 bacteria it takes only ten hours. In adverse conditions, they form structures known as **endospores** for reproduction.

Importance: There are harmful and useful bacteria.

Benefits of Bacteria

- returning nutrients to soil.
- compost making.
- sewage treatment.
- synthesizing vitamin K in the intestine of mammals.
- manufacture of vinegar, lactic acid, citric acid, in souring milk, making of butter, and cheese, and enzymes such as amylases and invertases.
- manufacturing of antibiotics (medicines).

Bacteria are useful to Ruminant animals for digesting cellulose in their stomach.

Bacteria are harmful to man and for his domestic animals by causing disease (table), food spoilage and toxic material production.

Yeasts

Yeast is a single-celled fungus. It has no chlorophyll and therefore, cannot obtain its own food by photosynthesis. Yeasts are with cell wall, nucleus, and cell membrane.

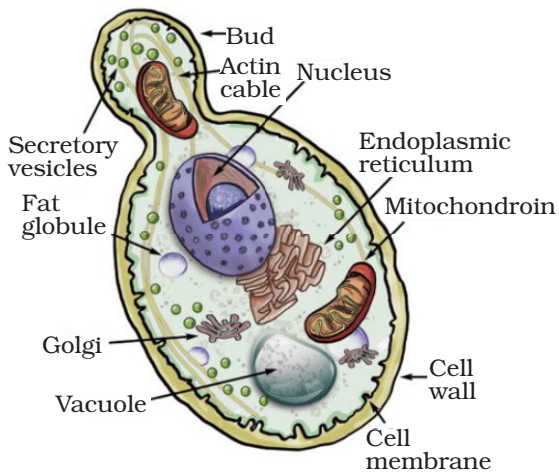


Figure 13. A yeast cell.

Reproduction

Yeast reproduces asexually by budding, which involves the following processes:

- The yeast cell grows in size.
- The nucleus also increases in size and divides.
- A new yeast cell (bud) grows on the side of the parent cell.
- The cell divides in to new cells.

Nutrition

Nutrition in yeast involves the breakdown of glucose in the absence of air. This is called alcoholic fermentation, since alcohol (ethanol) is one of the products.

Glucose → ethanol + carbon dioxide + energy

Habitat

It is found naturally on the skins of fruit such as grapes and is also found in fermented dough.

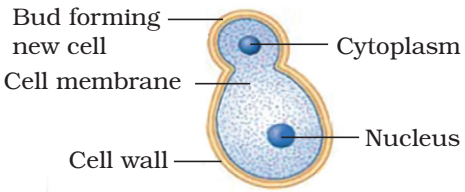


Figure 14. Budding in yeast

Locomotion

There is no structure for movement.

Importance : Human use of yeasts for food preparation or preservation and other purposes is extensive, yeasts are required for fermentation of beer, wine, bread and cultured foods.

Exercise

Choose the correct answer for each of the following questions.

1. Unicellular Eukaryotes are grouped in
   (a) Monera
   (b) Protista
   (c) Archaea
   (d) Fungi
2. Which of the following organisms will vanish if all the ponds and puddles are destroyed?
   (a) Plasmodium
   (b) Trypanosoma

(c) Leishmania
(d) Ascaris

3. In *Amoeba* and *Paramecium*, the cell organelle for osmo regulation is _____ .
   (a) Nucleus
   (b) Body surface
   (c) Contractile vacuole
   (d) Pseudopodia
4. Which class of organisms does the malarial parasite belong to?
   (a) Dinophyceae
   (b) Sarcodina
   (c) Ciliate
   (d) Sporozoa
5. Protozoa are classified on the basis of _____ .
   (a) Locomotory organelle
   (b) Shape
   (c) Number of nuclei
   (d) Size
6. Which of the following is **not** a characteristic feature of Prtozoans?
   (a) Binary fission
   (b) Contractile vacuole
   (c) Cell membrane as an outer body covering
   (d) Pseudopodia
7. *Trypanosoma* belongs to which of the following group of organisms?
   (a) Mastigophore
   (b) Sarcodina
   (c) Sporozoa
   (d) Ciliata

Sexually Transmitted Diseases (STDS)

A. Gonorrhoea – is caused by *Neisseria gonorrhoeae*

- Transmitted through sexual contact.
- The sympotoms are burning sensation while urination and yellowish white discharge from the penis and vagina.
- The pregnant woman who has untreated Gonorrhea can pass to her baby along the birth canal, which will affect the baby's eyes and causes blindness.

Control and prevention

- It can be prevented by ABC methods.
  (a) Sexual abstenance.
  (b) by being faithful to the sexual partner.
  (c) using condom.
- Responsible and sensible approach to sexual relationships
- Early treatment by antibiotics.

B. Syphilis – is caused by spiral shaped bacteria called Treponema pallidum.

- It is transmitted through sexual contact.
- The congenital syphilis can be transferred from the mother to fetus.
- The symptoms of syphilis have three stages.
- In earlier stage (i.e. primary stage) sores which are painless are formed at the sites of initial contact. This stage may be accompanied by swollen glands. The sores may last from one to five weeks and may disappear even without treatment. These sores are very infections.
- **The second stage of syphilis:** The symptoms are the rash of sores, tiredness, fever, sore throat, headaches, hoarseness, loss of appetite, patchy hair loss and swollen glands.
- These symptoms last 2-6 weeks and can disappear even without adequate treatment.
- The third or tertiary stage (late syphilis) may involve illness in the skin, bones, central nervous system and heart, causing irreversible problems that cannot be treated effectively.

HIV and AIDS

Distribution of HIV and AIDS (local, national and global levels).

- HIV (Human Immuno Deficiency Virus) is the virus that causes the disease AIDS or Acquired Immune Deficiency Syndrome.
- AIDS is mainly transmitted by sexual intercourse and it damages the immune system.
- So far, there is no cure or vaccine for the disease caused by HIV

ACTIVITY 6

Discussing causative agents of STI's and disease they cause

List and discuss causative agents of STI's and the disease they cause
Consult medical professionals by going to clinics and hospitals
Present your findings to the class.

Vaginal Candidiasis

Candidiasis is an infection caused

y a yeast called *Candida*. Sometimes Candida can multiply and cause an infection, if the environment inside the vagina changes in a way that encourages its growth.

Candidiasis in the vagina is commonly called a "vaginal yeast infection" or vaginal Candidiasis.

Symptoms:

- Vaginal itching or soreness.
- Pain during sexual intercourse.
- pain or discomfort when urinating.
- abnormal vaginal discharge.

Sporozoa

Sporozoans are the best known malarial parasites that belongs to the genus *Plasmodium*. It is transmitted during the bite of the female anophelis mosquito. The mosquito inject the plasmodium at the stage of sporozoites into the blood of human host. The sporozoites find thier way to the liver through the blood stream where it rapidly multiply asexually and form merozoites. Here, they reattack the liver and enter the blood and infect red blood cells. They cause RBC to enlarge and rupture. Finally, they release toxic substances, throughout the body of the human host, causing fever and chills which is the manifestation of malaria.

The merozoites devlop into gametocytes in human blood, which can be taken up by mosquito bite. Inside, the gut of mosquito, the gametocytes develop into male and female gamets. These gametes fuse sexually and form zygotes that gradully form sporozoites in salivary glands of mosquito.

Malaria can be prevented by using mosquito net, along the bed side to avoid mosquito bite, clearing marshy area to reduce the multiplication of mosquito and spraying insectcide.

Trichomoniasis

It is a sexually transmitted infection caused by a parasite (Protozoa) called *Trichomonas vaginalis.*

Symptoms

- Itching, burning, redness or soreness of the genitals.
- discomfort when peeing.
- A clear, white, yellowish, or greenish Vaginal discharge with a fishy smell.

ACTIVITY 7

Description of the flagellated protozoa parasite (Trichomonas vaginalis)
Form small groups of students.
Discuss on the complications caused by *Trichomonas vaginalis*.
Discuss on the symptoms of disease in women.
Refer this textbook, other books and the internet if available. Then present it to the class.

2.4 PARASITIC PROTOZOA AND DISEASES THEY CAUSE

(a) Amoebiasis **:** is a human infection of the large intestine caused by *Entamoeba histolytica*, an extracellular parasite protozoa, *Entamoeba histolytica* a lives in the gut of infected people. It can be passed out in their *faeces*.

Transmission: The parasite can actually survive for weeks, or even months, in soil, fertilizer, or water that is contaminated with faeces. If another person drinks the contaminated water or eats contaminated food they too can be infected.

Entamoeba histolytica can be present on the hands of an infected person with poor hygiene practices. E.histolytica also get into the blood stream from the gut and spread around the body to the liver, lungs and sometimes to other organs.

Symptoms: Abdominal cramps, bloody diarrhea, colitis (inflammation of the colon), fatigue, tissue destruction.

(b) Giardia lamblia (*Giardiasis*)

Giardiasis is an infection of the small intestine marked by stomach cramps, bloating, nausea and bouts of watery diarrhea. It is caused by a microscopic parasite called *Giardia lamblia*. Giardiasis spreads through contact with infected people, by eating contaminated food or drinking contaminated water.

G. lamblia are found in animal and human faces. The parasite also lives in contaminated food, water and soil.

Symptoms: fatigue, nausea, diarrhea, vomiting, loos of appetite, bloating and abdominal cramps.

(c) Plasmodium falciparum

Plasmodium falciparum is a unicellular protozoa parasite of humans, and the deadiest species of *Plasmodium* that causes malaria in human. The parasites transmitted through the bite of a female anopheles mosquito and causes the diseases most dangerous form, *Falciparum* malaria.

The particular virulence of this species derives from its ability to subvert the physiology of its host during the blood stage of its development. Most commonly, the patient shows combinations of the following symptoms: fever, chills, sweats, headaches, nausea and vomiting, body aches and general malaria.

Activity 8

Draw the life cycle of Plasmodium

Use this textbook, other books, and internets as a resource for your research

Present your findings to the class.

Activity 9

Discuss the effects and prevention of malaria and dysentery.

- Make peer groups.
- Discuss on the effects of malaria.
- Discuss on the prevention of malaria and dysentery.
- Discuss on the methods of prevention of malaria and dysentery.
- Present it to your class.

KEY TERMS

- Gametophyte
- Sporophyte
- Archegonium
- Antheridium
- Frond
- Hermaphrodite
- Metamorphosis

SUMMARY

- Living things are classified for the purpose of identification and understand thier relationships.
- In binomial classification every species has a genus and species name in binomial nomenclature, the genus name is capitalized.
- Based on morphological, behavioural anatomical, physiological and hereditary similarities are grouped at different levels of classification.
- The heirarchy of classifcations are kingdom, phylum, class, order, family, genus and species.
- A species is an inter breedable group of organisms that produces fertile offspring.
- In modern classification the five kingdoms: Monera, Protista, Fungi, Plantae and Animalia.
- Monera includes unicelluar and prokaryotic organisms.
- Protista includes animal-like (Protozoa) and plant-like (Algae), Eukaryotic and mostly unicellular organisms.
- Fungi encompasses Eukaryotic unicellular and multicellular organisms having cellwall and they are heterotrohic.
- Plantae encompases Eukaryotic, multicellular and photosynthetic plants.
- Animalia includes Eukaryotic, multicellular animals with nervous system.
- Unicellular organisms are organisms having single cell to carry out all the activities of life.
- Few viruses and some bacteria, protozoa and some unicelluar fungi are known to cause Sexulay Transmitted Infections (STI);
- AIDS is caused by HIV virus.
- Gonorrhoea and Syphilis are STIs caused by bacteria.
- Trichomnas vaginalis is a STI caused by protozoa.
- Vaginal candidiasis is a STI caused by fungus.
- The sporozo, a plasmodium cause malaria by the bite of mosquito

- Prasitic protozoa such as Amoeba, *Gardia* and Plasmodium are known to cause diseases.
- *Entamoeba histolytica* causes intestinal disease amoebiasis.
- *Gardia lambia* causes intestinal disease giardiasis.
- *Pasmodium falciparum* causes malaria.

Exercise

Choose the most exact answers for the following questions

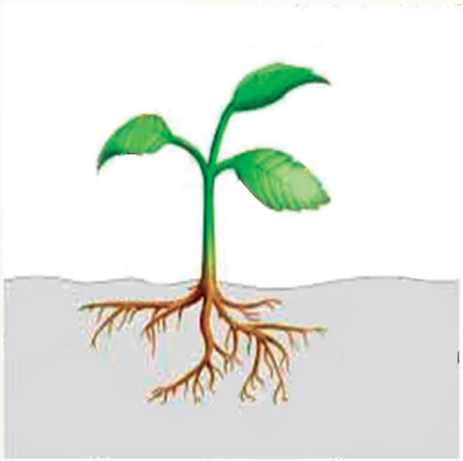
1. Which of the following is the importance of classifying living things? To:
   (a) Understand their relationships
   (b) Put them orderly
   (c) Identify living organisms
   (d) All of the above
2. Which of the following is the highest form of classifcation?
   (a) Kingdom
   (b) Phylum
   (c) Class
   (d) Order
3. Which of the following is the common feature of kingdoms Monera and Fungi?
   (a) Unicellular organisms
   (b) Prokaryotic cells
   (c) Cell wall
   (d) Chlorophyll
4. Which one is not the distinguishing feature of kigdom Plantae?
   (a) Photosynthesis
   (b) Chloroplast
   (c) Cell wall
   (d) Nervous sytem
5. Which of the following STIs is caused by a fungus?
   (a) Candidiy asis
   (b) Gonorrohea
   (c) Syphilis
   (d) Trychomonoasis
6. Which of the following diseases is caused by Plasmodium?
   (a) Giardiasis
   (b) Amoebiasis
   (c) Malaria
   (d) Typhoid

B10CH03

CHAPTER 3

MULTICELLULAR ORGANISMS AND REPRODUCTIVE STRUCTURES

Chapter Contents



Chapter Outcomes

At the end of this chapter the learners should be able to:

- outline the diversity of living things;
- discuss the basis of taxonomy (classification);
- discuss the relationship of viruses bordering between living and non-living things;
- listing the major characteristics of the;
- kingdoms Monera (bacteria), Protista (protists);
- fungi (fungi), Plantae (Plants) and Animalia (animals);
- classify organisms into kingdom, phylum, class, order family, genus and species;
- explain the basic characteristics of unicellular organisms;
- name unicellular organisms that are causative agents of diseases and the diseases they cause.

Introduction

New cells are formed after mitosis and cell division, then cells normally enlarge and become specialized for a particular function. Multicellular organisms consist of many groups of specialized cells, making up their tissues and organ. Differentiation is the process by which unspecialized structures become modified and specialized to perform of specific functions. In this chapter you will learn about the human reproductive structures and their functions as well as the development of embryo inside the mother's womb

3.1 Tissues, Organs and Systems

The five levels of organisation in a multicellular organism are:

Cells → tissues → organs → systems → organism

Cells are the smallest structural and functional units of life from which every living thing is composed. In a living organism, there are different types of cells, each having a particular function.

Some of the different types of cells found in plants include leaf epidermal cells, leaf palisade cells, and root tip cells.

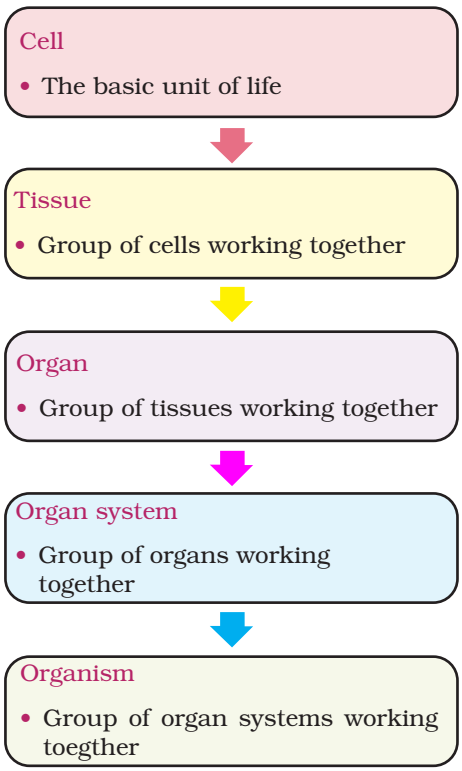


Figure 1. Shows cellular level of organization

(i) Cells found in the human body

The different types of cells found in the human body include skin cells, blood cells, muscle cells, nerve cells, sperm, and ova cells. Cells of a particular type are usually grouped together to form a tissue. Tissue consists of cells of the same shape and size, which carry out the same function.

Plant Tissue: Some of the tissues present in plants include photosynthetic tissue, epidermal tissue, conducting tissue, and strengthening tissue.

Animal Tissue : Some of the tissues present in animals include epithelial tissue, nerve tissue, muscle tissue, and connective tissue.

(ii) Organs

Tissue may be grouped together to form a functional unit called an organ. An organ consists of a number of different tissues, which combine to enable the organ to perform specific functions.

Plant Organs: Some organs present in plants a include leaf, stem, root, and flower.

Animal Organs : Some organs present in animals include heart, lungs, liver, and stomach.

(iii) Systems

Organs may be grouped together to form a system.

A system consists of several organs whose functions are coordinated.

Plant Systems : Some systems present in plants, include Root system, and Shoot system.

A. Plant Cells

The different types of cells found in the plant body include meristematic cells, epidermal cells, parenchyma cells, collenchyma cells, sclerenchyma cells, tracheid, vessel elements, sieve tube cells and companion cells.

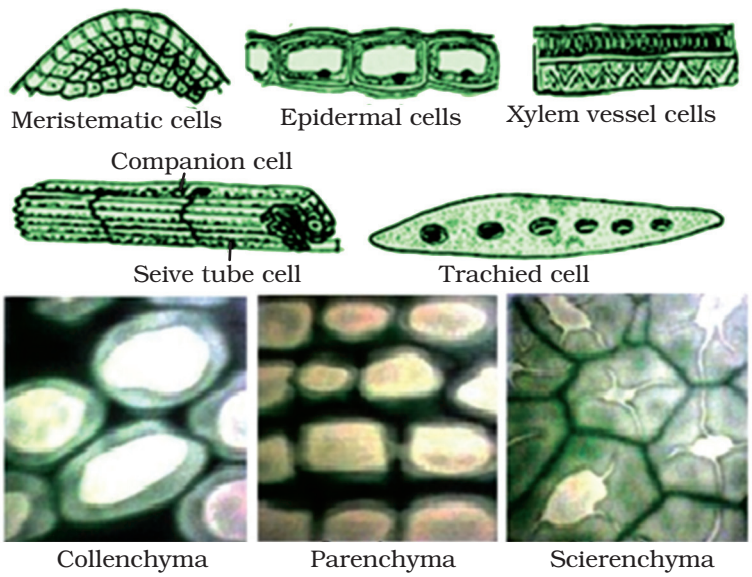


Figure 2. Plant cells

B. Animal Cells

The different types of cells found in the human body include skin cells, blood cells, muscle cells, nerve cells, sperm, and ova.

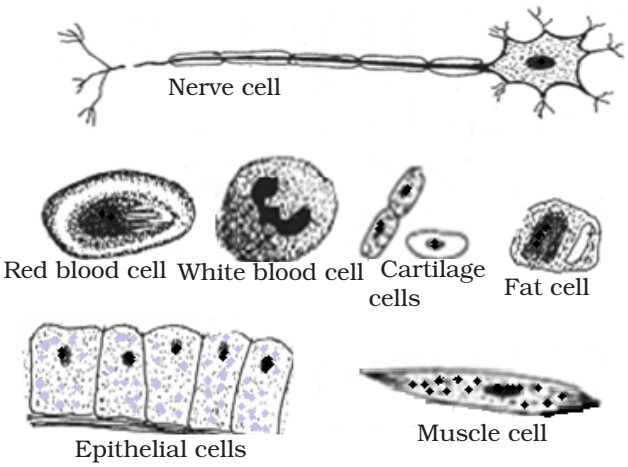


Figure 3. Animal cell types

Plant Tissues

Plant tissues are categorized broadly into the epidermal, photosynthetic tissue, conducting and strengthening tissue.

- Epidermal tissue : Cells forming the outer surface of the leaves and of the young plant body.
- Conducting tissue (Vascular tissue) : The primary components of vascular tissue, the xylem and phloem. These transport fluid and nutrients internally.

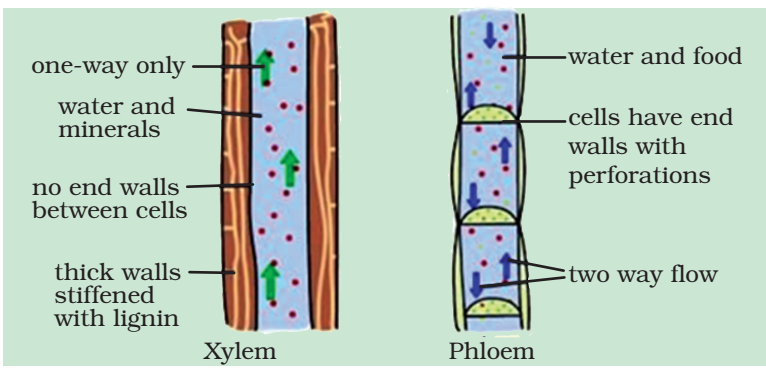


Figure 4. Vascular tissues of vascular plants

- Photosynthetic tissue (Ground tissue) : manufactures nutrients by photosynthesis and stores reserve nutrients.

Animal Tissues

There are four basic types of tissue in the body of all animals, including the human body.

Epithelial tissues are made up of cells that are tightly packed together. Different types of structures join the epithelial cells, together epithelial tissues are found primarily covering body surfaces and lining body cavities.

Connective tissues are made up of cells that are widely separated. Tendons, ligaments bones, cartilage, blood, and adipose are connective tissues.

Muscular tissues are designed for contraction and relaxation. Its function is to produce force and cause motion or movement within internal organs. Muscle tissue is separated into three distinct categories: visceral or smooth muscle, which is found in the inner linings of organs.

Skeletal muscle, which is found attached to bone in order for mobility to take place and cardiac muscle, which is found in the heart.

The Nervous tissue is found primarily in the brain, spinal cord, as well as in ganglia and other organs of the body. The major type of cell is called neuron. It is designed to receive and transmit nerve impulses Figure 5.

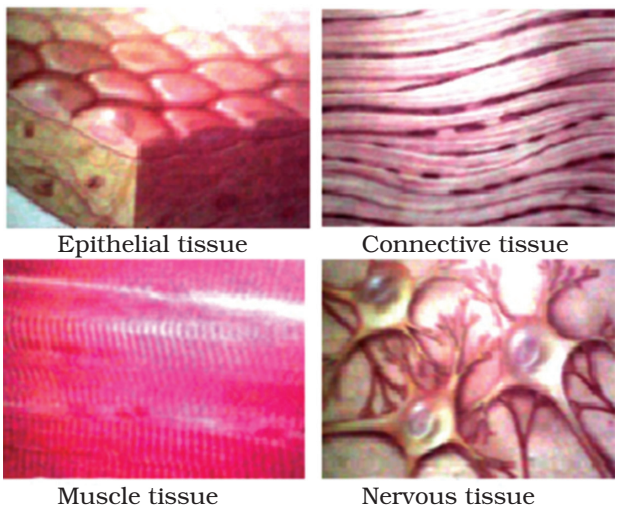


Figure 5. Some animal tissues

Table 1 The cell types, tissues & functions in animals

Tissue	Function
Epithelial	Protection, covering and for secretion.
Connective	Support, movement, connection, and fat storage
Muscle	Support, movement and work
Nervous	Receive, transfer and coordinate message.

Organs

Different tissues organized for one-function forms an organ. Organs are composed of more than one kind of tissue.

Plant organs : The major organs in plants are leaf, stem, root, and flower Figure 6.

(a) Root (b) Flower (c) Leaf

Figure 6. Plant organs

Animal Organs : Animals have several organs such as heart, stomach, intestine, lung, kidney, liver, eye, ear, and nose. (Figure 7)

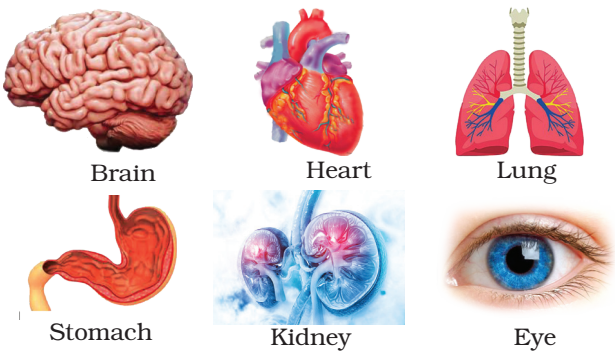


Figure 7. Some organs in humans

Organ Systems

Several organs organized to accomplish one function form an organ system

(i) Plant organ systems : The major organ systems in plants are vascular system, and shoot system. (Figure 8).

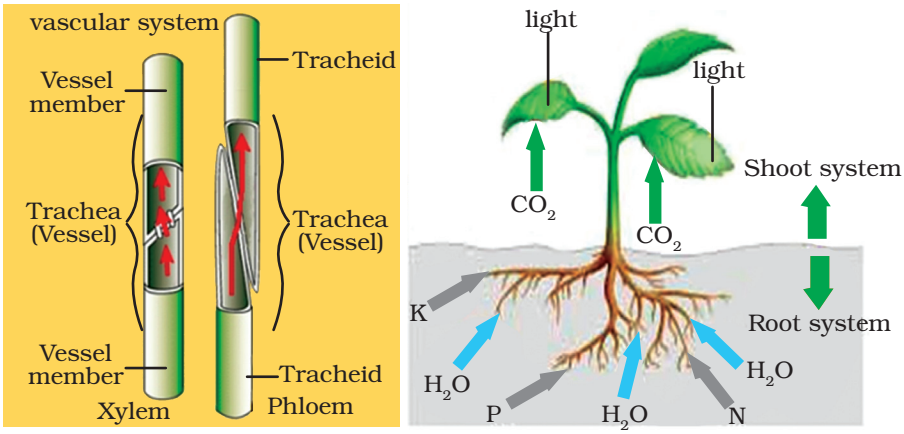


Figure 8. Plant organ systems

(ii) Human Organ Systems : The major systems in humans are digestive, circulatory, nervous, respiratory, reproductive, excretory, lymphatic, immune, endocrine, skeletal, muscular, etc. (Figure 9).

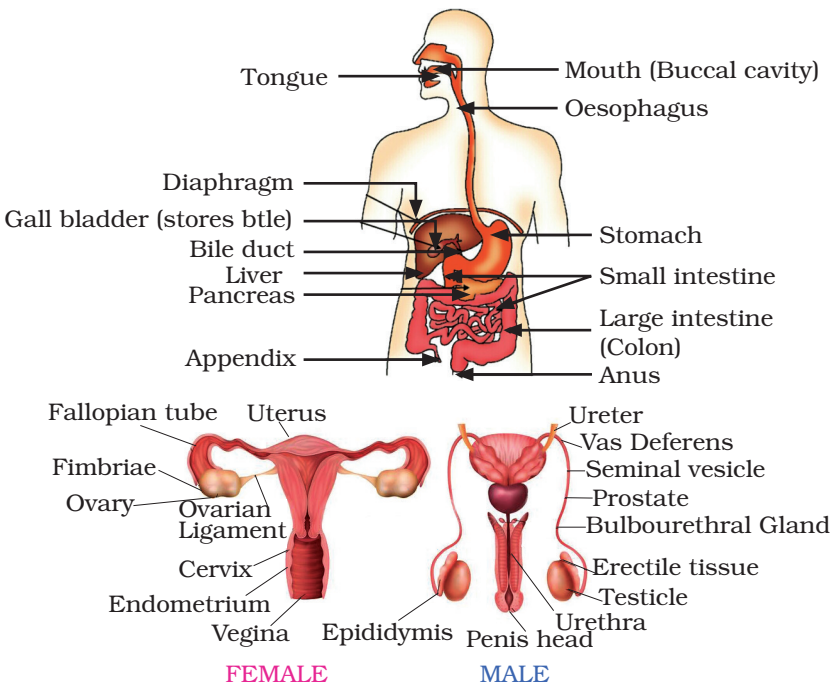


Figure 9. An example of organ systems: the organs making digestive system and the organs making male and female reproductive systems

Table 2 The organ systems in humans

System	Organs	Function
Circulatory	Heart, blood vessels, blood, lymph, and lymph structures	Transport cells and materials
Digestive	Stomach, small intestine, large intestine liver, pancreas & anus	Captures soluble nutrients from ingested food
Endocrine	Ductless glands	Coordinates and integrates the activities of the body
Urinary	Kidney, bladder, and associated ducts	Removes metabolic wastes from the blood stream
Nervous	Nerves, sense organs, brain, and spinal cord.	Receives stimuli, integrates information and directs the body
Reproductive	Ova & sperms	Carries out reproduction
Breathing	Lung and associated pathways	Capture oxygen and exchange gases
Skeletal	Bones, cartilage, and ligaments	Protects

3.2 General Characteristics

(a) Sponges

Habitat

All sponges are aquatic, mostly marine, rarely fresh water (e.g., Spongilla), solitary or colonial, sessile (attached to the substratum). Sponges like warmer water, they are not usually found in cold water.

Body Form

Their body is porous, viz., provided with pores. The pores are of two types: inhalant pores are called ostia (sing, ostium) and exhalent pores are known as oscula.

Symmetry

Most of the sponges are asymmetrical. Some are radially symmetrical.

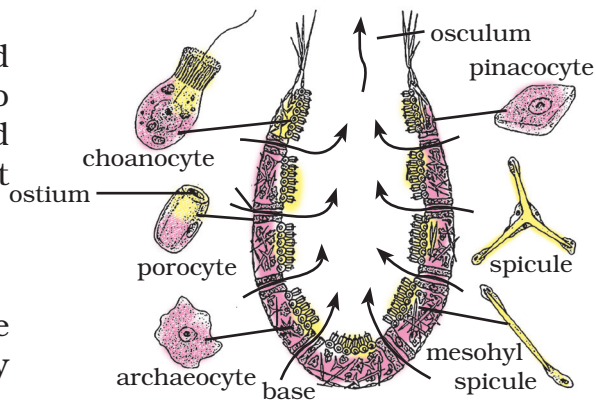


Figure 10. Longitudinal section of a sponge

Germ Layers

The sponges are the first multicellular diploblastic animals, i.e. derived only from two embryonic germ layers, viz., ectoderm and endoderm.

Level of Organization

The sponges have cellular level of organization.

Canal System

This system consists of pores and canals.

ACTIVITY 1

Draw a structure of sponge
Draw and label the structure of a sponge
State the functions of each labelled parts
Present the highlights to your class

The central body cavity of a sponge is called spongocoel or para gastric cavity. The continuous water current flowing through the canal system is very important for the life of a sponge. It brings in food and oxygen and carries away carbon dioxide, excretory matter and reproductive bodies. Thus the canal system helps the sponge in nutrition, respiration, excretion and reproduction.

Skeleton

Almost all sponges possess an internal skeleton. It may consist of calcareous or siliceous spicules or of fine spongin fibres or of both, located in the mesohyl layer.

Digestion

It is intracellular and takes place inside food vacuoles as in protozoans.

Circulation

Distribution of food from the ingesting cells to others is brought about by wandering amoebocytes of mesophyl layer.

Respiration

Exchange of gases occurs by diffusion through the plasma membranes of the cells as in protozoans.

Excretion

Removal of excretory matter also occurs by diffusion through the plasma membranes of the cells as in protozoans. Ammonia is chief excretory waste of sponges.

Reproduction

Both asexual and sexual reproductions occur in sponges. Asexual reproduction occurs by budding and gem mules. In fresh water and a few marine sponges, gem mules or internal buds are formed. Sponges are hermaphrodite. Fertilization is internal.

Unique Features

(i) Ostia and oscula present,
(ii) Presence of canal system and
(iii) Skeleton made up of spicules and spongin fibres.

ACTIVITY 2

Draw 3 different cell's of sponges
Draw three different cells a sponge
State the functions of each of the three cells
Then present to your class as interesting as possible

(b) *Hydra*

- Freshwater animals of the phylum Cnidaria and Class hydrozoa.
- Hydra has a tubular, radially symmetric body up to 10 mm.
- It has a simple adhesive foot called the basal disc.
- There are gland cells in the basal disc, that are responsible for adhesive properties.
- At the free end of the body is a mouth opening surrounded by one or few tentacles, each tentacle consists of specialized stinging cells called Cnidocytes.
- Cnidocytes contain specialized structures called Nematocysts.
- Nematocysts look like miniature light bulbs with coiled thread inside (Figure 11).

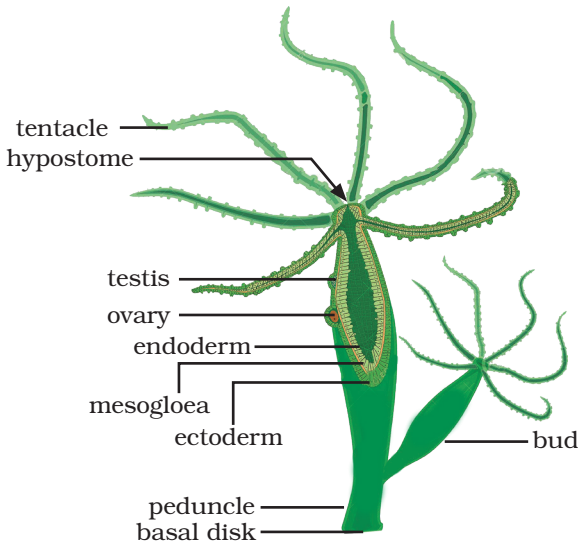


Figure 11. Structure of hydra

Activity 3

Drawing hydra

Draw and label the parts of hydra

State the functions of each labelled parts

Use this textbook, other books or internet as a resource

Make your presentation interesting to the class

Exercises

1. Which of the following is NOT true about sponges? They are
   (a) Aquatic
   (b) Sessile
   (c) Filter feeders
   (d) Motile
2. Which of the following is FALSE about *Hydra*?
   (a) They are predators
   (b) Move and trap prey by tentacles
   (c) Have both mouth and anus
   (d) They are aquatic and multicellular

3.3 Worms

(a) Flat worms Planarian

Flatworm Characteristics

- Flat bodies (gases move by diffusion)
- bilateral symmetry
- gastrovascular cavity
- some flatworms are parasitic, some are free living
- they have anterior and posterior heads and exhibit cephalization
- Planarian (also known as Dugesia) – lives in freshwater
- mostly a scavenger, also feeds on protists hermaphrodites
- has a simple brain (ganglia) and nervous system, plus 2 eyespots they can regenerate (regrow parts)

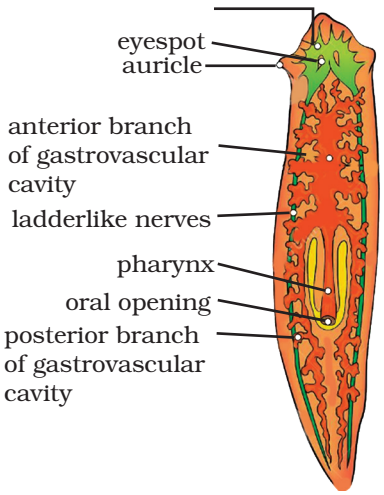


Figure 12. Planarian

Anatomy of the Planarian Characteristics

Brain (ganglia) – planarian can process information about their environment

Pharynx – used for suckling food in (the mouth is at the end of the pharynx)

Eyespot – simple eye, can detect light

Flame cells – located along the lateral edges, used for excretion

Intestine – digestion (does not have an anus)

Blood flukes: Adult worms have elongated tubular bodies, each male having a unique gynecophoral canal (schisto-soma = split body) in which a female worm resides. They live inside visceral blood vessels and are commonly known as blood flukes. They have digenetic life-cycles involving aquatic.

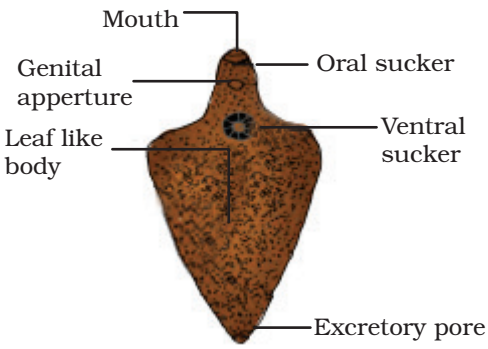


Figure 13. Liver fluke

Physical characteristics: Female human blood flukes are thin, cylindrical, and one-half to 1 inch (1.3 to 2.5 centimeters) long. Males are a little bit shorter and thicker. Males have small spiny suckers on the mouth and belly and a wrinkled back dotted with small bumps, snails as obligate intermediate hosts.

Liver fluke : The body of liver flukes is leaf-like and flattened. The body is covered with a tegument. They are hermaphrodites having complete sets of both male and female reproductive systems. They have simple digestive systems and primarily feed on blood.

Adults of *Fasciola hepatica* are large and broadly-flattened, measuring up to 30 mm long and 15 mm wide. The anterior end is cone-shaped, unlike the rounded anterior end of *Fasciolopsis buski.* Adults reside in the bile ducts of the liver in the definitive host (Figure 13).

Tape worms : The parasitic flatworms, such as tapeworms and liver flukes, are included within this large phylum. They are bilaterally symmetrical, triploblastic, they lack an anus, and they have no body cavity other than the gut.

(b) Parasitic Round Worms

Ascaris : *Ascaris lumbricoides* is also known as the common roundworm. The roundworms are different from the flatworms and tapeworms as they have cylindrical body, pseudocoelom and a complete digestive tract lined by endodermal epithelium.

Most of these roundworms are free living but some parasitic worms also exist. The species belonging to the genus *Ascaris* are large-sized and they inhabit in the intestines of the vertebrate hosts. Ascaris lumbricoides is the most common roundworm which is the gastro-intestine parasite of the man (Figure 14).

Ascaris body cavity : A spacious fluid filled cavity is present between the body wall and the visceral organs. The fluid filled cavity is called as pseudo coelom and it cannot be considered as the true coelom as,

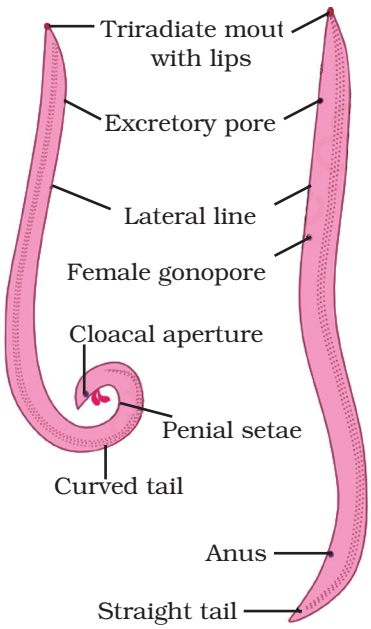


Figure 14. Adult male and female Ascaris

- It is not lined by the coelomic epithelium.
- It also has no relation with the reproductive and excretory organs.
- It is developed from the blastocoel.

The pseudocoelom of *Ascaris* consists of five giant mesenchymal cells also known as pseudocoelomocytes. From one of these cells numerous cytoplasmic strands extend out in the form of fenestrated membranes. These membranes form delicate layers over visceral organs and muscles of the body wall.

The pseudocoelom is filled with odorous protein rich fluid called pseudo coelomic fluid. This fluid helps in transportation of metabolites and also keeps the body expanded. Other constituents of this fluid are glucose, nitrogenous substances, sodium chloride and phosphate.

ACTIVITY 4

Explain the conditions for oral transmission of intestinal parasite

Work on with mixed groups

Each group is going to make a presentation to the class about the conditions of oral transmission of intestinal parasites to their host

Use this text book, other books and internet for your research

A. Hookworm

The two species that commonly infect humans have a similar morphology. A. duodenale worms are pale grey or slightly pink. The head is bent a little in relation to the rest of the body, forming a hook shape – hence the name. The hook is at the front end of the body. They have well-developed mouths with two pairs of teeth. Males measure approximately 10 by 0.5 mm, and females are often longer and stouter. Males also have a prominent copulatory bursa posteriorly (Figure 15).

Necator americanus is generally smaller than *Ancylostoma duodenale*, with males usually being 5 to 9 mm long and females about 10 mm long. Instead of the two pairs of *teeth in Ancylostoma duodenale, Necator americanus* has a pair of cutting plates in the buccal capsule. Also, the hook is much more defined in *Necator americanus*.

Physical Description

The worm is pinkish-white. Adult male hookworms range in size from 8-11 mm long, whereas adult females range in size from 10-13 mm long. This species is dimorphic, with the males having bursa characteristics and needle-like spicules with small tips, which are distally fused.

Figure 15. Hook worm

ACTIVITY 5

Out lining the methods of prevention of intestinal parasites.

Go to clinical laboratories, contact public health professional

Outline the effects of intestinal parasite

Outline the causes, common symptoms of intestinal parasites

Outline the different methods of prevention, i.e. how to take preventive measures.

Use this textbook, other books and internet for your research

Write a report

B. Filarial Worms

The filariae are thread-like parasitic nematodes (roundworms) that are transmitted by arthropod vectors. The adult worms inhabit specific tissues where they mate and produce microfilariae, the characteristic tiny, thread-like larvae. The microfilariae infect vector arthropods, in which they mature to infective larvae.

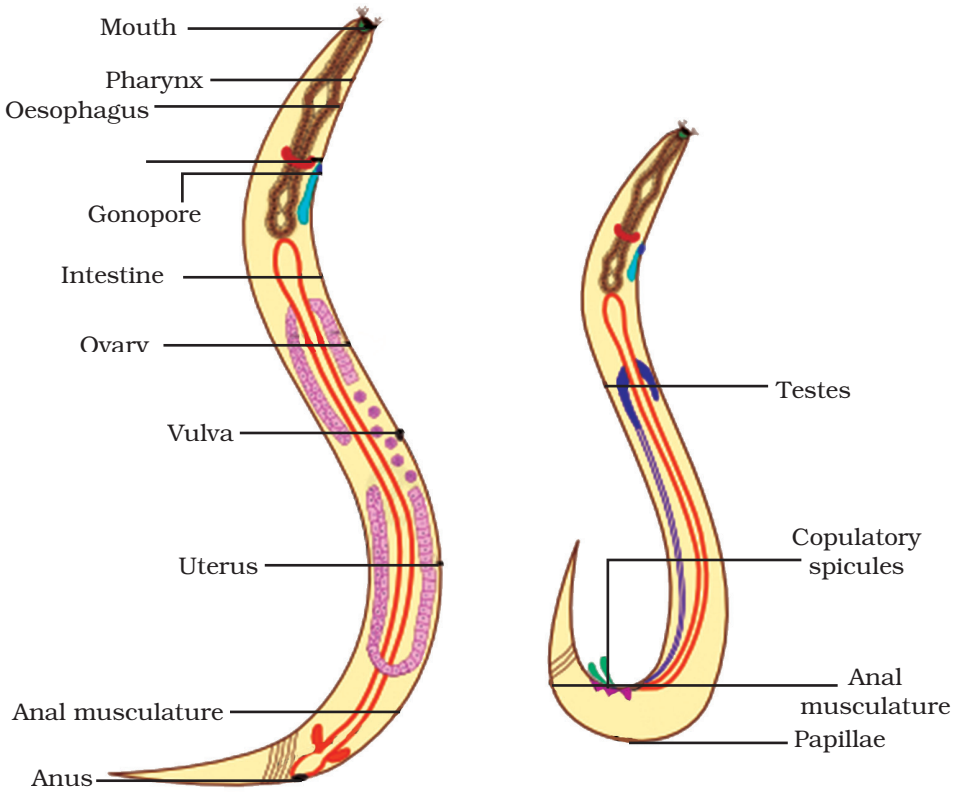


Figure 16. Filarial worms

ACTIVITY 6

Observing and drawing the structures of each of the worms listed below

Filarial worm
Tape worm
Hook worm
Round worm
Observe each of the worms critically.
Draw and label the pars of each worm

C. Segmented Worms

Earth worm

An earthworm's body is streamlined and every segment contains a number of bristles called setae. The streamlined shape helps the

earthworm travel through soil, and the bristles improve grip if the soil is wet. Circular muscles surround every segment of an earthworm's body. These muscles work alongside another group of muscles running down its entire body to help the earthworm move. To feed itself, an earthworm pushes its pharynx out of its mouth to grab its food, then takes the food back into its mouth and wets it with saliva (Figure 17).

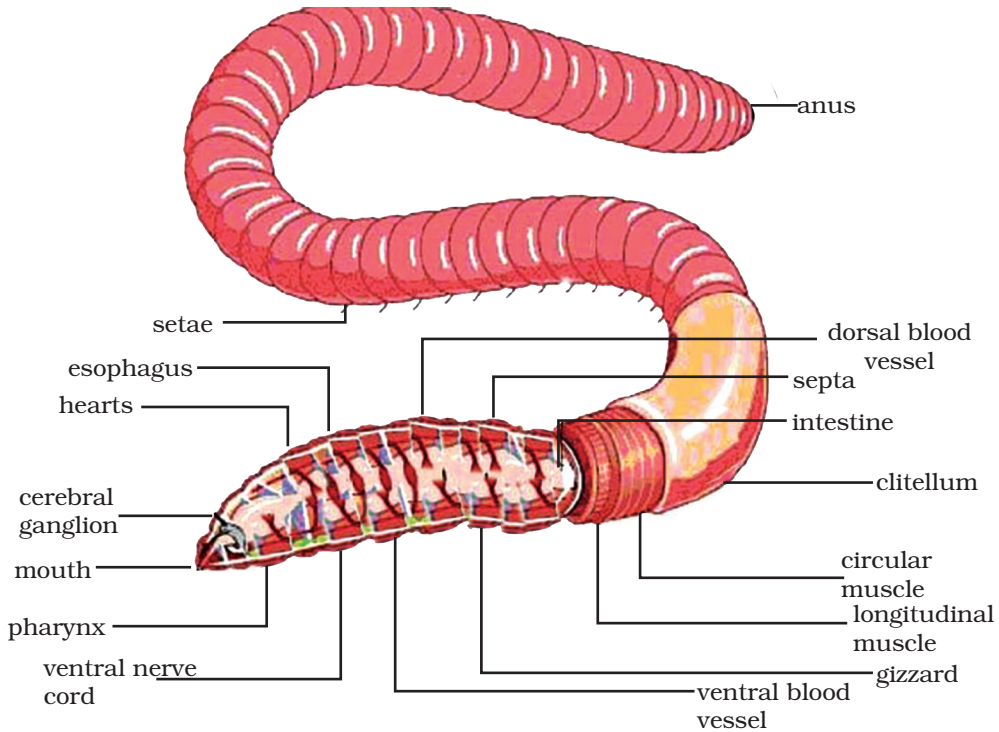


Figure 17. Earth worm

Physiological Characteristics

Some earthworm characteristics have evolved to help it regulate its bodily functions, like breathing, and protect itself, such as by excreting chemicals.

Many earthworms, release mucus to help them move more smoothly through soil. Some species of earthworm burrow, and their mucus creates a binding substance to stop the walls of their burrow caving in.

Behavioral Characteristics

An earthworm can't see or hear, but it is sensitive to vibration and light. Most species stay in soil, burrows or piles of leaves during daylight and on the surface of the ground during the night and early morning. An earthworm absorbs and loses moisture through its skin and migrates or reproduces when the ground is wet with dew.

An earthworm can live under submerged conditions, if the oxygen content of the water is high enough, but it moves to the surface to avoid suffocation when soil is extremely wet.

An earthworm is a hermaphrodite, meaning it has both female and male reproductive systems. Mating earthworms exchange sperm by lying side by side.

Activity 7

Dissecting an earthworm and identifying an external and internal features of an earthworm

You need:

Safety goggles, dissecting pins, gloves, forceps, lab safety apron, scissors, paper towel, scalpel, water, dissecting prob, preserved earthworm, hand lens, dissecting tray

Method

1. Put on safety goggles, gloves and a lab apron
2. Place earthworm in the dissecting tray with its dorsal side face up
   - Use dissecting pin to secure each end on the tray
   - Lift up the skin with a pair of forceps and snip an opening with a pair of dissecting scissors
3. Use a hand lens as you observe all parts of the worm, externally and internally
4. Locate the clitellum, which extends from segment 33 to segment 37
5. Using the forceps and dissecting pins, carefully pull apart the two flaps of skin and pin them flat on the tray.
6. Finish cutting the rest of worm open from the first incision through to the anus.
7. Refer again to the diagram of the ventral view of the worm to locate and identify the external parts of its reproductive system.
   - Find out the reproductive organs, crop gizzard, intestine and hearts
   - Draw and label the external and internal structures of the worm

Leeches

The classification characteristics of leeches are-The body of leeches is formed with several ring-like structures. The excretion organ is nephridia. Leeches have a closed circulatory system. Leeches have real silom covered with mesoderm. The nervous system is formed with a pair of cerebral ganglia and two axial nerves.

Habitation: Leeches live in the land mainly. They can also be found in the water.

Figure 18. Leech

Food : Leech is a segmented parasitic animal. It survives on the blood of other animals such as mammals, fishes, frogs, etc. leech eats small animals, worms, snails, etc. Generally, the food is dependent on the type of leech.

Structure: Leeches have a body formed with several ring-like structures. They have a total of 34 segments in their body. They have one to four pairs of eyes in the anterior end. Leeches have two suckers in the front end and the back end. The posterior sucker helps to attach to the host and the anterior sucker helps to suck blood. The entire volume of the body becomes large after sucking the host's blood (Figure 18).

Exercise

Choose the correct answer from the alternates provided.

1. Which of the following flat worms is non-parasitic?
   (a) Tape worm
   (b) Liver fluke
   (c) Planaria
   (d) Bllod fluke
2. Which of the following round worm cause Elephantiasis?
   (a) *Ascaris*
   (b) *Filaria*
   (c) *Trichina*
   (d) *Hook worm*
3. Which of the following is NOT the feature of segmented worms?
   (a) All are parasitic
   (b) Have circulatory system
   (c) Have developed digestive system
   (d) Have nervous system
4. Which of the following is TRUE about worms?
   (a) All have well developed digestive system
   (b) All are multicellular and invertebrates
   (c) All have proper movement organs
   (d) All of the above

3.4 Human reproductive structures

The human reproductive organs:

- produce reproductive cells within gonads.
- male gonads produce sperm cells.
- female gonads produce egg cells.

When these sperm cells and egg cells unite together during sexual intercourse they produce offspring.

A. The male reproductive organs and the functions of the male reproductive structures.

The human male reproductive system (Figure 19) consists of the:

- testes
- penis,

- vas deferens,
- scrotum,
- urethra,
- prostate glands,
- seminal vesicles, and
- Cowper's glands.

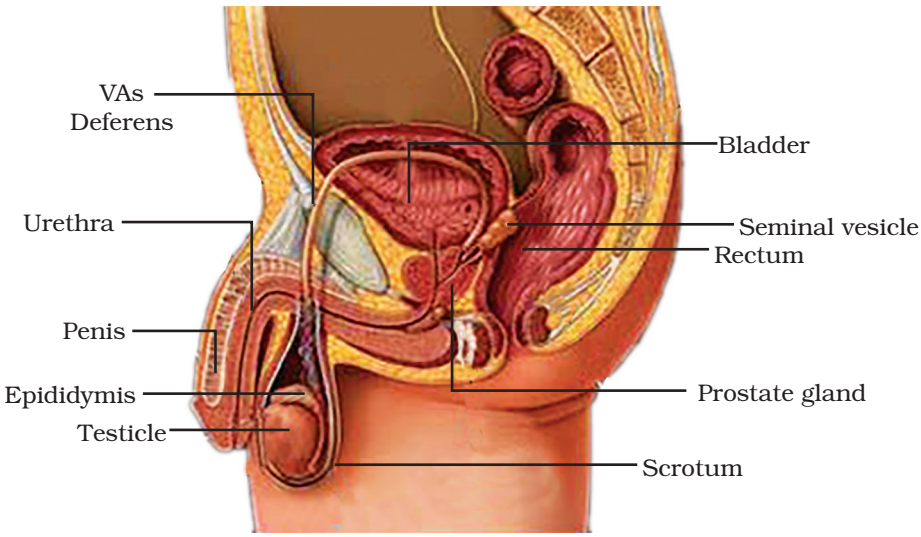


Figure 19. The human male reproductive system

Testes

- They are made up of seminiferous tubules lined with germinal epithelium cells.
- Produce sperm cells.
- Produce the sex hormone, testosterone to maintain secondary sexual characteristics.
- Are stimulated by follicle stimulating hormone coming from the pituitary gland.

Penis

- It is an erectile cylindrical organ for sexual intercourse
- Ejaculates semen (sperm cells with fluid).

Scrotum

- A sac-like structure on the lower end of the penis.
- Ventilates the testes to have lower temperature for maturation of sperm cells.

Epididymis

- It is a coiled tubule.
- Situated at the outside surface of each testis.
- Stores sperm cells for maturation.

Vas Deferens

- It is a long tube from epididymis to the urethra.
- Transports sperm cells mixed with a fluid as semen.

Prostate Glands

- Are small glands at the base of the urinary bladder.
- Produce alkaline fluid for sperm cells' motility through the vagina.

Seminal Vesicle

- Are glands.
- Produce nutritious substance to feed sperm cells for its mobility.

Cowper's Gland

- Very small gland below the prostate.
- Secretes mucus to lubricate the end of penis and urethra.

Urethra

- It is a tube inside the penis.
- Discharges sperm cells as semen during sexual intercourse.
- Passes out urine during urination.

Table 3 Parts of the male reproductive system and their functions

Reproductive part	Function
Testes	Produces sperm cells and sex hormone

Penis	Ejaculation of semen into the vagina
Scrotum	A sac-like structure that encloses the testes
Epididymis	A coiled tube on the testis to store sperm cells
Vas deferens	A long tube to transport semen

B. The Female Reproductive Structures

The human Female Reproductive system consists of ovaries, vagina, uterus, fallopian tube, cervix, vulva and clitoris.

The female internal reproductive organs are the vagina, uterus, fallopian tubes, and ovaries.

Vagina

The vagina is a fibromuscular canal leading from the outside of the body to the cervix of the uterus or womb. It is also referred to as the birth canal in the context of pregnancy. The vagina accommodates the male penis during sexual intercourse.

Cervix

The cervix is the neck of the uterus, the lower, narrow portion where it joins with the upper part of the vagina. It is cylindrical or conical in shape and protrudes through the upper anterior vaginal wall (Figure 20).

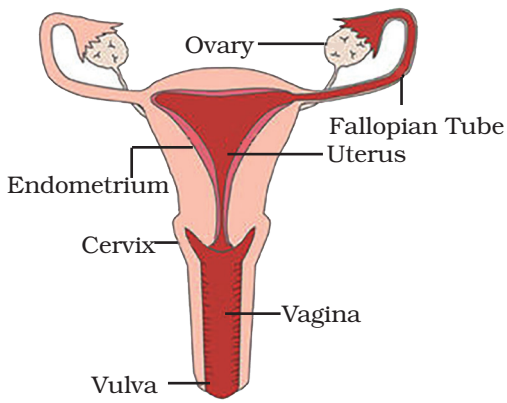


Figure 20. The female reproductive system

Uterus

The uterus or womb is the major female reproductive organ. It is a wide muscular tube for implantation of the fertilized egg cell. The uterus provides mechanical protection, nutritional support, and waste removal for the developing embryo and fetus. In addition, contractions in the muscular wall of the uterus are important in pushing out the fetus at the time of birth.

Fallopian Tube (Ovary Duct)

The Fallopian tubes are two tubes leading from the ovaries into the uterus. On maturity of an ovum, the follicle and the ovary's wall rupture, allowing the ovum to escape and enter the Fallopian tube. Fertilization takes place in the fallopian tube.

Ovaries

The ovaries are small, paired organs located near the lateral walls of the pelvic cavity. These organs are responsible for the production of the egg cells (ova) and the secretion of hormones (estrogen and progesterone). The process by which the egg cell (ovum) is released is called ovulation. The speed of ovulation is periodic and impacts directly to the length of a menstrual cycle.

Clitoris:

- An erectile and sensitive tissue, like a penis.
- Is found in the upper front part of the vagina.

Vulva:

- the external genital of the female reproductive system.
- Contains labia major and **labia minor**.

Myths about Human Reproduction

(a) Phases of moon affect menstruation

(b) It is hard to envision how a moon - menstruation connection would be biologically beneficial to human reproduction.

(c) Reproductive hominess need to be in balance. This is a common modern myth in gynecology.

(d) Lying prone after sex increases chances of becoming pregnant.

(e) How low should a woman lie flat after sex?

(f) Woman were never meant to through menopause.

(g) The female orgasm can't just be for pleasure - it must be related to improving the chance of pregnancy.

(h) The human papilloma virus vaccine is associated with premature Ovarian failure.

(i) Men stay fertile forever.

Various Stages of Human Life

Human life cycle is the cycle that occurs in human beings and involves a time period for different stages of life. The major six stages of the human life cycle are known that starts with the prenatal stage where fertilisation takes place and foetal development occurs inside a mother and then ends with the death of human beings. Therefore, old age is the final stage of the life cycle and death is the end of the human life cycle. The Human Life Cycle consists of various stages that include foetus, baby, childhood, adolescence, adulthood and elderly; these are discussed in detail as follows:

Stage 1: Fetus- It is a creation called zygote with the fusion of an egg from the mother and a sperm from the father. Zygote looks like a bundle of cells that divides rapidly and turns into an embryo, after about 2-4 weeks inside the mother's womb. It takes about 8 weeks for the embryo to turn into a human body shape and it is called the fetus.

Stage 2: Baby- After nine months in the mother's womb, a baby is born. Babies under 1 year of age are called infants and are fed on mother's milk. Newborn babies are able to suck, breathe, swallow and cry when they feel hungry/cold/hot or any other uncomfortable situation. This is the way of expressing themselves as they cannot talk at this stage.

Stage 3: Childhood- This among the various stages of human life can be divided into 3 substages, namely.

Toddler: It is a child who is a grown-up baby and is between the ages of 1-3 years. Here, a child slowly learns crawling, walking, talking, running, jumping, identifying things and eating by themselves.

Pre-schooler: It is a child who is between the ages of 3-5 years. At this sub-stage of childhood, the child can communicate properly, read, write, make friends and indulge in various childhood activities.

Primary School Kid: It is a child who is between the ages of 5-12 years. At this stage, a child or primary schooler has developed good muscle control and coordination, eye-hand coordination, personal habits, thinking patterns, awareness of safety issues and personal habits and choices.

Stage 4: Adolescence—In this human life cycle stage, a child grows into an adolescent through puberty period. Puberty is the process of physical changes where a child's body matures into an adult body that

is capable of sexual reproduction. It starts from the age of 13 years and continues up to 19 years of age. Adolescents are also called teenagers as they belong to thirteen to nineteen years of age range. Many hormonal changes in the body take place that appear externally too. Some of the changes taking place in boys and girls include turning taller, heavier and stronger, getting hair under arms, on arms and legs and around genitals, oily skin and more sweating. Boys' specific changes are deep and rough voice, hair on face, broader chests, shoulders and muscles and girls' specific changes include development of breasts, bigger hips and start of menstruation cycle. It is considered that the adolescence stage is difficult to manage for parents as there are behavioral and attitudinal changes in teenagers and they find more comfortable in being independent in their day-to-day activities.

Stage 5: Adulthood—This stage comprises people who fall in the range of ages between 20-65 years and they are called adults. This is the right age for the process of reproduction and making babies. Adults can be young adults i.e. 20-36 years, middle-aged adults i.e. 36-55 years and older adults i.e. 55-65 years.

Stage 6: Elderly—A person who reaches 65 years of age generally belongs to the elderly group. The average life expectancy of a person can range from 70-85 years. It also depends on the overall health and fitness of a person. The healthier a person is, their life expectancy is more.

Menstruation

Menstruation and Prgenancy

Is the monthly bleeding, takes place in an adult woman reproductive system.

Occurs normally from the **early teenage** (12 - 15) until **menopause**, around age 50.

- Does not takes place during pregnancy.
- Is counted from the first day of one period to the first day of the next period.
- On average 28 days long.
- Involves ovulation and menstruation.

Ovulation

- Is the movement of an egg cell from the ovary to the oviduct.
- Occurs at about the 14th day of the beginning of menstruation.

Menstruation

- Is a flow of blood from the uterus through the cervix and the vagina.
- Is shedding of the thickened uterine wall blood vessels.
- Mostly lasts from 3-5 days.

What happens during the menstrual cycle?

During menstrual period:

Usually by Day 7

- bleeding stops.

Around Day 14

- Hormones cause the mature follicle to burst and release an egg cell or result in ovulation

Between Day 7 and 14:

- One follicle will continue to develop and reach maturity.
- The wall of the uterus starts to thicken, waiting for a fertilized egg cell to implant.
- The uterine wall is rich in blood and nutrients.

Over the next few days, the egg travels down the fallopian tube towards the uterus. When a sperm cell, unites with the egg cell, fertilization takes place in the fallopian tube. Then, the fertilized egg cell will continue moving down the fallopian tube and attach to the wall of the uterus.

- If the egg is not fertilized, hormone levels will drop around day 25.
- The egg will break apart and be shed with the uterus. Then the extra blood leaves through the vagina that indicates the next menstrual cycle to begin.

A. Phases of the Menstrual Cycle

The menstrual phase

- is characterized by the breaking down of the wall of the uterus.
- is the loss of blood through the vagina.
- lasts 3 to 5 days.

The proliferative phase

- Is mainly characterized by the release of egg from the ovary (ovulation).
  - Usually happens after 9-10 days of the last days of menstruation.

The secretory phase

- Happens from the 14th to 28th day of the beginning of menstruation day.

At about the 28th day, the level of progesterone drops and the wall of the uterus starts breaking down and the menstrual phase begins.

- The average length of the menstrual cycle is about 28 days.
- The menstruation or the period of bleeding which usually lasts in about 4 days.
- Menstruation is followed by the critical period {about 10 days}, and then by the safe period (about 14 days).

The chance of pregnancy is

- high if there is sexual intercourse within the critical period i.e. 10-18 days form the beginning of menstruation.
- low in menstrual and safe periods.

Therefore, limiting sexual intercourse to the safe period minimizes the chance of unwanted pregnancy.

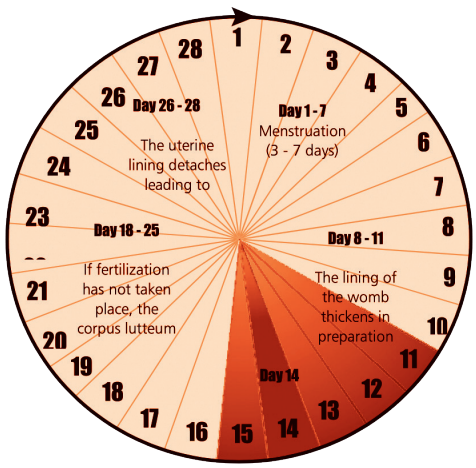


Figure 21. The menstrual cycle

B. Fertilization

Is the union of male sex cell or sperm and a female sex cell or egg.

- Takes place in the fallopian tube if there is sexual intercourse during ovulation.

During fertilization

- A single sperm cell fuses with the egg cell and penetrates its wall.
- Sperm cell combines its nucleus with the nucleus of the egg cell.
- Fusion of the two nuclei forms zygote.
- the fertilized ovum in the fallopian tube finds its way to the uterus for attachment.

After fertilization

- The ovary keeps on producing progesterone for the first 3-4 months of pregnancy.
- Placenta starts producing additional progesterone until the birth of the child to avoid overlapping of pregnancy.

Menstrual Hygiene

Menstruation is a biological process in adolescent girls and premenopausal women, whereas menstrual health and hygiene are the social, political and economic factors that allow them to safety manage this biological process so that it has as little impact on their life as possible. Menstrual hygiene management is defined as women and adolescent girls using a clean menstrual management material to absorb or collect blood that can be changed in privacy as often necessary for the duration of menstrual period.

Menstrual hygiene management is comprised of

Access to menstrual products

Access to soap and water.

Access to safe menstrual disposal.

Access to education about menstration.

C. Pregnancy and sexualy transmitted diseases prevention

Pregnacy follows fertilization for the development of the implanted embryo into foetus and it occurs in the uterus.

During prgnancy additional progesterone horme one is produced by placenta for the formation of more blood vessels can control the development of the embryo. Besides progesterone inhibits ovulation to avoid overlapping of pregnancy.

In addition to placenta a tissue called umblical cord is formed to exchnge materials between the mother and the foetus through blood by diffusion.

The foetus is suspended in the uterus in the amniotic fluid surrounded by amniotic membrane. At the end of pregnancy the amniotic membrane breaks by which the embryo is enforced to leave the uteurs by the aaction of labour as a cosequence of strong uterus contraction caused by oxytocin hormone, these events result child birth or parturition.

STIs Prevention

STIs are transmitted due to mixed sexual behaviour. Therefore , it is advisable to prevent oneself from these STI by avoiding risky sexual behaviour and practicing

- Abstinennce or avoiding sexual intercourse
- Wearing condoms during sexual intercourse
- Avoid risky sexual behaviours such as commiting sexual intercourse with drug users including alcohol and forced sex without condom.

If risky sexual behaviours are not challenged they lead to exposure to STI that affect reproductive health and not treated cause infertilty and birth to deformed babies.

Birth Control Methods

Birth control methods are methods used to prevent fertilization by avoiding the union of an egg cell and sperm cell.

The most effective method of avoiding fertilization for youngsters like young generation is abstinence from sexual intercourse.

In addition to avoiding sexual intercourse, there are a number of methods used to control birth. These methods include:

- Natural methods (rhythm methods, allow sexual intercourse to safe period) and (coitus interrupts avoids ejaculation into vagina).

- Barrier methods (male and female condoms, diaphragm, and IUD),block union of sperm cell and egg cell.
- Hormonal methods (oral pills, injections implantable), prevent ovulation.
- Permanent birth control methods (tubal ligation and vasectomy) prevent ejaculation and ovulation.

Contraceptive Pills

- Are tablets, taken orally by a woman for 21 days between menstruation to
- Avoid fertilization.
- Contain progesterone that prevents ovulation.

In the absence of ovulation the egg will not be produced and reach fallopian tube. Therefore, no chance of fertilization even if there is sexual intercourse.

Condom

- A thin rubber tube used by a man.
- Is used to collect and avoid sperm cells entry into the female reproductive system though there is sexual intercourse.

ACTIVITY 8

Using visual aids to demonstrate natural family planning methods

(a) From group of 4-5 students using visual aids to demonstrate the challenges of family planning method.
- Demonstrate why girls can't use this method.
- Demonstrate why this method of prevention can't prevent STI and HIV

(b) In your demonstration encourage girls to consider double protection.

Use this textbook, other books, internet and movies as a resource

Abstinence

Abstinence is simply not having sexual intercourse. If you're abstinent, it means you've decided not to have sex-this includes vaginal, oral and anal sex.

Abstinence prevents pregnancy by not giving the opportunity for semen to enter the vagina. A sperm can't fertilize an egg if you don't have vaginal intercourse.

Practicing Abstinence

Abstinence is the safest way to avoid getting an STI or HIV.

To practice abstinence effectively and consistently you need to:

- Set your own limits and feel good about your decision.
- Believe that having sex is not something to do, because everyone is doing it.
- Want to uphold your personal, religious or moral beliefs.
- Accept that you can enjoy intimacy in a variety of other ways.

Effectiveness: Abstinence is the only form of birth control that is 100% effective in preventing pregnancy. Practicing abstinence ensures that a woman won't become pregnant because there's no opportunity for a sperm to fertilize an egg.

Exercise

1. What are the part of he human male and female reproductive organs reponsible for gamete and sex hormones production?
   (a) Penis and vagina
   (b) Scrotum and oviduct
   (c) Testes and ovaries
   (d) Urethra and Uterus
2. The part of the human female reproductive organ where fertilizations occurs is _____.
   (a) Fallopian tube
   (b) Cervix
   (c) Womb
   (d) Clitoris
3. The period of which a human female experience menstrual cycle? During
   (a) Pregnancy
   (b) Menopause
   (c) Senescence
   (d) Adolescence
4. Which of the following are the precondtions for pregnancy?
   (a) Sexual intercourse
   (b) Ovulation

(c) Fertilization
(d) All of the above

5. What is the structure that allow exchnge of materials between the foetus and the mother during pregnancy?
   (a) Placenta
   (b) Umblical cord
   (c) Amnitic membrane
   (d) Amniotic fluid
6. Which of the following are means of preventing STIs and unwanted pregnancy?
   (a) Abstinence
   (b) Wearing condom
   (c) Avoiding risky sexual behaviour
   (d) All of the above
7. The role of contraceptive methods are:
   (a) Prevention of STIs
   (b) Avoiding pregnancy
   (c) Limiting number of children per family
   (d) All of the above

3.5 Substance abuse and Sexual Desire

It is a common misconception that substance abuse can enhance sexual desire and function. While this might be true on occasion, the effects wear off quickly and often result in decreased interest in sexual activity. Although alcohol is the number one drug responsible for damaging sexual performance, drugs such as cocaine, heroin, marijuana, and more can also have a detrimental effect. Substance abuse can also make it physically difficult to have sex. A male might become incapable of sustaining an erection, and males and females may find that they are unable to achieve orgasm.

Scientifically, a drug is any substance, other than food, that is taken to change the way the body or the mind functions. In other words, a drug is any chemical that, when it enters the body, affects the way the body works. Alcohol, caffeine, nicotine, and medications are all drugs. A drug must be able to pass from the body into the brain. Drugs change the messages to brain cells send to each other and to the rest of the body. They do this by interfering with the brain's own chemical signals: neurotransmitters.

Drug abuse or substance abuse refers to the use of certain chemicals for the purpose of creating pleasurable effects on the brain. Substance abuse is the medical term used to describe a pattern of using a substance (drug) that causes significant problems or distress. Substance abuse, as a recognized medical brain disorder, refers to the abuse of illegal substances, such as marijuana, heroin, cocaine, or methamphetamine.

Substances frequently abused include

- Alcohol
- Marijuana
- Prescription medicines, such as pain pills, stimulants, or anxiety pills
- Methamphetamine
- Cocaine
- Opiates
- Hallucinogens
- Inhalants

Drugs may be categorized or classified according to certain shared symptomatologies or effects. The Drug Recognition Experts (DRE) categorization process is premised on these long-standing, medically accepted facts. DREs classify drugs in one of seven categories: central nervous system (CNS) depressants, CNS stimulants, hallucinogens, dissociative anesthetics, narcotic analgesics, inhalants, and cannabis. Drugs from each of these categories can affect a person's central nervous system.

Classifying Drugs and Substances Abused

People can abuse any substance, medication, compound, or drug that induces either altered states of consciousness, euphoria, or both. Most of this abuse can lead to severe withdrawal, which needs a medically managed detox if the individual wants to stop. The many types of drug abuse cover the entire spectrum of compounds.

(i) Alcohol: The Most Common Type of Drug Abuse

Alcohol generates short-term euphoria and sedation. Perhaps the most widely abused substance available. Prolonged Abuse induces severe physical handicaps, liver damage, and, eventually, mental

health deterioration. Alcohol can act as a hypnotic sedative. It works by depressing the central nervous system. Alcohol slows down bodily functions such as heart rate, blood pressure, and breathing. Alcohol generates a variety of effects that run the gamut from minor sedation to complete anesthesia. Due to high amounts of sugar in most beverages, a dangerous combination of mild stimulant and powerful depressant is created. Signs of alcohol abuse include slurred speech, impaired motor functioning, impaired judgment, staggering behaviors.

(ii) Narcotics

Narcotics derive from the Greek word for benumb (Narko). Medically it refers to a type of drug abuse that induced sleep or have analgesic, pain-killing properties. Today, people associate the term with drugs that fall into the classification of Opiates, such as Morphine, Heroin, and their analogs like Hydrocodone (Vicodin). However, the legal definition of Narcotics differs from the medical definition. Thus, the two different classifications consequently cover a broad range of psychoactive compounds and drugs. The first type of drug abuse people truly deemed a Narcotic was liquor. Its use goes back to ancient times. The side effects of Narcotics intoxication include:

- Drowsiness
- Difficulty concentrating
- Sense of apathy
- Decreased physical activity
- Constriction of the pupils
- Flushing of the face and neck
- Constipation
- Nausea and vomiting
- Respiratory depression

(iii) Opioids/Opiates

While the intended purpose of opioids and opiates is to dull or relieve extreme pain, its ability to create feelings of euphoria makes it one of the most commonly abused drugs. Opioids and opiates trick the brain into producing higher amounts of chemical neurotransmitters. The increase in chemical neurotransmitters causes a person to experience the “high” sensation that is so addicting.

it has long been known for that opioids – legal painkillers like OxyContin or Vicodin and illicit street heroin – can inhibit sexual behavior. Opioids can also:

- Lower testosterone levels
- Cause decreased libido
- Create orgasm difficulties in both sexes

At levels of abuse, the likelihood of sexual dysfunction increases dramatically. Long-term heroin use results in sexual dysfunction across all clinical domains:

- Erectile function
- Orgasmic function
- Sexual desire
- Intercourse satisfaction
- Overall satisfaction

Abuse of opioids can affect your sex life in a number of damaging ways. Long-term use of opioids can affect sex hormones in the brain by releasing the gonadotropin-releasing hormone (GnRH) in excess.
Some examples of opioids/opiates include:

- Fentanyl
- Hydrocodone
- Heroin
- Morphine
- Oxycodone
- Opioids/opiates can be taken in a variety of ways including through an inhaler, oral pills, injections and patches

What are the Effects of Drug Abuse?

Substance use disorders are associated with a wide range of short- and long-term health effects. They can vary depending on the type of drug, how much and how often it's taken and the person's general health.

A. Short-term Effects

Abusing a drug, or misusing a prescription medication, can produce other short-term effects, such as:

- Changes in appetite
- Sleeplessness or insomnia
- Increased heart rate
- Slurred speech
- Changes in cognitive ability
- A temporary sense of euphoria
- Loss of coordination

B. Long-term Effects

Drug abuse, especially over an extended period, can have numerous long-term health effects. At the chronic stage it can alter a person's brain structure and function, resulting in long-term psychological effects, such as:

- Depression
- Anxiety
- Panic disorders
- Increased aggression
- Paranoia
- Hallucinations

Long-term drug use can also affect a person's memory, learning, and concentration. The long-term physical effects of drug use vary depending on the type of drug and the duration of use.

Ways of Preventing Drugs Abuse

While there is no one way or guaranteed way to prevent someone from abusing drugs and alcohol, there are things that everyone can do to prevent substance abuse.

Here are the top five ways to prevent substance abuse:

1. Understand how substance abuse develops. Substance abuse starts by:
   - Using addictive drugs (illicit or prescribed) for recreational purposes.
   - Seeking out intoxication every time you use.
   - Abusing prescription medication.

2. Avoid temptation and peer pressure. Develop healthy friendships and relationships by avoiding friends or family members, who pressure you to use substances. It's often said "we become most like those we surround ourselves by," meaning if you surround yourself with people who abuse drugs and alcohol you are more likely to as well.
3. Seek help for mental illness. Mental illness and substance abuse often go hand in hand. If you are dealing with a mental illness such as anxiety, depression or post-traumatic stress disorder you should seek professional help from a licensed therapist or counselor.
4. Examine the risk factors. Look at your family history of mental illness and addiction, several studies have shown that this disease tends to run in the family, but can be prevented. The more you are aware of your biological, environmental and physical risk factors the more likely you are to overcome them.
5. Keep a well-balanced life. People often turn to drugs and alcohol when something in their life is missing or not working. Practicing stress management skills can help you overcome these life stressors and will help you live a balanced and healthy life. Develop goals and dreams for your future. These will help you focus on what you want and help you realize that drugs and alcohol will simply get in the way and hinder you from achieving your goals.

Activity 9

Drama

Prepare a drama that a female refusing to have sex due to her unsafe period of the menstrual cycle.

Demonstrate how you care for a girl during menstruation

Case study - What influences sexual desire

I like kissing my partner. We have been dating for a year, and we were very close. His parents work, so his house is empty after school. We went to his house and we were sitting on his bed, kissing. Things felt good for a while, and then he started to want to do more, and I did not want to. He told me I owed him for letting me kiss him for so long. I tried to say no, but he is bigger than me. At some point I just kind of froze. I did not know what to do or why he was acting this way. He raped me. I cannot believe he did it. I love him. I thought he would come to his senses and stop. He is a good man. I do not know what to do.

From group 4-5 students conduct class discussion on the effects of hormones, drugs and substance abuse on sexual desires.

Make your discussion interesting and lively as possible.

Role Play: on resisting things that influences sexual desire

In this activity one will model a few good example of how to respond to a girl who faced sexual raping.

SUMMARY

- A tissue is a group of cells with a particular function.
- An organ is a group of tissues with a specific function.
- A system is a group of organs with a particular function.
- Sponges are multicellular aquatic, sessile and filter feeder animals.
- Hydra is a multicellular, aquatic and predator animal with tentacles and nervous system for movement.
- Flat worms are invertebrate animals, mostly living as parasites due to undeveloped digestive, movement and sensory organs.
- Round worms are invertebrate animals mostly living as parasites, due to undeveloped sensory and movement organs.
- Segmented worms are also invertebrate animals with circulatory system, sensory system and movement organs. Some of the like such as leeches are parasitic.
- Human male reproductive organs include penis, testes or male gonads for sperm sex hormone production and scrotum or sac-like structure enclosing testes for sperm cells maturity.
- Human female reproductive organs include vagina, ovaries or female gonads for egg cells production and sex hormones, fallopian tube for fertilization, uterus for pregnancy.
- Human life cycle involves the infancy, juvenile, adolescence, adult and senescence stages.
- Menstruation, is the bleeding of the an adult female reproductive system to remove unfertilized egg with blood through the vagina.
- Menstruation, is a sign of no pregnancy and no attainment of menopause stage.
- Pregnancy, is the development of embryo into foetus controlled by progesterone hormone.
- Placenta, is a tissue formed during pregnancy for additional progesterone for development of uterus and embryo also to prevent overlapping of pregnancy.
- Umblical cord, is a tube with blood vessels formed during pregnancy to exchange material between the mother and the foetus through blood.

- Pregnancy and STIs are prevented by abstinence and wearing condom also by challenging risky sexual behaviours.
- Contraceptives are methods against conception to prevent unwanted pregnancy. They play role in limiting the number of children within a family and also to prevent the transmission of STI especially condom.
- Drug, is any chemical that impact the body specially, the Central nervous system.
- Drug abuse, is the use of drugs other than the intended medical purpose.
- Drugs can be stimulant, depressant, seducers and hallucinauts the most abuse drugs are alcohol, opiates and narcotics.

Exercise

1. Male *Ascaris* can be distinguished by the presence of a structure called _____ .
   (a) Presence of suckers
   (b) Elongated body
   (c) Tapering tail with pineal spicules
   (d) Curved tail with pineal spicules
2. *Ascaris* is found as endoparasite in_____.
   (a) Intestine of man
   (b) Blood of man
   (c) Body cavity of man
   (d) Muscles of pig
3. The cuticle in *Ascaris* is an adaptation for_____.
   (a) Parasitism
   (b) Locomotion
   (c) Growth
   (d) Reproduction
4. Cysterercus is the larva of one of the following.
   (a) Liver fluke
   (b) Tapeworm
   (c) *Ascaris*
   (d) Mollusca
5. All flatworms differ from all roundworms in having _____.
   (a) Triploblastic body
   (b) Solid mesoderm

(c) Bilateral symmetry
(d) Metamorphosis in the life history

6. Which stage in the life cycle of *Taenia solium*, insects are the intermediate host?
(a) Hexacanth larva
(b) Oncosphere
(c) Cysticercus larva
(d) Miracidium

7. Which of the following show anaerobic respiration?
(a) Earthworms
(b) Rabbit
(c) Echinoderm
(d) Tapeworms

8. What is TRUE about *Taenia saginata*?
(a) Life history has pig as an intermediate host
(b) There are two large suckers on scolex
(c) Rostellar hooks are absent
(d) Rostellum has double circle of hooks

9. Which one of the following is an example of Platyhelminthes?
(a) *Trypanosoma*
(b) *Schistosoma*
(c) *Wuchereria*
(d) *Plasmodium*

10. Which one is not a larval stage of flatworms?
(a) Cercaria
(b) Miracidium
(c) Redia
(d) Bipinnaria

11. Which constitutes the correct pairing?
(a) Flatworm-Planaria
(b) Fish-Snail
(c) Dogfish-Sea Urchin
(d) None of the above

12. Anus is absent in_____.
(a) Fasciola
(b) Periplaneta
(c) Pheretima
(d) Unio

B10CH04

CHAPTER 4

ARTHROPOD AND BIOLOGICAL CONTROL OF PESTS

Chapter Contents

Chapter Outcomes

At the end of this chapter the learners should be able to:

- describe and classify arthropods according to their morphology;
- explain the process of metamorphosis (complete & incomplete) and Ecdysis (molting) in arthropods;
- discuss the role of vectors (cockroach, mosquito, house-fly, and tsetse fly);
- explain the general characteristic's of butterfly;
- elaborate on the economic importance of the honey bees and termites;
- discuss pests, their economic importance and control measures;
- describe the features and economic importance of grasshoppers.

Introduction

The phylum Arthropoda contains a wide diversity of animals with hard exoskeletons and jointed appendages. Many familiar species belong to the phylum Arthropoda are insects, spiders, scorpions, centipedes, and millipedes on land, crabs, crayfish, shrimp, lobsters, and barnacles in water. Arthropods are considered the most successful animals on earth. The phylum includes more species and more individuals than all other groups of animals combined. Over 85 percent of all known animal species are arthropods. They live in the widest range of habitats and eat the greatest varieties of food.

Arthropods are bilaterally symmetrical, segmented, coelomate animals having jointed appendages and haemocoel and the body covered by exoskeleton formed of chitinous cuticle, respire by gills or trachea, book gill, book lung or body surface and undergo molting periodically.

4.1 Arthropods: General Characteristics and Classification

A. General Characteristics and Classification

Phylum Arthropoda is the largest animal group which constitutes the largest percentage of the world's organisms. It is estimated that about 84% of all known species of animals belong to this phylum. This phylum includes several large classes and contains the class Insecta which itself represents a major portion of the animal species in the world. They possess the ability to survive in every habitat.

The term "Arthropoda" is derived from two Greek words 'arthros' meaning 'joint' and 'podos' meaning 'leg'. Hence the word "Arthropoda" means "jointed legs". Arthropods are protostomic, eucoelomic organisms and they have functional segmentation body with a pair of the jointed appendage. They also have a bilaterally symmetrical body with external chitinous cuticle. Some species of arthropods bear wings for aerial movement. They are the successful animal groups which show a great variety of adaptations. Among them, some live-in aquatic environments, some inhabit in terrestrial habitat and others are adapted for aerial habitats.

The arthropoda characteristics are mentioned below:

- The body is triploblastic, segmented, and bilaterally symmetrical.

- They exhibit organ system level of organization.
- The body is divided into head, thorax, and abdomen.
- Their body has jointed appendages which help in locomotion.
- The coelomic cavity is filled with blood.
- They have an open circulatory system.
- The head bears a pair of compound eyes.
- The exoskeleton is made of chitin.
- The terrestrial Arthropods excrete through malpighian tubules while the aquatic ones excrete through green glands or coaxal glands.
- They are unisexual and fertilization is either external or internal.
- They have a well-developed digestive system.
- They respire through the general body surface or trachea.
- They contain sensory organs like hairs, antennae, simple and compound eyes, auditory organs, and statocysts.

Classification of Phylum Arthropoda

Arthropods can be grouped into several subphyla, with each of these subphyla then divided into different classes. The classification of phylum Arthropoda are as follows:

Crustacea

- They are aquatic, terrestrial, or parasitic.
- The head is fused with the thorax region known as the cephalothorax.
- Respiration occurs through gills or general body surface.
- The body is covered by a single large carapace.
- They possess two pairs of antennae and five pairs of appendages.
- They excrete through green glands or antennal glands.
- They have a pair of compound eyes and gonopores.
- Development is indirect. Larval stage is present.
- E.g., *Daphnia*, *Palaemon (Figure 1).*

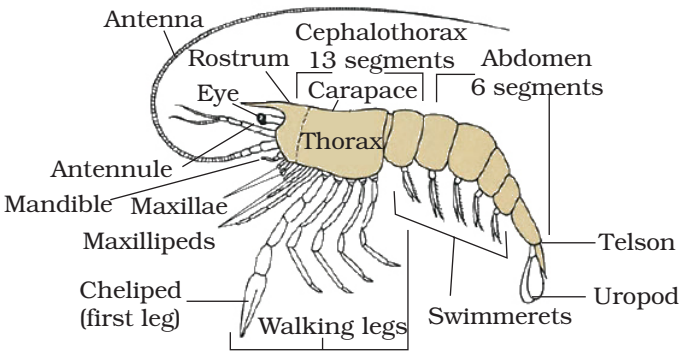


Figure 1. Crustacea

Myriapoda

- These are mostly terrestrial.
- The body is elongated with numerous segments.
- The head is provided with antennae, two pairs of jaws, and a pair of simple eyes.
- They contain numerous legs.
- The upper lip of the mouth contains epistome and labrum, and the lower lip contains a pair of maxillae.
- A pair of mandibles is present inside the mouth.
- They respire by trachea and excretion occurs by malpighian tubules.
- E.g., *Julus*, *Scolopendra (Figure 2)*.

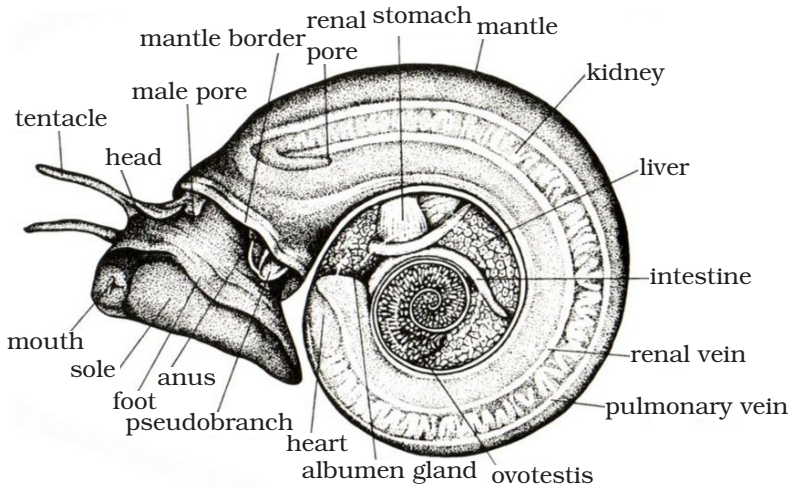


Figure 2. Gastropod

Hexapoda

- They are mostly terrestrial.
- The body is differentiated into head, thorax, and abdomen.
- Head bears a pre-segmental acron.
- The thorax is divided into three segments.
- The abdomen has 7-11 segments.
- They have three pair of appendages.
- It has a pair of compound eyes
- They respire through gills and trachea.
- Malpighian tubules are the excretory organ.
- Development is indirect, and the larval stage is present.

e.g., *Tabernus*, *Mosquitoes*, *Ants (Figure 3)*.

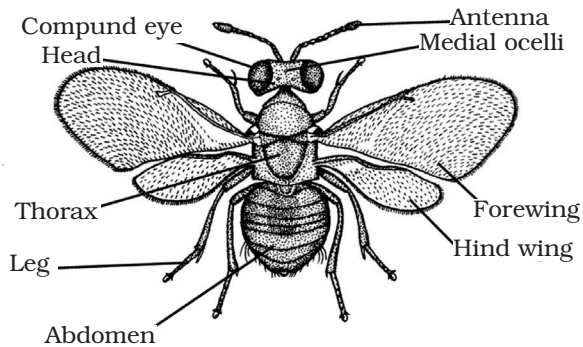
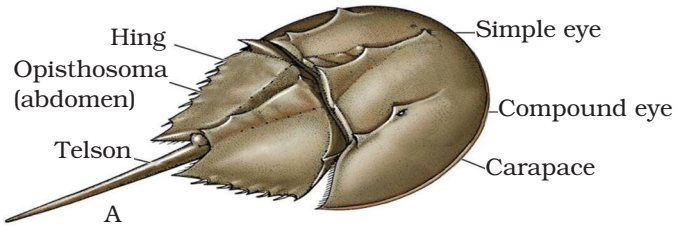


Figure 3. Flies

Chelicerata

- They are mostly found on land.
- The body is differentiated into cephalothorax and abdomen.
- Antennae are absent.
- The abdomen is divided into 13 segments.
- It has four pairs of interior appendages.
- They respire through trachea or gills.
- The Malpighian tubules help in excretion.

E.g., *Aramea*, *Limulus (Figure 4)*.



Limulus limus - horseshoe crab

Figure 4. Limulus limus (Chelicerata)

Trilobitomorpha

- These are primitive arthropods and are extinct.
- They were found in abundance during the Paleozoic era.
- The body was divided into three lobes- one median and two lateral lobes.
- Head bore a pair of compound eyes and a pair of antennae.
- There was no structural differentiation of the body parts.
- The body was divided into head, thorax and pygidium.
- Appendages are biramous (Figure 5).

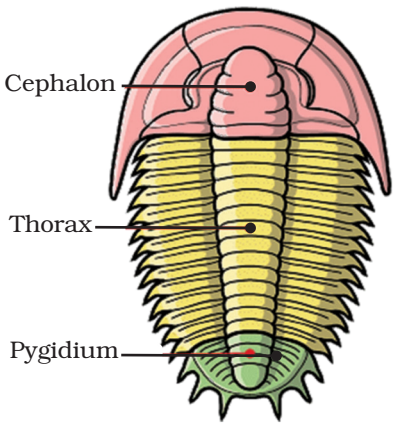
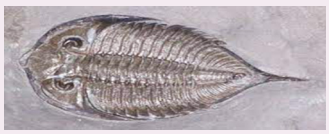


Figure 5. Trilobites

The Subphyla and Classes lists the classes within each of these subphyla and shows an example of a typical member of each subphylum.

Table 1 Subphyla and Classes of Arthropods

Subphylum	Class	Examples	Common members
Trilobitomorpha	Trilobites (extinct)		Extinct

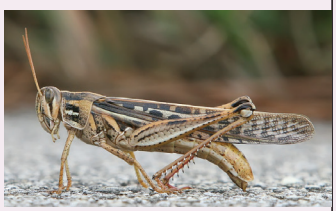
Myriapoda	Chilopoda Diplopoda Pauropoda Symphyla		Centipedes Millipedes
Chelicerata	Arachnids Xiphosura Pycnogonida		Spiders Scorpions Mites Ticks Horseshoe crabs Sea spiders
Crustacea	Remipedia Cephalocarida Branchiopoda Maxillopoda Malacostraca		Lobsters Crabs Shrimp Barnacles Krill
Hexapoda	Collembola Diplura Protura Insecta		Ants Flies Grasshoppers Beetles Butterflies Moths Bees Springtails
Arthropods	Insecta Crustacean Arachnida Chilopoda Diplopoda		????

Figure 6 shows a traditional phylogenetic tree illustrating the relationships between the arthropod subphyla.

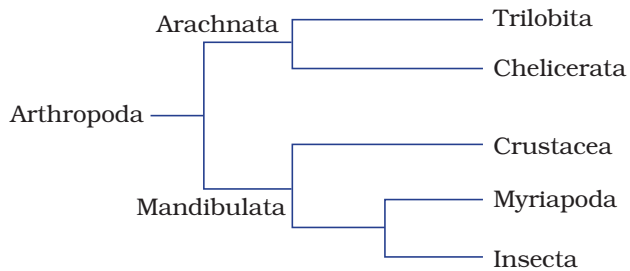


Figure 6. A phylogenetic tree showing the relationships between different arthropod subphyla.

Activity 1

Field trip

Work on with mixed groups in the field trip

You need:

Insect net, killing jar, ethyl acetate, observation jar, insect field guide, forceps, pinning block, spreading board, insect pins, display case, relaxing chamber supplies, field note book, crow bar or screw driver, camera, traps

Methods:

1. Use a killing jar

Add ethyl acetate into the jar

Put insect in and quickly close the lid

Take out a specimen out of the killing jar

Either pin the insect immediately or store it in a glass in envelope.

2. Use a spreading board and insect pins.

For winged insects insert the pin through the right side of the thorax.

Identify the insects you collected

Observe their external body structures

Record the information you observed in a field notebook

Present to your class

3. Study specimens

Study the external structures, mouth parts of grasshopper, cockroach, weevils and cotton strainers.

B. Morphology and Life Processes

Morphologically, arthropods have segmented bodies, including jointed appendages, and are covered with a chitinous cuticle that serves as an exoskeleton. Arthropods must undergo periodic molts as growth and development proceeds. Sexes are separate. Morphological differences between sexes are few in some species, marked in others.

(i) Respiration in Arthropoda

Respiration involves the exchange of gases between the body and the environment. There are two types of respiration in arthropoda. They are:

Aquatic Respiration

Aquatic respiration involves the utilization of oxygen dissolved in water. Aquatic arthropods (crustaceans and the chelicerate horseshoe crabs) possess gills for respiration. Although they vary in structure and

location, the gills are always outgrowths of the integument (skin) and are therefore covered by the exoskeleton, which is thin in this area and not a barrier to the exchange of gases.

Aerial respiration

Terrestrial arthropods possess tracheae and book lungs, as respiratory organs. Tracheae are a system of tiny tubes that permit passage of gases into the interior of the body.

Insects mainly breathe by the tracheal system, consist of elastic air tubes known as tracheae, called the tracheal system. The trachea is distributed all over the body like the circulatory system of vertebrates, hence the air is in direct contact with cells and tissue of the body. It means the tracheal system serves for the transport of oxygen and carbon dioxide so there is no respiratory function of blood. So insects cannot have the capacity to conduct oxygen by pigments or have a poor capacity for oxygen transport. The tracheal system is consists of the following part.

Spiracles: It is the entry point of air, stigma, or spiracles open side of the body. Spiracles are mainly 10 in number among these 2 are thoracic and 8 are abdominal.

Tracheae: It is an extensive network of branches of tubes, wall of these tubes is made up of three layers, intima, epithelium, and basement membrane.

Tracheoles: The branches of the tracheae are called tracheoles.

Air sac: In some insects, tracheae are open into air sacs. It can fill and empty by muscular movement.

In some arthropods the tracheal tubes are bathed by blood, but in insects the minute terminal endings (tracheoles) are embedded in the tissues, even within muscle cells. The tracheal tubes (but not the tracheoles) are molted along with the rest of the exoskeleton. Tracheae are found in myriapods, insects, and arachnids. Tracheal systems are highly efficient for these small, terrestrial animals. The small, external openings (spiracles) reduce water loss, the chitinous lining prevents collapse, and the small size of the arthropod and consequent short length of the tubule eliminates the need for moving gases in and out by active ventilation (Figure 7).

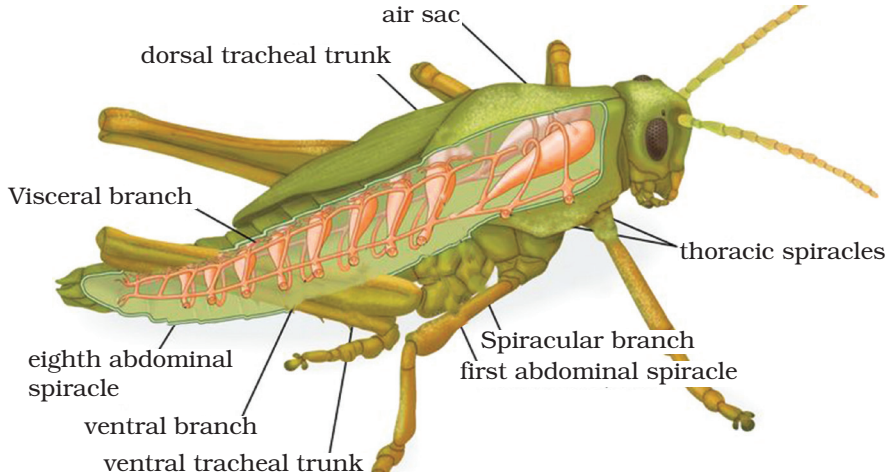


Figure 7. The respiratory system of a grasshopper, showing spiracles in the thorax and abdomen.

Lungs are mainly respiratory organs of arachnids such as scorpions, spiders, etc. Book lungs are sac like structures, within which there are delicate folds that are arranged like the leaves of a book. These folds are richly supplied with blood. Each book lung consists of an air cavity or atrial chamber on the ventral side which opens to the outer side by a slit-like spiracle or stigmata that opens on the ventro-lateral side of the sternum (Figure 8).

(ii) Feeding in Arthropoda

Arthropods exhibit every type of feeding mode.

They include carnivores, herbivores, detritus feeders, filter feeders, and parasites. Typically, paired appendages around the mouth are used for collecting and handling food and are usually specialized in accordance with the particular diet of the animal. For example, the insect family Aphididae has mouthparts adapted for piercing vegetation and sucking out plant juices (Figure 9).

Figure 8.

How do Most Arthropods Feed

Most arthropods are scavengers, eating just about

anything and everything that settles to the ocean floor. Skeleton shrimp feed detritus, algae or animals. Crabs feed on mollusks they crack with their powerful claws.

Most soil-dwelling arthropods eat fungi, worms, or other arthropods. Root feeders and dead-plant shredders are less abundant. As they feed, arthropods aerate and mix the soil, regulate the population size of other soil organisms, and shred organic material.

Figure 9. Feeding in Arthropods

Filter feeding crustaceans have setae on modified appendages that act as filters Filter feeding may have developed in association with swimming, with early morphological adaptations occurring on the appendages of the body trunk. subsequent adaptations appear to have favored forward filtering appendages.

Activity 2

Drawing 3 different cell s of sponges

Draw three different cells a sponge

State the functions of each of the three cells

Then present to your class as interesting as possible

Exercise

Choose the best answer from the alternatives provided

1. Metamerically segmented, bilaterally, symmetrical animas bearing jointed appendages are the characteristics of _____ .
   (a) Helminthes
   (b) Annelida
   (c) Mollusca
   (d) Arthropods
2. Pronounced cephalization is characteristic of _____ .
   (a) Echinoderms
   (b) Annelida
   (c) Mollusca
   (d) Arthropoda

3. Hemcoelic body is characteristic of _____.
   (a) Ascaric
   (b) Leech
   (c) cockroach
   (d) Snails
4. Most primitive arthropods belong to the class _____ .
   (a) Arachnida
   (b) Insecta
   (c) Onychophora
   (d) Myriapoda
5. True and complete metamorphosis is found in _____ .
   (a) Silverfish
   (b) Grasshopper
   (c) Cockroach
   (d) Moth & mosquito
6. The mouth parts of housefly are of
   (a) Piercing and sucking type
   (b) Biting and chewing type
   (c) Sucking and sponging type
   (d) Biting sucking and piercing type
7. Arthropod exoskeleton is _____.
   (a) Softene
   (b) Flexible
   (c) Hardened and inflexible
   (d) Softened and flexible
8. Arthropod exoskeleton is made of _____.
   (a) Chitin only
   (b) Chitin and protein
   (c) Protein and collagen
   (d) Collagen and chitin
9. Crustacea have cuticle hardened by _____ .
   (a) Potassium salts
   (b) Collagen
   (c) Calcium salts
   (d) Magnesium salts

(iii) Mouth Parts and Body Segments of Arthropoda

Arthropod Mouthparts

The mouthparts of arthropods have evolved into a number of forms, each adapted to a different style or mode of feeding. Most mouthparts represent modified, paired appendages, which in ancestral forms would have appeared more like legs than mouthparts. In general, arthropods have mouthparts for cutting, chewing, piercing, sucking, shredding, siphoning, and filtering. This article outlines the basic elements of four arthropod groups: insects, myriapods, crustaceans and chelicerates. Insects are used as the model, with the novel mouthparts of the other groups introduced in turn.

Insect Mouthparts

Insects are the largest group of animals that occupy every type of habitat available on earth with the possible exception of sea. They also feed on a variety of food in different habitat condition. They are plant feeding, predators, parasitic and decomposers, for which they must possess different types of feeding apparatus.

Insect mouthparts exhibit a range of forms. The earliest insects had chewing mouthparts. Specialisation includes mouthparts modified for siphoning, piercing, sucking and sponging. These modifications have evolved a number of times. For example, mosquitoes (which are flies) and aphids (which are bugs) both pierce and suck; however, female mosquitoes feed on animal blood whereas aphids feed on plant fluids. An overview of the individual mouthparts of chewing insects: (Figure 10).

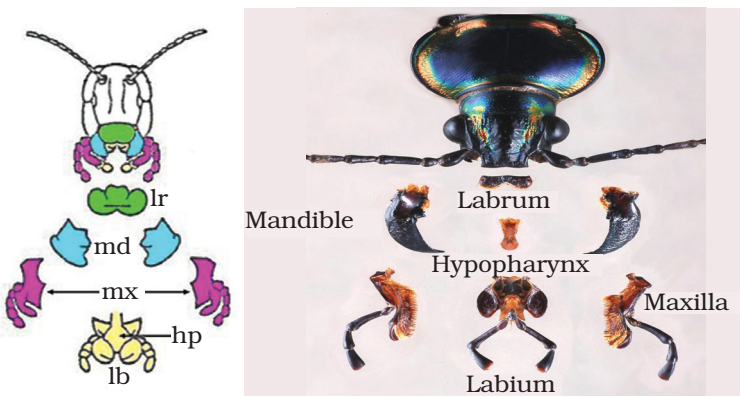


Figure 10. Chewing mouthparts of a grasshopper. Legend: lr, labrum; md, mandibles; mx, maxillae; hp hypopharynx; lb, labium.

Labrum

The labrum is a flat extension of the head covering the mandibles. Unlike other mouthparts, the labrum is a single, fused plate. It is the upper-most of the mouthparts and located on the midline. It serves to hold food in place during chewing by the mandibles and thus can simply be described as an upper lip.

Mandible

Chewing insects have two mandibles, one on each side of the head. They are typically the largest mouthpart of chewing insects, being used to masticate (cut, shred, tear, crush, chew) food items. They open outwards and come together medially.

Maxilla

Paired maxillae cut food and manipulate it during mastication. Maxillae can have hairs and "teeth" along their inner margins. At the outer margin, the galea is a cupped or scoop-like structure, which sits over the outer edge of the labium. They also have palps, which are used to sense the characteristics of potential foods.

Labium

The labium is a single structure, although it is formed from two fused secondary maxillae. It can be described as the floor of the mouth and functioning in close the mouth of the insect. With the maxillae, it assists manipulation of food during mastication.

Hypopharynx

The hypopharynx is a somewhat globular structure, arising from the base of the labium. It assists swallowing. It performs the role of the tongue found in large vertebrate.

Myriapods comprise four classes of arthropod, each with a similar morphology: Class Chilopoda (centipedes); class Diplopoda (millipedes); class Pauropoda; and class Symphyla. Myriapod mouthparts are similar to those of chewing insects, although there is some variation between the myriapod classes. A labrum is present but sometimes is not obvious and forms an upper lip, The labium is formed by first maxillae in diplopoda. The preoral cavity so-formed contains paired mandibles and any maxillae which are present.

Forcipules

Centipedes, in addition to their mouthparts, possess a pair of "poison claws", or forcipules. These, like the maxillipeds of crustaceans, are modified legs and not true mouthparts. The forcipules arise from the first body segment, curving forward and to the midline. The tip is a pointed fang, which has an opening from a venom gland. The forcipules are used to capture and envenomate prey (Figure 11).

Figure 11. Ventral view of forcipules of a centipede, arising from the first body segment

Crustaceans

Crustaceans possess paired mandibles with opposing biting and grinding surfaces. The mandibles are followed by paired first and second maxillae. Both the mandibles and the maxillae have been variously modified in different crustacean groups for filter feeding with the use of setae (Figure 12).

Maxillipeds

Up to the first three pairs of legs are modified to maxillipeds, which assist manipulation of food items by passing food forward to the mandibles for chewing or to the maxillae for cutting into smaller pieces.

Figure 12. The mouthparts of an edible crab: the third maxillipeds conceal the remaining mouthparts

Setae

Filter feeding crustaceans have setae on modified appendages that act as filters. Filter feeding may have developed in association with swimming, filtering appendages generate water currents that bring food items into reach for collection by setae. Other setae may be used to brush the filtering setae clean, and yet other setae may transport food items to the mouth.

Cirri

Barnacles have thoracic appendages modified for feeding called the cirri, which filter suspended food particles from water currents and pass the food to the mouth.

Chelicerates are in part defined by possessing chelicerate appendages, although crustaceans also possess chelate appendages. Chelicerates are more easily distinguished from other arthropods in lacking antennae and mandibles.

Figure 13. Types of chelicerae: (A) jackknife, (B) scissor, and (C) 3-segmented chelate

Chelicerae are chelate appendages that are used to grasp food. For example, in horseshoe crabs, they are like pincers, whereas in spiders, they are hollow and It contains venom glands and are used to inject venom to disable prey prior to feeding. In some spiders, the chelicerae have teeth, which are used to macerate prey items to assist digestion by secreted enzymes. Those spiders without toothed chelicerae inject digestive enzymes directly into their prey (Figure 13). Mites and ticks have a range of chelicerae. Carnivores have chelicerae that tear and crush prey whereas herbivores can have chelicerae that are modified for piercing and sucking. In sea spiders, the chelicerae are short and chelate and are positioned on either side of the base of the proboscis or sometimes vestigial or absent.

Proboscis

Sea spiders possess a tubular proboscis forward from the body trunk, at the end of which is the opening to the mouth. The proboscis is well developed and more mobile and flexible.

Body segment of Arthropoda

Insect body is differentiated into three distinct regions called head, thorax and abdomen (grouping of body segments into distinct regions is known as tagmosis and the body regions are called as tagmata) (Figure 14).

Head

First anterior tagma formed of 5-7 fused segments and bears the eyes, antennae, and mouthparts. Head is attached or articulated to

the thorax through neck or Cervix. Head capsule is sclerotized and the head capsule excluding appendages formed by the fusion of several sclerites is known as cranium.

Functions of Head

(i) Food ingestion
(ii) Sensory perception
(iii) Coordination of bodily activities
(iv) Protection of the coordinating centers

Thorax

Second and middle tagma which is three segmented, namely prothorax, mesothorax and metathorax. Appendages used for movement are attached to the thorax. Each of the segments of the thorax bears one pair of legs and if wings are present they are found on the meso- and metathorax only. Meso and metathorax with wing are called as pterothorax.

Functions of thorax is mainly for locomotion.

Abdomen

Third and posterior tagma. This tagma is made up of 9-11 segments , is highly flexible and generally do not bear any appendages. Eight pairs of spiracles are present in the first eight abdominal segments. Eighth and ninth abdominal segments contains the female genital structure and ninth segment with male genital structure.

Function: Concerned with reproduction and metabolism.

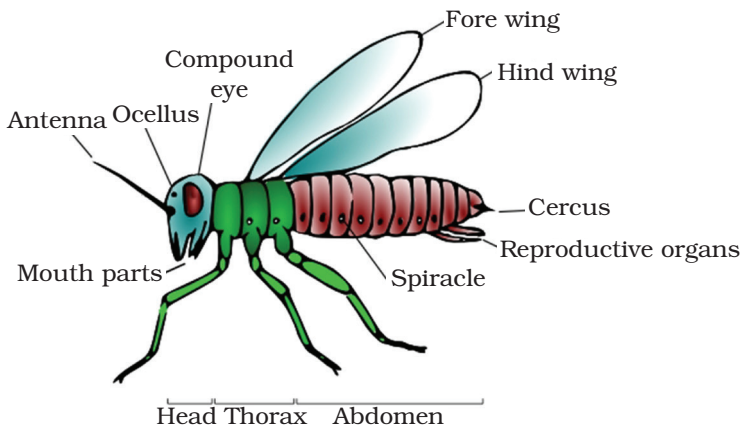


Figure 14. Insect Body Regions: Head, Thorax, and Abdomen

Insect Legs

Insect have three pairs of legs, one pair on each of the three segments of the thorax and are generally called the fore-, mid-, and hind legs. Any of the pairs of legs may be heavily modified and are important for locomotion, prey capture, mating, etc. All insect legs contain the same basic parts. From proximal (toward or against the body) to distal (away from the body) the parts of an insect leg are: coxa, trochanter, femur, tibia, and tarsus. The tarsus almost always has one or two claws at the type used to grasp the substrate (Figure 15).

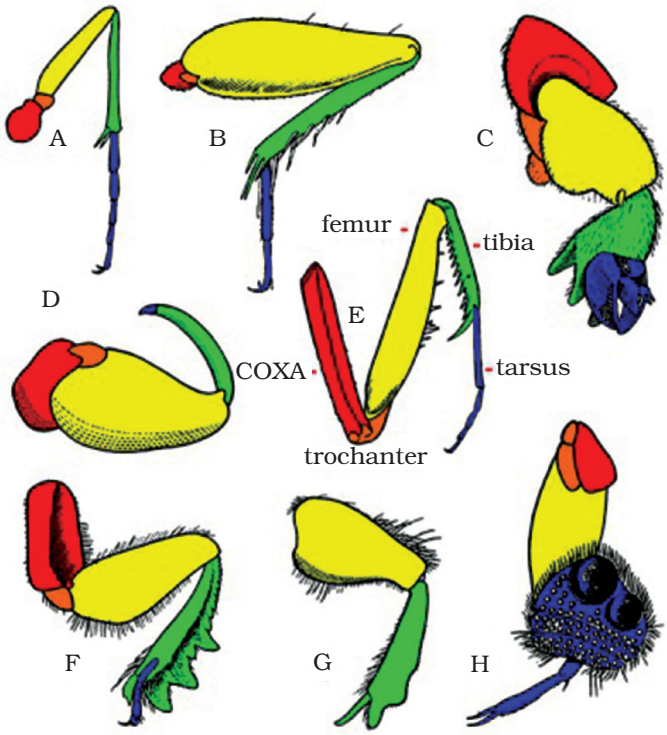


Figure 15. Insect Legs, right, shows legs modified for numerous purposes: A, running; B, jumping; C, digging; D, grasping; E, catching; F, walking and digging; G, reduced leg used for walking and digging; H, male leg modified for grasping females during mating.

C. Reproductive System and Life Cycle

With few exceptions, the sexes are separate in arthropods; i.e., there are both male and female individuals. The paired sex organs, or gonads, of each sex are connected directly to ducts that open onto the ventral surface of the trunk, the precise location depending upon the arthropod group.

In arthropods, sperm are commonly transferred to the female within sealed packets known as spermatophores. Among some arachnids, such as scorpions, and some mites, the stalked spermatophore is deposited on the ground. Either the female is attracted to the spermatophore chemically or the deposition of the spermatophore occurs during the course of a nuptial dance, and the male afterward maneuvers the female into a position in which she can take up the spermatophore within her genital opening. Centipedes also utilize spermatophores with an accompanying courtship behavior. in most insects the spermatophores are placed directly into the female genital opening by the male during copulation. Many arthropods transfer free sperm rather than spermatophores. These include many crustaceans, millipedes, some insects (such as dipterans and hemipterans), spiders, and some mites.

Figure 16. A pair of mating damselflies (Mnais mneme).

Copulation

Arthropod eggs are usually rich in yolk, but in all groups, there are species whose eggs have little yolk. Some specialized methods of reproduction found among certain arthropods include the development of unfertilized eggs (parthenogenesis), the birth of living young, and the formation of several embryos from a single fertilized egg (polyembryony) (Figure 16).

The eggs of many crustaceans hatch into larvae which have fewer segments than the adult. The earliest larval hatching stage is a minute nauplius larva, which possesses only the first three pairs of appendages. Additional segments and appendages then appear at regular intervals with molting. In most chelicerates and insects,

almost all of the segments are present at hatching, although in insects the body form may differ from that of the adult. Many insects, such as grasshoppers, crickets, and true bugs, hatch as nymphs, which superficially resemble the adult but lack wings. They gradually acquire these adult features during the nymphal instars. Other insects, such as beetles, butterflies, moths, flies, and wasps, hatch as larvae (grubs, caterpillars, maggots) that differ markedly from the adult. The larvae inhabit different environments and eat different foods than the adults. In these insects a pupal stage with metamorphosis bridges the gap between the larva and the adult form.

Myriapods have the general body form of the adult on hatching though they may lack some of the segments. Most millipedes hatch with only seven trunk segments. Some centipedes hatch with all of the adult trunk segments, but others have fewer than the adult.

The young of most arachnids are similar to the adult. The female scorpion gives birth to her young, which immediately climb onto her back. Female wolf spiders also carry their young, and prior to hatching they carry the white egg case attached to the posterior spinnerets. Unlike other arachnids, mites and ticks hatch as six-legged larvae, which acquire the fourth pair of legs at a later molt.

4.2 Metamorphosis and Molting

Metamorphosis is the process of development of an organism that involves distinct stages with an abrupt change between them. In arthropods the animal moves between stages by moulting its exoskeleton. The new exoskeleton will have developed beneath the old skin. After moulting the new skin is inflated and then hardens. Complete metamorphosis and incomplete metamorphosis are two growth types of insects where the body form of insects changes during their lifecycle.

Complete Metamorphosis

Complete metamorphosis is the type of insect development that includes egg, larva, pupal, and adult stages, which differ greatly in morphology. The lifecycle of butterflies, ants, fleas, bees, beetles, moths, and wasps are examples of the complete metamorphosis. The lifecycle of ants is shown (Figure 17).

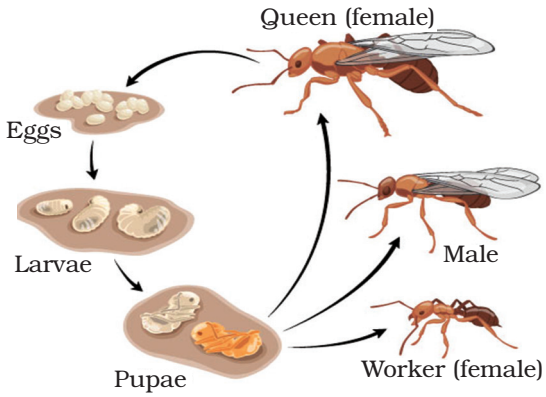


Figure 17. Complete metamorphosis in ants

The complete metamorphosis starts with the laying of eggs by the female insect. The larva, which is the second stage of the complete metamorphosis, are hatched from the eggs. The larval stage can completely differ from the adult stage in morphology, behavior, and/or habitat. The larval body is soft and worm-like. The characteristic feature of the larva is their ravenous feeding. Due to this great appetite for food, the larval stage shows very fast growth. During their growth, larva molts their skin several times. The pupal stage begins with the formation of cocoons around the larvae. Butterfly cocoons are shown in (Figure 18).

The larva is inactive and does not feed when they are inside the cocoons. Their bodies develop more segments, internal organs, legs, and wings. The pupal stage may exist from 4 days to several months. They break out of the cocoon frees a fully developed larva.

Figure 18. Butterfly Cocoons

Incomplete Metamorphosis

Incomplete metamorphosis refers to a type of insect development in which gradual changes occur in the insect during the development from the egg to the adult. The three stages of the incomplete metamorphosis are egg, nymph, and adult. The eggs are laid by the female insect. In most cases, the eggs are covered by an egg case, which protects and hold the eggs together. The eggs hatch into younger nymphs. The nymph resembles the adult without wings. The nymph is also smaller than the adult. The nymph eats the same food as the adult. It develops into the adult through a series of molts. It shed its exoskeleton 4-8 times. When it becomes an adult, the molting does not occur. Insects that have an incomplete metamorphosis life cycle include true bugs, grasshoppers, cockroaches,termites, praying mantises, crickets, and lice. The incomplete metamorphosis of lice is shown in (Figure 19).

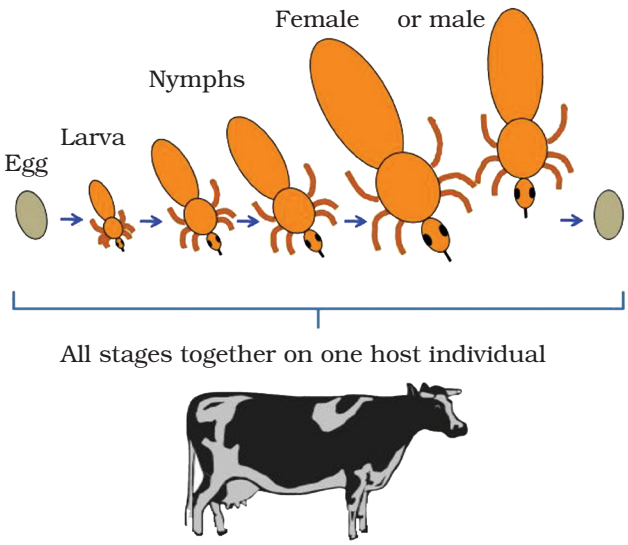


Figure 19. Incomplete Metamorphosis in lice

Molting

One of the general characteristics that defines the phylum Arthropoda (which includes insects, spiders, and crustaceans) is an external skeleton, also called an exoskeleton . The arthropod exoskeleton completely covers the outside of the body and the muscles inside adhere to it. Exoskeletons are hard and protect the body. Because

the exoskeleton is hard and rigid, an arthropod cannot grow unless it sheds its old exoskeleton and secretes a new one. This process is called molting.

Arthropod growth is limited to molting, so growth happens in steps rather than continuously. The stages between moltings are called instars. The extent of an individual's growth between molts and the length of time between molts are related to the temperature as well as to the amount of food and water an individual gets.

Warmer temperatures and more food and water can shorten the instar length and make the individual bigger. The length of the day is used to determine the timing of molting. Most insects after their final molt they are sexually mature adults. Most insects with wings acquire wings only in their adult stage. Beneath the exoskeleton is an underlying cell layer called the epidermis, which secretes the exoskeleton, also called the cuticle. The exoskeleton is noncellular and made of chitin and proteins, which give the exoskeleton its rigid and protective properties. The exoskeleton and the epidermis together form the integument of an arthropod.

The arthropod builds a new exoskeleton underneath the old one. The epidermis pulls away from the existing exoskeleton. This creates a space between the epidermis and the exoskeleton. This space is filled with a gel that promotes shedding of the old exoskeleton (Figure 20).

Ecdysis consists of splitting the exoskeleton, usually along the back of the arthropod, and crawling out of the old exoskeleton.

Figure 20. Molting in grasshopper

4.3 Vectors

Vectors are frequently arthropods, such as mosquitoes, ticks, flies, fleas and lice.

Vectors can transmit infectious diseases either actively or passively:

- Biological vectors, such as mosquitoes and ticks may carry pathogens that can multiply within their bodies and be delivered to new hosts, usually by biting.

- Mechanical vectors, such as flies can pick up infectious agents on the outside of their bodies and transmit them through physical contact.

Diseases transmitted by vectors are called vector-borne diseases

Many vector-borne diseases are *zoonotic* diseases, i.e. diseases that can be transmitted directly or indirectly between animals and humans. These include for example tick-borne Encephalitis and Leishmaniosis. Many vector-borne diseases are considered as emerging infectious diseases :

- Disease that appears in a *population* for the first time.
- That may have existed previously but is rapidly increasing in *incidence* or geographic range.

Some vectors are able to move considerable distances. This may affect the transmission ranges of vector-borne zoonotic diseases. Vectors can be introduced to new geographic areas for example by:

- Travel of humans and international trade;
- Animal movement, for instance of livestock;
- Migratory birds;
- Changing agricultural practices;
- By the wind movement.

Mosquitoes

General Characteristics

Mosquitoes have two pairs of wings, but their second pair of wings are reduced to short, peg-like structures called halters. Mosquitoes have thin, long bodies and three pairs of extremely long legs. They have scales along the veins of their wings and long beak-like, sharp sucking mouth parts called a proboscis. These two features distinguish mosquitoes from other flies. Mosquitoes also have feathery or hairy antennae.

Mouthparts of Mosquito

In female mosquitoes, all mouthparts are elongated. The mouthpart of a mosquito includes the labium, labrum, mandibles, maxillae, hypopharynx. The adult mosquito has a needle-like structure that function in piercing into the skin and sucking the blood. The mosquito's mouth, also called a proboscis, isn't just one tiny spear. It's a sophisticated

system of six thin, needlelike mouthparts that scientists call stylets, each of which pierces the skin, finds blood vessels and makes it easy for mosquitoes to suck blood.

The mouthparts include labium, labrum-epipharynx, hypopharynx, mandibles and first maxillae. These mouthparts are characterized by stylets which are long and pointed. The labium is a fused mouthpart that forms the floor and encloses all other mouthparts like a sheath. It is also called as proboscis.

Labrum-epipharynx: This is a compound structure formed by the fusion of labrum and epipharynx. Labrum-epipharynx is a stylet that has a ventral groove, which forms the food canal with the hypopharynx.

Hypopharynx: It is a long flat stylet structure that forms the food canal with the labrum-epipharynx for sucking the blood. It also contains the salivary canal that injects saliva into the blood of the warm-blooded vertebrates.

Mandibles: Two mandibles are present each on either side. These are styles with blade like tips. They are useful to make a wound in the skin of the host. There are two first maxillae one on each side. These are the styles that bear serrated tips. Each maxilla bears a maxillary palp.

Feeding in Mosquito

Mosquitoes feed on sweet nectar, fruit, and other sugary substances. The females of some mosquito species also feed on blood, which they need in order for their ovaries to mature and for their eggs to develop. The female blood meal can take place before or after she has mated. Female mosquitoes detect their blood hosts partly through the sense of smell and partly by sight. The distance over which a mosquito can detect a blood host can range from 20-90 ft (6-27 m). Mosquitoes are known to feed mammals, birds, lizards, fish, bats, and even caterpillars (Figure 21).

Life cycle of Plasmodium

The malaria parasite *life cycle* involves two hosts. During a blood meal, a malaria-infected *female Anopheles mosquito* inoculates sporozoites into the human.

Lifecycle

The natural history of malaria involves cyclical infection of humans and female *Anopheles mosquitoes*. In humans, the parasites grow and multiply in the liver cells and then in the red cells of the blood. In the blood, successive broods of parasites grow inside the red cells and destroy them, releasing daughter parasites ("merozoites") that continue the cycle by invading other red cells.

The blood stage parasites are those that cause the symptoms of malaria. When certain forms of blood stage parasites (gametocytes, which occur in male and female forms) are ingested during blood feeding by a female Anopheles mosquito, they mate in the gut of the mosquito and begin a cycle of growth and multiplication in the mosquito. After 10-18 days, a form of the parasite called a sporozoite migrates to the mosquito's salivary glands.

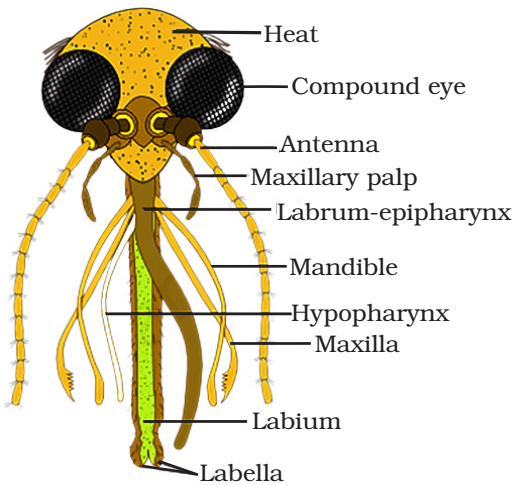


Figure 21. Piercing and chewing type mouth parts of mosquito

When the Anopheles mosquito takes a blood meal on another human, anticoagulant saliva is injected together with the sporozoites, which migrate to the liver.

Thus the infected mosquito carries the disease from one human to another (acting as a "vector"), while infected humans transmit the parasite to the mosquito,

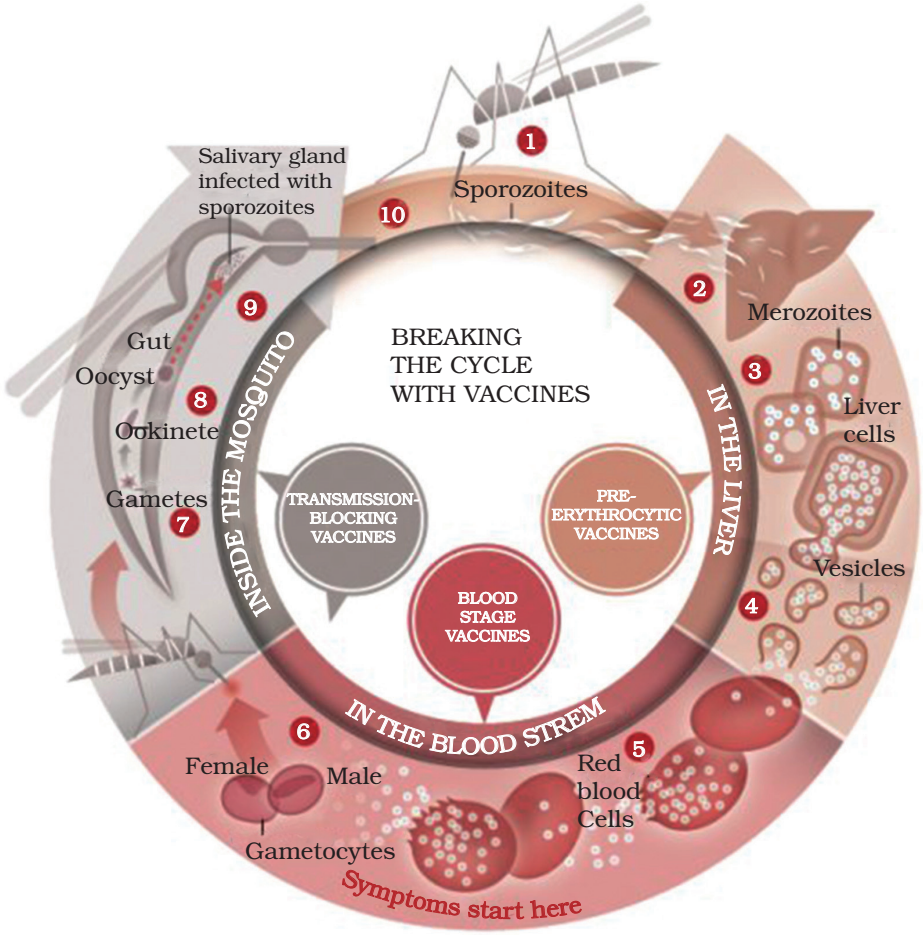


Figure 22. Life cycle of Plasmodium parasite

Activity 3

Diagramming the life cycle of *Anopheles mosquito*.
Draw the life cycle of *Plasmodium*.

Malaria infection begins when an infected female *Anopheles* mosquito bites a person, injecting *Plasmodium* parasites, in the form of sporozoites, into the bloodstream.

- The sporozoites pass quickly into the human liver.
- The sporozoites multiply asexually in the liver cells over the next 7 to 10 days, causing no symptoms.

- In an animal model, the parasites, in the form of merozoites, are released from the liver cells in vesicles, journey through the heart, and arrive in the lungs, where they settle within lung capillaries. The vesicles eventually disintegrate, freeing the merozoites to enter the blood phase of their development.
- In the bloodstream, the merozoites invade red blood cells (erythrocytes) and multiply again until the cells burst. Then they invade more erythrocytes. This cycle is repeated, causing fever each time parasites break free and invade blood cells.
- Some of the infected blood cells leave the cycle of asexual multiplication. Instead of replicating, the merozoites in these cells develop into sexual forms of the parasite, called gametocytes that circulate in the blood stream. When a mosquito bites an infected human, it ingests the gametocytes, which develop further into mature sex cells called gametes.
- The fertilized female gametes develop into actively moving ookinetes that burrow through the mosquito's midgut wall and form oocysts on the exterior surface.
- Inside the oocyst, thousands of active sporozoites develop. The oocyst eventually bursts, releasing sporozoites into the body cavity that travel to the mosquito's salivary glands. The cycle of human infection begins again when the mosquito bites another person.

Activity 4

Collecting mosquito larvae

You need:

- White tray
- Small nylon gauze net
- Pipette

Method:

Dip a white tray to stagnant pond water

Use a small nylon gauze net

Fine gauze prevents loss of small larvae

Remove the new from the water and empty into a white tray.

Use pipette to remove mosquito larvae

Bring your collection to the Lab. for observation

Recognize the characteristics of mosquito larvae

Learn morphological features used in identifying a larvae specimen
Write a report.

ACTIVITY 5

Listing method of controlling the spread of malaria
Use this textbook, other books, or internet for your book research

Tsetse Flies

General characteristic: Tsetse flies are robust, sparsely bristled insects that usually range from 6 to 16 mm (0.2 to 0.6 inch) in length. Tsetse flies are rather drab in appearance: their color varies from yellowish brown to dark brown, and they have a gray thorax that often has dark markings. The abdomen may be banded.

Mouthparts

The mouthparts are very important to the life of the fly. They are long and narrow and can pierce the skin of an animal, so that blood can be sucked up into the fly. Saliva can be passed down the mouthparts into the animal being fed on.

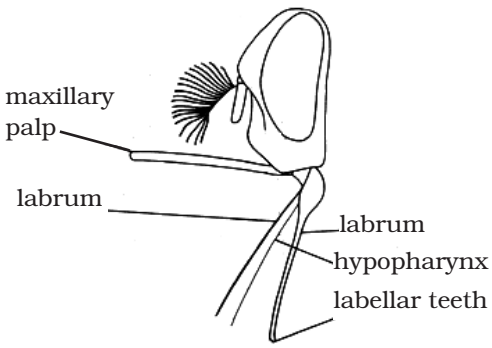


Figure 23. Mouthparts tsetse fly

A pair of maxillary palps help to protect the more delicate proboscis. The proboscis is very narrow. It is made up of three parts, the labium, the labrum and the hypopharynx

The labium is the thickest of these very thin structures. At the free end it has a large number of very small teeth (labellar teeth). The teeth can cut their way through the skin of an animal, so that the fly may suck blood. The other end of the labium, where it is attached to the head of the fly, is swollen. This part (the thecal bulb) contains the muscles that cause the teeth to move.

The labrum forms a tube through which blood is sucked up from the animal being bitten. The tube is called the food canal.

The hypopharynx is an extremely narrow tube through which saliva is pumped into the host animal as the fly feeds (Figure 23).

Feeding

Tsetse flies are distinguished in part by a forward projecting piercing proboscis on the head that is capable of puncturing skin. They readily feed on the blood of humans, domestic animals, and wild game (Figure 24).

Figure 24. Tsetse fly sucking blood meal

Life Cycle of Tsetse Fly

Tsetse fly have an unusual life cycle which may be due to the richness of their food source. Female tsetse only fertilizes one egg at a time and retain each egg within their uterus to have the offspring develop internally during the first larval stages. During this time, the female feeds the developing offspring with a milky substance which is secreted by a modified gland in the uterus. In the third larval stage, the tsetse larva finally leave the uterus and begin their independent life. However, the newly independent tsetse larva simply crawls into the ground, forms a hard-outer shell called the puparial case in which it completes its morphological transformation into an adult fly. This life stage has a variable duration, generally twenty to thirty days, and the larva must rely on stored resources during this time. The female must obtain enough energy for her needs, for the needs of her developing offspring, and to store the resources which her offspring will require until it emerges as an adult.

- Technically these insects undergo the standard development process of insects which comprises oocyte formation, ovulation and fertilization, development of the egg, five larval stages, a pupal stage, and the emergence and maturation of the adult.

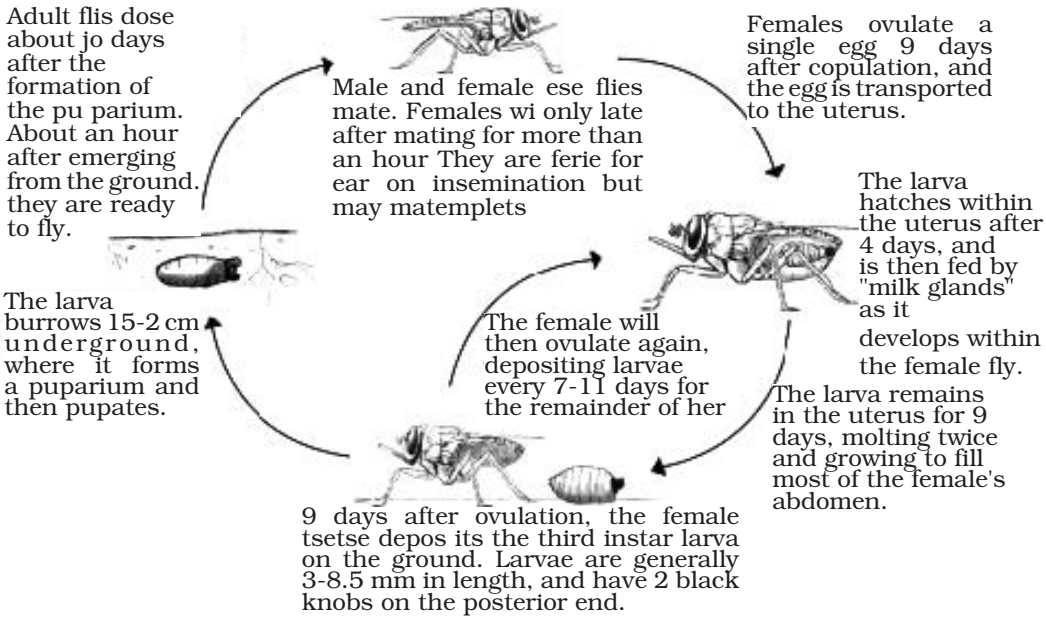


Figure 25. Life cycle of Tsetse fly

Activity 6

Drawing and labelling the parts of Arthropods in each class

Draw and label the pars of the insects in each class of arthropod, for instance grasshopper, mosquito, millipeds, crabs, crayfish, spider etc.…

Exercise

1. Which of the following parasites is responsible for the cause of African sleeping sickness or gambiense fever?
   (a) *Leishmania*
   (b) *Trypanosoma*
   (c) *Entamoeba*
   (d) *Trichomonas*
2. Tsetse fly is a vector for sleeping sickness. Which of the following parasite transmits the infective stage?
   (a) *Wuchereria bancrofti*
   (b) *Leishmania donovani*

(c) *Plasmodium falciparum*
(d) *Trypanosoma gambiense*

3. Epithelium of the stomach of the mosquito "Amoebiasis" or amoebic dysentery is caused by_____.
   (a) *Trypanosoma histolytica*
   (b) *Entamoeba histolytica*
   (c) *Entamoeba gingivalis*
   (d) *Plasmodium vivax*
4. Which of the following statement is TRUE about the malarial parasites?
   (a) Malarial parasites can be best obtained from a patient when the temperature comes to normal
   (b) Malarial parasites can be best obtained from a patient, an hour before the rise of temperature
   (c) Malarial parasites can be best obtained from a patient, a few hours after the temperature reaches normal
   (d) Malarial parasites can be best obtained from a patient when the temperature rises with rigor
5. Which of the following is "Glossina palpalis" a vector for?
   (a) Filariasis
   (b) Plague
   (c) Dengue
   (d) Gambian fever
6. An important drug used for the treatment of malaria – Quinine is extracted from
   (a) Red ants
   (b) Calyx of cinnamon
   (c) Bark of *ocimum*
   (d) Bark of *Cinchona*
7. Entamoeba gingivalis found in the buccal cavity of man causes _____ .
   (a) No disease
   (b) Pyorrhea
   (c) Bronchitis
   (d) Amoebic dysentery
8. "Trypanosomiasis" is transmitted by one of the following vector.
   (a) Fruit fly
   (b) Tsetse fly
   (c) Housefly
   (d) Mayfly

House Fly

General Characteristics of housefly. The housefly is a medium size common insect, from light to dark gray in color. The body is divided into three parts:

Head: The head bear a pair of compound eyes, a pair of antenna and a retractile proboscis, which is adapted for sucking liquid food. Male eyes are closer together, while female eyes are set apart widely.

Thorax: Thorax has 2-4 well developed dark longitudinal stripes. Thorax bears a pair of wings and three pair of legs. The legs and the body are covered with short and stiff hairs, called tenent hairs which secretes a sticky substance.

Abdomen: The abdomen is 4 segmented and shows light and dark marking. In female a tube like structure is extended from the abdomen when the fly lays her eggs.

Mouthparts

Although some flies can bite, the house fly can't. Its mouthparts are made of soft, spongy structures called a labella and a proboscis. The labella gently dabs liquids into the proboscis, which then sucks up the liquid. If the fly encounters solid food it wants to eat, it drops saliva onto it, turning the food into a liquid. The mouthparts include a long proboscis tube made by labrum – epipharynx, hypopharynx, labium and a pair of unjointed maxillary palps on sides of proboscis (Figure 26).

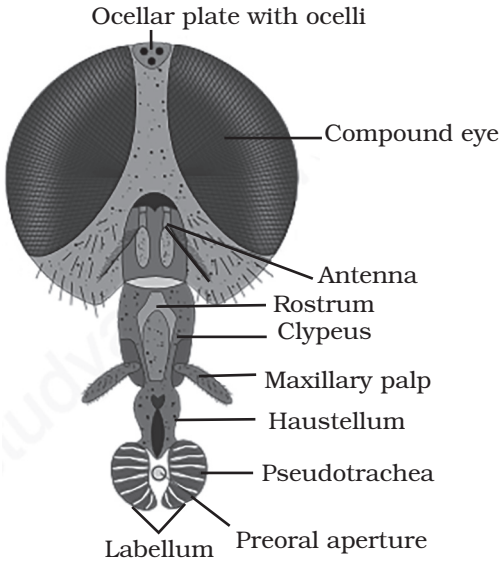


Figure 26. Mouth parts of house fly

Feeding

Flies are attracted to food sources around homes and businesses, including food waste. They also feed and breed on dead animals, drains and faeces, where they come into contact with many pathogenic microorganisms. Flies eat just about anything and everything, using their feet to touch every potential food item to see if it tastes

good. Fruit, sewage, candy, or rotting garbage are all equally delicious to a house fly. In the process of tasting everything, of course, a multitude of bacteria and viruses are spread from everything the fly contacts.

Life cycle of House Fly

The housefly undergoes a complete metamorphosis.

Egg: The female lays about 120-150 eggs in one siting. Eggs are laid in horse manure and other decaying material. They are creamy white in color and are about 1-2 mm in length. The fly lays from 600-900 eggs during her life time. The eggs hatch in hours.

Larva: The larva is 12 segmented, white in color and about 1-2 mm in length at birth. At the anterior and posterior end of the body a pair of spiracles are present. The larva feed on decaying organic matters. The larval period lasts from 2-7 days.

Pupa: The pupa is dark brown in color. The pupa stage lasts from 3-6 days but in winter it may be prolonged.

Adult: The complete life cycle from egg to adult may take 5-6 days during summer. Flies do not live longer than 15 days in summer and 25 days in winter (Figure 27).

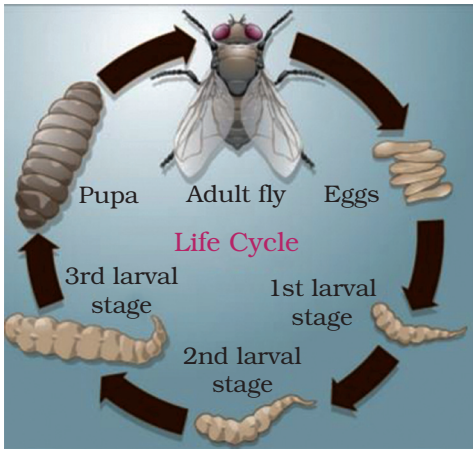


Figure 27. Life cycle of House fly

Transmission of Disease

House flies are strongly suspected of transmitting at least 65 diseases to humans, including typhoid fever, dysentery, cholera, poliomyelitis, yaws, anthrax, tularemia, leprosy and tuberculosis. Flies regurgitate and excrete wherever they come to rest and thereby mechanically transmit disease organisms.

Cockroach

General characteristics

The cockroach is characterized by a flattened oval body, long threadlike antennae, and a shining black or brown leathery integument. The head

is bent downward, and the mouthparts point backward instead of forward or downward as is the case in most other insects.

(i) It belongs to the phylum Arthropoda.

(ii) Exoskeleton is made of chitin and jointed.

(iii) It has spiracles (respiratory openings) on lateral side of the segments of thorax and abdomen for exchange of gases.

(iv) It has jointed legs for fast running. It has sensory bristles on legs which guide it during locomotion.

(v) It has well developed compound eyes and sensory cells on long antenna to enable the animal move in the dark.

Mouthparts

The mouthparts of cockroach are biting and chewing type. This biting and chewing type of mouthparts are considered as the most primitive and unspecialized of all the mouthpart types (Figure 28).

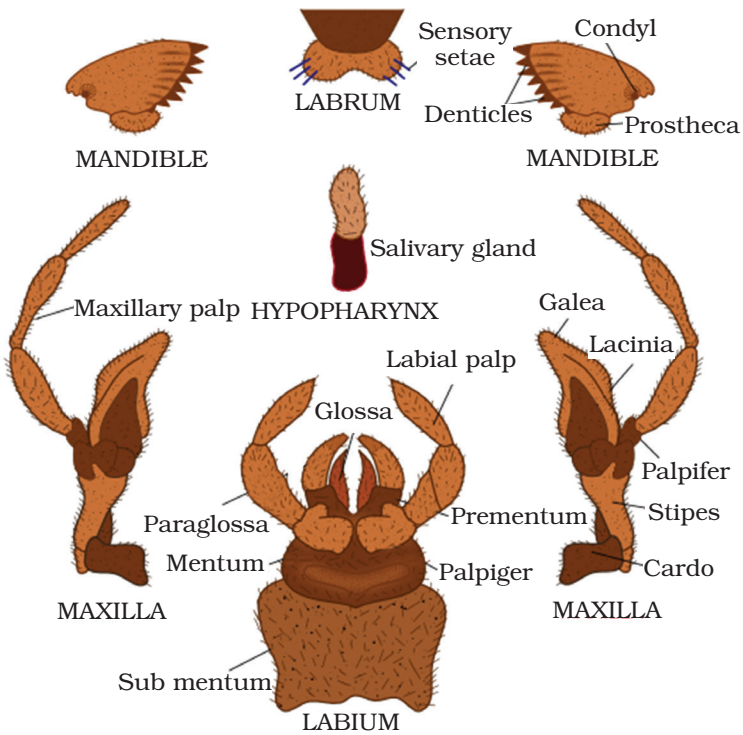


Figure 28. Mouth parts of cockroach

The mouthparts of cockroach are developed to suit its habit of feeding on solid food and as a result it has well developed mandibles. The mouthparts also include labrum, mandibles, and a pair of first maxillae, labium, and hypopharynx.

Labrum: The mouth is covered by labrum. It is also known as upper lip. Labrum helps in tasting and also handling the food.

Mandibles: These are a pair of triangular, hard, unjointed, stout, chitinised structures. The mandibles are located on either side of mouth behind labrum. They are dentate along their inner margins and are masticatory in function. First pair of maxillae: A pair of first maxillae is located behind mandibles on either side of the mouth. The maxillary palps are used for cleaning the antennae and also the front pair of legs.

Labium: Labium is formed by the fusion of second pair of maxillae. It is also known as lower lip. Hypopharynx: It is chitinous, grooved and a rod-like structure found hanging into the preoral cavity. It is also known as ligula or tongue.

Feeding

They are omnivores, so many types of food are attractive to them including sugars, proteins and fats. They feed on virtually any source of food including mould, decaying and faecal matter, which they can then carry on their bodies to hygiene-critical areas.

Life Cycle

The life cycle of a cockroach follows through three stages of incomplete metamorphosis: (1) egg, (2) nymph and (3) adult (Figure 29).

Cockroaches undergo egg and nymphal stages before becoming adults. Eggs produced by female cockroaches are enclosed in resilient egg cases known as oothecae. The oothecae of cockroach species contain a range of nymph numbers which is dependent on species. The time it takes for eggs to hatch into nymphs varies between species as well and depends upon environmental conditions. Nymphs free themselves from the oothecae by working in concert.

Nymphs resemble adults in appearance and behavior, although they are smaller in size and do not have wings. Nymphs undergo a series of molts before becoming fully mature adults. After the final molt, nymphs of some cockroaches are equipped with wings. After nymphs molt, they are pale in color. Nymphal cockroaches that have recently molted are

often misidentified as albino roaches. Within a few hours, they will darken to the proper color.

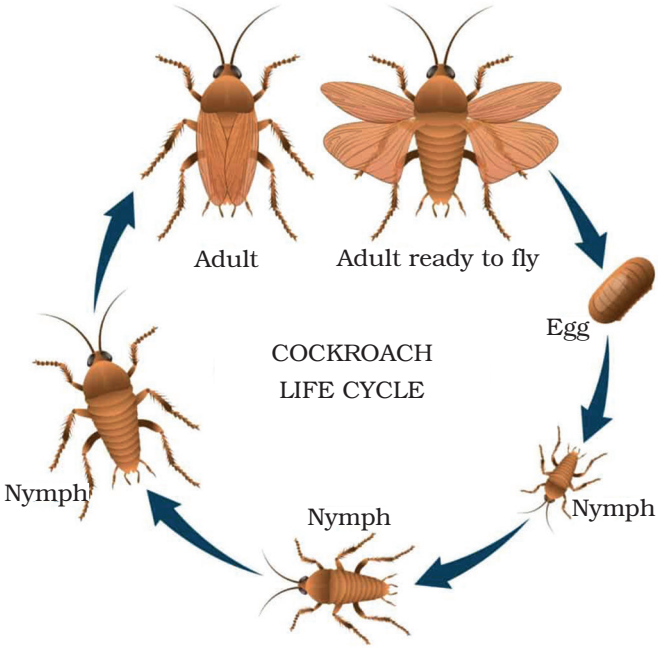


Figure 29. Life cycle of cockroach

Adult cockroaches have an average lifespan of around a year but it depends on species. Temperature and other environmental conditions greatly affect the survival of cockroaches.

How do cockroaches spread diseases? As they are reservoirs of organisms that cause disease rather than vectors, cockroaches can spread diseases through their droppings and saliva or by direct contact.

4.4 Caste Systems in Social Insects

Social insects are insects that live together in colonies or communities. There may be millions of individual insects in one community. Bees, wasps, ants and termites are examples of social insects. Social insect has an organization based on cast system and different casts of the insect carry different duties within the colony. Common characteristics of all social insects are:

They form huge colonies.

- Genetically related but reproductively confined to a single queen and the males that fertilize her.
- Their behavior is controlled by a chemical substance called pheromones.
- There is co-operation in caring for the offspring
- Show division of labor.

The Honey Bee

The bee that man keeps for honey is the smaller honey bee or Apis. There are different species of Apis, all with similar habits. A honey bee colony, consists of three types or castes of bees. These are: the queen, drones and workers (Figure 30).

The Queen

The queen is the fertile egg laying female. The queen is nearly twice as large as the worker bee. Usually there is a single queen in a hive.

- The queen mate with several male bees (drones) and will remain fertile for life.
- The queen lays thousands of eggs.
- Fertilized eggs develop into females (worker bees) and queen.
- Unfertilized eggs develop into males (Drones).
- The type of food provided for female larva determines whether they will become queen or workers. This food is called **royal jelly.**
- The queen secretes powerful pheromones within the nest that control the behavior of the workers at different stages of their development. This maintain the identity and social structure of the colony.

The Worker Bees

The workers are sterile females working on behalf of themselves and of the fertile members of the community. Workers are smaller than the queen or drones.

- Worker bees collect food for the colony. Also, they care for the young.
- They defend the hive from enemies.

- The worker bees have a clear division of labor depending upon their age.

Table 2 The Periods of work activity of worker bees

Days 1–3	Cleansing cells for reuse and incubation
Days 4 – 9	Devoted to nursing the grubs (larvae) Feeding the larvae on regurgitated food mixed with special secretions from the salivary glands.
Days 10 – 16	Wax making and cell building
Days 17 – 19	Receive the nectar which foraging bees bring back to the hive, convert it into honey bee and store it in cells.
Day 20	Entrance guards, nectar and pollen foraging

In bees, information is exchanged between individuals, foraging bees communicate to group of workers, on their return by means of the "waggle dance".

The waggle dance of a worker bee is the way the bee communicates the location of new food source to other worker bees.

The waggle dance is used when food is found more than 100 meters from the hive. This tells fellow – workers the precise direction and approximate distance of a newly discovered food source.

The dance is performed on the vertical cone surface (or on the floor, at the hive entrance). The "dancing" bee emits buzzing noises, vibrates its wings, and laterally vibrates its body. The round dance of the bee is used when food is close to the hive (approximately less than 100 meters).

The behavior of honey bee is determined by genetic constitution, upbringing and pheromones.

The Drones

The drones are males. Their duty is to fertilize the queen.

- The male bees are kept on standby during the summer for mating with virgin queen.
- Drone has a barbed sex organ, mating is follows death of the drone.
- Drone doesn't have a stinger. They have no use in the winter and expelled from the hive in the autumn (Figure 30).

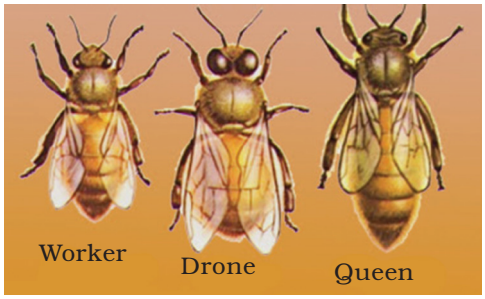


Figure 30. Different castes of honeybee

The hive of a honey bee contains a comb made of six-sided chambers called cells. The queen lays a single egg in each cell. Each develops in to a larva. After the pupal stage the new bee emerges from the cell and joins the colony.

The sex of a bee is determined by fertilization. Drones develop from unfertilized eggs. Females come from fertilized eggs. A queen bee develops from a female larva that is fed a substance called royal jelly. Female larvae not fed royal jelly become workers.

Some worker bees specialize in caring for the queen, making new hive cells, and feeding larvae. Others gather flower pollen and nectar.

Termites

Another group of social insects are the termites, or "white ants". They are not ants, but belong to a completely different insect group. Ants have a life history of complete metamorphosis, whereas, termites have an incomplete metamorphosis.

Termites live in nests, some underground, while others build the wrongly called "termite hills" which can reach heights of 8 - 10 feet, or more. These hard hills are made from particles of soil cemented together by the saliva of termites.

Different castes of termites live in the colony. The caste system consists of reproductive and sterile individuals.

Reproductive Individuals

These are males (Kings) and females (queens). At an early stage in their adult life both sexes have wings, they are pigmented and have functional eyes and sex organs.

Workers:

These are sexless or sterile, wingless, sightless (blind) and usually without pigment. This latter characteristic give them the name "white ant" Workers build nests and provide food for egg-laying female and all other colony members. They feed the young and care for them (Figure 31).

Soldiers

Like the workers, soldiers are sexless and wingless but are armed with a pair of large jaws. The soldiers can bite and inject a poison. Some soldiers do not have jaws but can spray poison at an enemy. These are called nasute soldiers. The soldiers guard the nest and prevent enemies from entering.

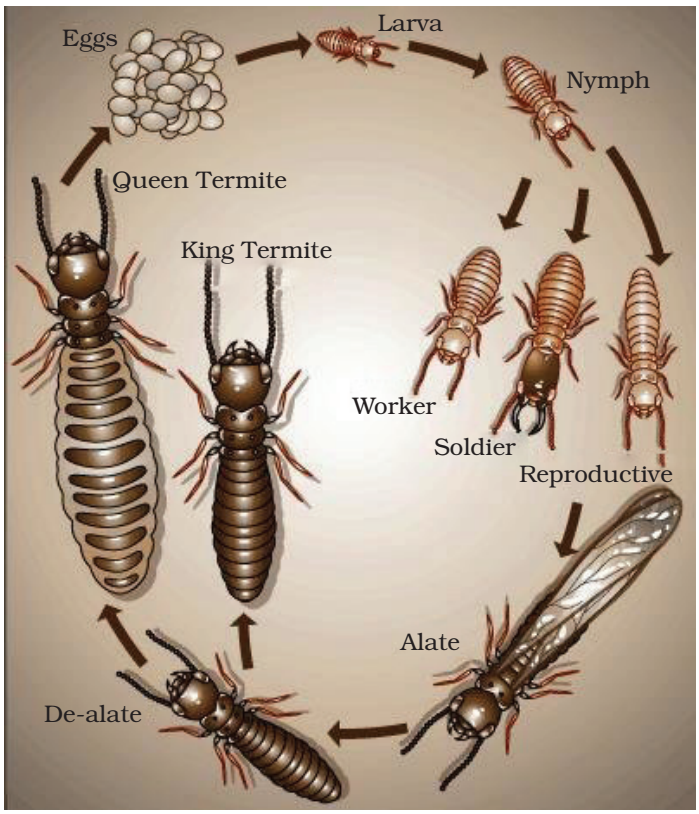


Figure 31. Life cycle of Termite

During the dry season, a small number of eggs are fed. The nymphs which hatch are larger and have eyes, wings and reproductive organs.

These winged termites live in the nest. At the beginning of the rains they come out and fly weakly around.

A large number of termites eaten by birds, others eaten by insects or lizards, and are even taken by men for food in some countries.

Those that survive form pairs – one male and one female.

They mate and lay a few eggs which hatch into workers. As soon as the workers are able to take over the work they seal up the king and queen. From then on the king and queen mate and lay eggs only.

Termites are important to man because they feed on fallen leaves and dead vegetation, speeding up the process of decay and the return of plant nutrients to the soil. Termites form tunnels that help to aerate the soil.

4.5 Economic importance of Social insects

Bees

Honey bees are used commercially for large scale pollination (agricultural crops and other plants) and honey production.

Bees also pollinate crops such as clover and alfalfa that cattle feed on, making bees important to our production and consumption of meat and dairy.

Honey bees (*Apis mellifera*) are economically essential insect pollinators all over the world. They provide ecologically for pollination of natural, wild vegetation plants and agricultural crops; as a result, they play a significant role in the landscape and natural resource preservation

Honey bees are of huge economic importance, vital for the pollination of many fruit, vegetable and seed crops. Also a wide variety of important products are made from the honey, beeswax, pollen, royal jelly and propolis that bees produce.

Bees contribute to the global food supply via pollinating a wide range of crops, including fruits, vegetables, oilseeds, legumes, etc. The economic benefit of bees to food production per year was reported including the cash crops, i.e., coffee, cocoa, almond and soybean, compared to self-pollination.

Honey is the most well known and most profitable of the direct products resulting from the efforts of honey bees. Honey is an antioxidant and as such may help in the prevention of cancers. Honey has medicinal value.

- Antibacterial property can cure cuts, burns & sore throat
- Antibiotic property protects skin & eyes. Honey also promotes growth of healthy tissues
- Beeswax is used in the production of candles and cosmetics. Oil obtained from bees wax is used to cure wounds.

Activity 7

Economic importance of honeybees and termites
State the economic importance of honeybees and termites.
Use this textbook, internet, or other books
Write a report

Termites

Termites are important in ecosystem as they consume and recycle plant, litter, and dung, and facilitate the release of nutrients back to the ecosystem

Harmful species of termites are considered as pests of agricultural crops, forestry trees, and woods due to their malicious activities causing considerable economic loss globally. Termites chew and bore timber, causing either a considerable degrade of the material or resulting in the death of the host tree.

Termites are pests of wooden portions of buildings and pastureland as well as non-cellulose materials such as dam linings, bridges and electrical cables. They are often a major constraint for reforestation, especially in the semi-arid and sub-humid tropics.

The economic importance of termites extends to mineral exploration, particularly in regolith-dominated terrain, where mineral deposit haloes have been masked by exotic and redistributed weathered materials.

- There are many dangers and problems termites pose when they invade homes
- They are very destructive hence, may destroy fruit trees, flowers and vegetables
- They also destroy furniture

Activity 8

Discussing honeybees and termites as social insects
Discuss the division of labor and behavior of honeybees and termites

Use this textbook, internet, or other books
Write a report

Exercise

Choose the correct answer from the suggested alternatives.

1. A typical insect has
   (a) Three body regions
   (b) No wings
   (c) Two airs of compound eyes
   (d) Three pairs of wings
2. To which body part of the insect are the legs attached?
   (a) Head
   (b) Thorax
   (c) Abdomen
   (d) A and B
3. Which insect damages the wooden frame work of homes?
   (a) Termite
   (b) Ant
   (c) Butterfly
   (d) Locust
4. The body part of an insect that contains the reproductive structure is called _____.
   (a) Head
   (b) Thorax
   (c) Abdomen
   (d) Leg
5. Which of the following casts of honeybee is also known as "egg laying machine" of the hive?
   (a) The worker
   (b) The soldier
   (c) The queen
   (d) The drone
6. Which of the following are **NOT** social insects?
   (a) Wasps
   (b) Termites
   (c) Ants
   (d) Locusts

7. Which of the following shows the life cycle of mosquitoes?
   (a) Egg-larva-pupa-nymph
   (b) Egg-larva-pupa-adult
   (c) Egg-nymph-Adult-larva
   (d) Egg-nymph-pupa-Adult
8. House fly transmits diseases such as_____
   (a) Typhoid and dysentery
   (b) Tuberculosis and syphilis
   (c) Syphilis and typhoid
   (d) Typhoid and malaria
9. Which of the following insects has one pair of wings?
   (a) Dragonfly
   (b) Bee
   (c) Locust
   (d) Housefly
10. Which of the following insects have a sharp needle-like mouth parts for piercing and sucking blood?
   (a) Locusts
   (b) Bees
   (c) Mosquitoes
   (d) Beetles

4.6 Pests

Insect Pests

A pest can be described as any organism capable of causing damage to crop plants. Pests are organisms considered harmful or detrimental to humans, his possessions and other human interests.

Economic importance of insect pests

- Insect pests destroy crops in the field through their biting, chewing, boring, sucking and defoliation activities.
- Spots of injuries by insects may predispose crops to disease attack.
- They increase the cost of production during the course of controlling them as a result of purchasing chemicals and labor incurred iN their application.

- Some are carriers or vectors of diseases e.g. Aphids are vectors of bean common mosaic virus and white flies as vectors of tomato leaf curl virus
- They reduce the quality of produce in the field as well as in the store e.g. Potato tuber moth on Irish Potatoes
- They render vegetables and fruits making unattractive and unmarketable e.g. damage on crucifer leaves by diamond back moth
- They generally reduce the yield of crops due to their feeding on the leaves and the harvestable parts of the crop
- They cause reduction in viability of stored produce.
- They can also cause total death of crop plants where the whole plant succumbs to the pest damage leading to reduction of profits or total loss. Example banana weevil *Cosmopolites sordidus*, burrowing nematode

Chemical Control

The word "pesticide" is a general term used to describe a substance (or mixture) that kills a pest, or it prevents or reduces the damage a pest may cause. Pests can be insects, mice or other animals, unwanted plants (weeds), fungi, bacteria or viruses.

Pesticides can also include any substance that is used to modify a plant's growth (regulator), drop a plant's leaves prematurely (defoliant), or act as a drying agent (desiccant). Pesticides are usually chemicals, but they can also be made from natural materials such as animals, plants, bacteria, etc.

The elimination of pests or the inhibition of their reproduction, development, or migration is known as pest control. The control of pests has a great influence on the world economy.

In the field of agriculture, pest control is used to protect farm crops and forests trees that are harvested for their wood. Pest control has also contributed to the management of many health-threatening diseases, including plague, encephalitis, yellow fever, malaria, and typhus.

The most common method of pest control is the use of pesticides chemicals that either kill pests or inhibit their development.

Pesticides are grouped into five main categories depending on the purpose they are usually applied for. The first group are the fungicides,

which act against fungi. Then there are herbicides which are used against weeds. Herbicides are taken up by the leaves or the roots of the weed, causing it to die. Insecticides that, as the name suggests, destroy harmful insects, and then there are acaricides which protect plants from mites. Finally there are nematicides to control nematodes that attack the plants.

Chemical pesticides are often used to control diseases, pests or weeds. Chemical control is based on substances that are toxic (poisonous) to the pests involved. Problems using chemical control include residues, crop damage, killing of beneficial insects and poisoning of humans and their animals.

Biological Control

Biological control is the use of living organisms to suppress pest populations, making them less damaging than they would otherwise be. Biological control can be used against all types of pests, including vertebrates, plant pathogens, and weeds as well as insects (Figure 32).

Figure 32. Methods of Biological Pest Control

The biological control of pests involves exposing them to predators or parasites.

Insect predators also have been used to control the bean beetle, tomato hornworms, and aphids. Another biological method is the use of bacteria against grubs, or insect larvae. For example, the bacterium Bacillus thuringiensis is used to control the caterpillar larvae of the gypsy moth, as well as the larvae of mosquitos

Biological control agents of plant diseases are most often referred to as antagonists. Biological control agents of weeds include seed predators, herbivores, and plant pathogens. Natural enemies of arthropods fall into three major categories: predators, parasitoids, and pathogens

Predators

Predators catch and eat their prey. Predators, such as lady beetles and lacewings, are mainly free-living species that consume a large number of preys during their lifetime.

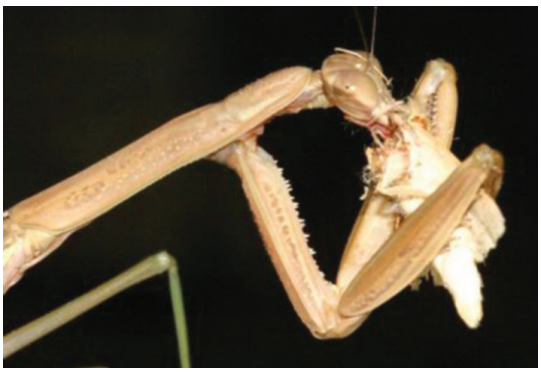


Figure 33. Preying mantid consuming insect prey.

Parasitoids

Parasitoids are species whose immature stage develops on or within a single insect host, ultimately killing the host. Parasitoids (sometimes called parasites) do not usually eat their hosts directly. Adult parasitoids lay their eggs in, on, or near their host insect. When the eggs hatch, the immature parasitoids use the host as food. Many parasitoids are very small wasps and are not easily noticed.

Figure 34. Parasitic ichneumonid wasp.

Pathogens

Pathogens are disease-causing organisms. Just as many other organisms get sick, so do insects. The main groups of insect disease-causing organisms are insect-parasitic bacteria, fungi, protozoa, viruses, and nematodes. Biological control using pathogens is often called microbial control. The insect-parasitic nematodes,

Figure 35. Uninfected Beet armyworm (bottom), and beet armyworm killed by a nuclear polyhedrosis virus.

infect soil-dwelling insects and occur naturally or can be arteficialy introduced.

As with all biological control agents, it is especially important to match the correct microbial control agent with the correct pest in order for them to be effective.

KEY TERMS

- Arthropoda
- Metamorphosis
- Vectors
- Royal jelly
- Pests
- Pesticide
- Predator
- Parasitoid

SUMMARY

- Arthropoda are invertebrate animals having jointed appendages or legs. It is a phylum of triploblastic, haemocoelomic, segmented body having head, thorax and abdomen, a chitinous exoskeleton and jointed legs and appendages.
- Arthropods is basically subdivided into five subphyla:
- Trilobites had disappeared in the Permian–Triassic extinction event.
- Chelicerates consist of arthropods such as spiders, mites, scorpions, horseshoe crabs, and other related organisms.
- Myriapods consist of arthropods such as the centipedes, millipedes, and their other relatives.
- Crustaceans are considered to be primarily aquatic and are basically characterized by having biramous appendages. Examples that are included in the Crustaceans are crabs, lobsters, crayfish, shrimp, and many more.
- Hexapods mainly consist of insects and three small orders of insects such as the animals with six thoracic legs.
- Sexual reproduction is the most preferred option by the arthropods that live in the aquatic environment and it is done by means of external fertilization. All the terrestrial arthropods are known to reproduce by the means of internal fertilization.

- Aquatic arthropods (crustaceans and the chelicerate horseshoe crabs) possess gills for respiration.
- Terrestrial arthropods possess tracheae and book lungs as respiratory organs.
- Molting and metamorphosis are two types of events in the lifecycle of animals. Molting mainly refers to the shed of the exoskeleton in arthropods. Metamorphosis is the transformation process of the animals from an immature form to a mature form.
- Complete and incomplete metamorphos are stages of growth and development in insects. The two occur in stages where they start with the egg stage and end with the adult stage. Complete metamorphosis occurs in four stages; egg, larva, pupa, and adult. Incomplete metamorphosis occurs in three stages; egg, nymph, and adult.
- Vectors are living organisms that can transmit infectious pathogens between humans, or from animals to humans. Many of these vectors are bloodsucking insects, which ingest disease-producing microorganisms during a blood meal from an infected host (human or animal) and later transmit it into a new host, after the pathogen has replicated.
- Honey bees rely on an important social structure that is highly organized. The colony itself-taking up residence in the hive consists of three types of honey bee: queen bees (egg producers), worker bees (infertile females), and drones (males whose purpose is to find and mate with a queen bee).
- A termite colony includes two major castes-sterile castes and reproductive castes. The caste system and the size of the colony are controlled by a pheromone, called social hormone, which is secreted by the members of reproductive castes (e.g., king and queen).
- Honey bees are used commercially for large scale pollination and honey production.
- Termites are important in the ecosystem as they consume and recycle wood, litter, leaf, and dung and release the nutrients back to the ecosystem.
- Insect pests destroy crops in the field through their biting, chewing, boring, sucking and defoliation activities.
- Chemical control of pests in agriculture and horticulture is a method of controlling pests through chemicals poisonous for pests.
- Biological control is the use of living organisms to suppress pest populations.

Exercise

1. The midgut of Arthropod receive secretion from _____ part.
   (a) Digestive tract
   (b) Reproductivetract
   (c) Pituitary gland
   (d) All
2. In Arthropod the need to molt during growth provide an opportunity for
   (a) Parthenogenesis
   (b) Metamorphosis
   (c) Both
   (d) None
3. Exoskeleton of Arthropod is made up of _____ .
   (a) Wax and chitin
   (b) Chitin and soft protein
   (c) Chitin and tanned protein
   (d) Protein and wax
4. The malignant tertian Malaria is caused by _____.
   (a) *Plasmodium malariae*
   (b) *Plasmodium ovale*
   (c) *Plasmodium falciparum*
   (d) *Plasmodium vivax*
5. Which of the following organisms will vanish if all the ponds and puddles are destroyed?
   (a) *Plasmodium*
   (b) *Trypanosoma*
   (c) *Leishmania*
   (d) *Ascaris*
6. Which class does the malarial parasite belong to?
   (a) Dinophyceae
   (b) Sarcodina
   (c) Ciliata
   (d) Sporozoa
7. *Trypanosoma* belongs to which of the following group?
   (a) Mastigophora
   (b) Sarcodina
   (c) Sporozoa
   (d) Ciliata

8. Which of the following protozoan causes African sleeping sickness
   (a) *Plasmodium vivax*
   (b) *Entamoeba gingivalis*
   (c) *Trypanosoma lewsii*
   (d) *Trypanosoma gambiense*
9. Which of the following is **NOT** correct about insects?
   (a) They are the largest group of animals
   (b) They all are harmful to man
   (c) They are found all over the world
   (d) They show metamorphosis in their cycle.
10. Insects which transmit disease causing agents from a patient to a healthy person are called
   (a) Hosts
   (b) Vectors
   (c) Parasites
   (d) Pathogens
11. Which of the following is the feeding stage in the life cycle of insects?
   (a) Egg
   (b) Larva
   (c) Pupa
   (d) (b) and (c)
12. Which sequence shows the life cycle of an insect that undergoes incomplete metamorphosis?
   (a) Egg → larva → Adult
   (b) Egg → pupa → adult
   (c) Egg → Nymph → adult
   (d) Egg → larva → pupa → adult
13. Which of the following is NOT true about harmful insects?
   (a) They spread disease
   (b) Eat and destroy crops
   (c) They kill armful pests
   (d) Spoil food

B10CH05

CHAPTER 5

PLANT LIKE ORGANISMS (ALGAE, MOSSES, FERNS, FUNGI) AND PHOTOSYNTHESIS

Chapter Contents

Chapter Outcomes

At the end of this chapter the learners should be able to:

- describe the general characteristics, structures and life cycles of Algae, Mosses Ferns, and Fungi;
- explain the economic importance of Algae and Fungi to human;
- describe the process of reproduct ion in Algae;
- explain types of nutrition of Fungi;
- describe symbiotic relationship of Fungi in relation to parasitism and saprophytism;
- list common Fungal diseases of Plants and Animals such as (athlete foot, ringworm dishcloth, blight;
- explain the process of Photosynthesis.

Introduction

The term algae was first introduced by Linnaeus in 1753, meaning the Hepaticae. The algae comprise of a large heterogeneous assemblage of plants which are diverse in habitat, size, organisation, physiology, biochemistry, and reproduction. Mosses are a phylum of non-vascular plants. They produce spores for reproduction instead of seeds and don't have flowers, stem or true roots. Instead of roots, all species of moss have rhizoids. Fern, class of non-flowering vascular plants that possess true roots, stems, and complex leaves and that reproduce by spores. The ferns constitute an ancient division of vascular plants, some of them as old as the carboniferous period and perhaps older. Their type of life cycle, dependent upon spores for dispersal, long preceded the seed-plant life cycle. A fungus is a Eukaryote that digests food externally and absorbs nutrients directly through its cell walls. Most fungi reproduce by spores and have a body (thallus) composed of microscopic tubular cells called hyphae. Fungi are heterotrophs and, like animals, obtain their carbon and energy from other organisms.

Photosynthesis definition states that the process exclusively takes place in the chloroplasts through photosynthetic pigments such as chlorophyll a, chlorophyll b, carotene and xanthophyll. All green plants and a few other autotrophic organisms utilize photosynthesis to synthesize nutrients by using carbon dioxide, water and sunlight. The by-product of the photosynthesis process is oxygen. As it turns out, some of the light energy absorbed by pigments in leaves is converted to chemical energy. Light energy is converted to chemical energy during the first stage of photosynthesis, which involves a series of chemical reactions known as the light-dependent reactions.

5.1 Algae

Algae exist in environments ranging from oceans, rivers, and lakes to ponds, brackish waters and even snow. Algae are usually green, but they can be found in a variety of different colors. For instance, algae living in snow contain carotenoid pigments in addition to chlorophyll, hence giving the surrounding snow a distinctive red hue.

Algae are defined as a group of predominantly aquatic, photosynthetic, and nucleus-bearing organisms that lack the true roots, stems, leaves, and specialized multicellular reproductive structures of plants. It is an

important group of Thallophyta (Thallos — a sprout; phyton — a plant), the primitive and simplest division of the plant kingdom. The orderly systematic study of algae is called Phycology. The algae are chlorophyll-containing primitive plants, both prokaryotic and eukaryotic, starting from unicellular to multicellular organisations. Multicellular forms of algae include the giant kelp and brown algae. Unicellular forms include diatoms, euglenophyta and dinoflagellates.

Characteristics of Algae

The general characteristics of algae are common to plants as well as animals. For instance, algae can photosynthesize like plants, and they possess specialized structures and cell-organelles, like centrioles and flagella, found only in animals. Listed below are some of the general characteristics of algae.

- Algae are photosynthetic organisms.
- Algae can be either unicellular or multicellular.
- Algae lack a well-defined body, so, structures like roots, stems or leaves are absent.
- Algae are found where there is adequate moisture.
- Reproduction in algae occurs in both asexual and sexual forms. Asexual reproduction occurs by spore formation.
- Algae are free-living, although some can form a symbiotic relationship with other organisms.

Classification of Algae

F.E. Fritsch (1935, 1945) in his book "The Structure and Reproduction of the Algae" proposed a system of classification of algae. He treated algae giving rank of division and divided it into 11 classes. His classification of algae is mainly based upon characters of pigments, flagella and food reserve. Eleven classes proposed by Fritsch are as follows.

Class Chlorophyceae (Green Algae)

Unicellular, colonial or multicellular green plants, generally with simple structure; principal pigments are chlorophyll a and b, carotenes and xanthophylls as in higher plants, contained in plastids. The stored form of food is mostly starch and frequently aggregates around the pyrenoids. Reproduction is by asexual and sexual means. Zoospores biflagellate or

quadriflagellate flagella anterior isokontae, whiplash type having cell wall made of cellulose and pectin, fresh water or marine. Examples are *Chlamydomonas, Chlorella, Oedogonium* and Volvox.

Class Xanthophyceae (Yellow Green Algae)

Mostly unicellular, most advanced forms have a simple filamentous habit; principal pigments are chlorophyll a and e, β-carotene and xanthophylls, food reserve is mostly fat; sexual reproduction rare and isogamous. Cell wall frequently consists of two overlapping halves, constituents are pectin and silica, sometimes cellulose, the motile cells with two unequal flagella at the anterior, one tinsel and the other whiplash type, most abundant in fresh water, a few are marine. Examples are Botrydium, Bumilleriopsis, *Tribonema*, and *Vaucheria*.

Class Chrysophyceae (Golden Algae)

Mostly unicellular, colonial and filamentous forms, principal pigments are chlorophyll a, β-carotene and xanthophylls; stored form of food is fat; sexual reproduction rare, specialized resting cells known as cysts produced endogenously, flagellated forms have either one flagellum tinsel type or when two, one tinsel and one whiplash type. Cell wall consists of pectin and silica, fresh water and marine.

Examples are *Chrysamoeba*, *Chrysocapsa*, *Lagynion*, *Ochromonas*, *Chromulina* and *Synura*

Class Bacillariophyceae (Diatoms)

All unicellular or colonial, principal pigments are chlorophyll a and c, β-carotene and xanthophylls, storage product in the form of fat, sexual reproduction is of widespread occurrence by auxospore formation. Cell wall of pectin and silica, silicified cell wall, precise nature of motile bodies not known.

Examples are *Cyclotella*, *Thalassiosira* (centrics), *Fragilaria* and *Bacillaria*, *Navicula* and *Nitzschia* (pennates).

Class Cryptophyceae

Unicellular flagellated forms, principal pigment nature not definitely known except the phycobilins, reserve food in the form of starch; cell wall is made of cellulose, two unequal flagella; sexual reproduction rare and isogamous.

Examples are *Chilomonas*, *Cryptomonas*, *Falcomonas*, *Chroomonas*, *Rhinomonas*, and *Teleaulax*.

Class Dinophyceae

Many of them are with motile unicelled structure, principal pigments are chlorophyll a and c, β-carotene and xanthophylls; reserve food is starch or fat; sexual reproduction rare and isogamous.

Examples are *Porocentrum Ceratium*, *Dinophysis*, *Gonyaulax*, *Tetradinium*, *Noctiluca*, *Peridinium*, and *Polykrikos*.

Class Chloromonadineae

Unicellular, chromatophore bright green with excess of xanthophylls; reserve food is fat, motile cells are biflagellate, only fresh water, Example is *Vaucheria*.

Class Euglenineae

Simple unicellular or colonial motile organisms, pigments chlorophyll a and b, β-carotenes, xanthophyll; reserve food a polysaccharide paramylon, related to starch and fats. Sexual reproduction not proved definitely; no cell wall, motility by flagella, usually one or sometimes more, tinsel type.

Examples are *Colacium*, *Euglena*, *Eutreptiella*, *Phacus* and *Peranima*

Class Phaeophyceae (Brown Algae)

Structurally the most complex algae, simple filaments to massive plant bodies. Pigments include chlorophyll a and c, β-carotene and xanthophylls , Stored food in the form of laminarin (polysaccharide) and mannitol form of alcohol. Cell wall constitution algin, fucoidin and cellulose. Sexual reproduction ranges from isogamy to oogamy, two unequal flagella attached laterally, one tinsel and the other whiplash type; most of the species are marine.

Examples are *Fucus*, *Laminaria*, *Nereocystis*, *Pelvetia* and *Sargassum*.

Class Rhodophyceae (Red Algae)

Most forms multicellular, pigment contents are chlorophyll a and d, α- and β carotene and xanthophylls, phycobilins-r-phycoerythrin and r-phycocyani. Reserve food in the form of floridean starch. Cell wall constitution polygalactose sulphate esters and cellulose; motile cells at

any stage of the life history are unknown. Sexual reproduction advanced oogamous type, mostly marine, a few are fresh water.

Examples are *Bangia*, *Chondrus*, *Corallina*, *Gelidium*, *Porphyra*, and *Rhodymenia*.

Class Cyanophyceae/Myxophyceae (Blue-Green Algae)

Simple unicellular, colonial or multicellular bodies; lacking nuclear, mitochondrial and chloroplast double membranes. Cell wall composed of pectin or cellulose; most forms are embedded in mucilaginous or gelatinous sheaths. Pigments not in organized bodies as in other cases; principal pigments are chlorophyll-a, β-carotene, xanthophyll's and phycobilins, c-phycoerythrin and c-phycocyanin. Reserve food in the form of cyanophycean starch; no motile cell has been observed at any stage. Reproduction is of the bacterial type, 'False' branching and special types of cells called 'heterocyst' are characteristic features in many. Most diverse in distribution, from pole to pole, almost everywhere, ubiquitous. Examples *Nostoc*, *Anabaena*.

Phytoplankton

Phytoplankton are the autotrophic components of the plankton community and a key part of ocean and freshwater ecosystems. The name comes from the Greek words Phyton, meaning 'plant', and planktos meaning 'wanderer' or 'drifter'. Phytoplankton, also known as microalgae. They are similar to terrestrial plants in that they contain chlorophyll and require sunlight in order to live and grow. Most phytoplankton are buoyant and float in the upper part of the ocean, where sunlight penetrates the water. Phytoplankton also require inorganic nutrients such as nitrates, phosphates, and sulfur which they convert into proteins, fats, and carbohydrates.

Some phytoplankton are bacteria, some are protists, and most are single-celled plants. Among the common kinds are cyanobacteria, silica-encased diatoms, dinoflagellates, green algae, and chalk-coated coccolithophores.

Phytoplankton are extremely diverse, varying from photosynthesizing bacteria (cyanobacteria), to plant-like diatoms, to armor-plated coccolithophores (Figure 1).

Like land plants, phytoplankton have chlorophyll to capture sunlight, and turn it into chemical energy by the process called photosynthesis.

They use carbon dioxide, and release oxygen. All phytoplankton photosynthesize, but some get additional energy by consuming other organisms.

Figure 1. Different types of phytoplankton

The two main classes of phytoplankton are dinoflagellates and diatoms. Dinoflagellates use a whip-like tail, or flagella, to move through the water and their bodies are covered with complex shells. Diatoms also have shells, but they are made of a different substance and their structure is rigid and made of interlocking parts. Diatoms do not rely on flagella to move through the water and instead rely on ocean currents to travel through the water.

In a balanced ecosystem, phytoplankton provide food for a wide range of sea animals including shrimp, snails, and jellyfish. When too many nutrients are available, phytoplankton may grow out of control and form harmful algal blooms. These blooms can produce extremely toxic compounds that have harmful effects on fish, shellfish, mammals, birds, and even people.

Green Algae (Chlorophyta)

Green algae are organisms which are characterized by having chlorophylls a and b as the major photosynthetic pigments; starch located within the chloroplast as the major storage product and the flagella of the whiplash (smooth) type

Chlorophyta are commonly known as green algae and sometimes, loosely, as seaweed. They grow primarily in freshwater and saltwater, although some are found on land. They may be unicellular (one cell), multicellular (many cells), colonial (a loose aggregation of cells), or coenocytic (one large cell). Chlorophyta convert sunlight to starch that is stored in cells as a food reserve.

Green algae, variable in size and shape, include single-celled (*Chlamydomonas*, desmids), colonial (*Hydrodictyon*, *Volvox*), filamentous

(*Spirogyra*, *Cladophora*), and tubular (*Actebularia*, *Caulerpa*) forms. Sexual reproduction is common, with gametes that have two or four flagella. Asexual reproduction is by cell division (*Protococcus*), motile or nonmotile spores (*Ulothrix*, *Oedogonium*), and fragmentation (Figure 2).

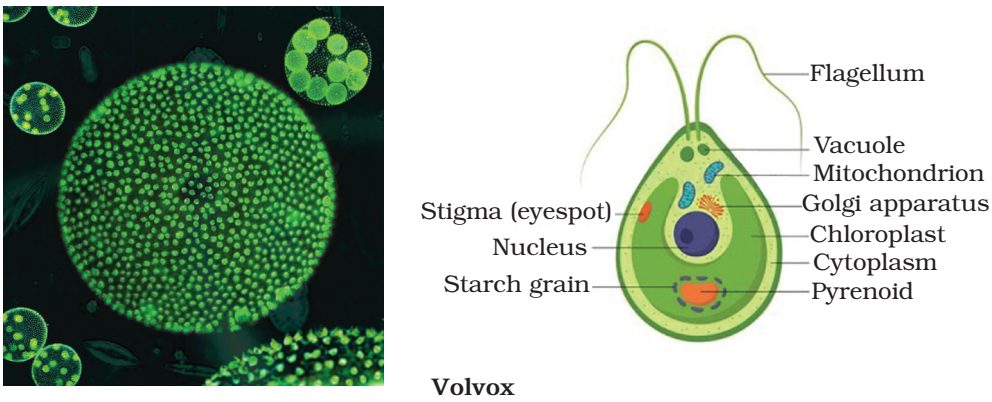


Figure 2. Colonies of Volvox globular contain thousands of individual cells. Each cell usually has two flagella that propel it through substances such as water.

Spirogyra Reproduction

Spirogyra are free-floating green algae present in freshwater habitats such as ponds, lakes, etc. Spirogyra are commonly known as "water silk or pond silk". They have a filamentous and unbranched vegetative structure. Spirogyra are photosynthetic and contribute substantially to the total carbon dioxide fixation carried out. They increase the level of oxygen in their habitat. Many aquatic organisms feed on them (Figure 3).

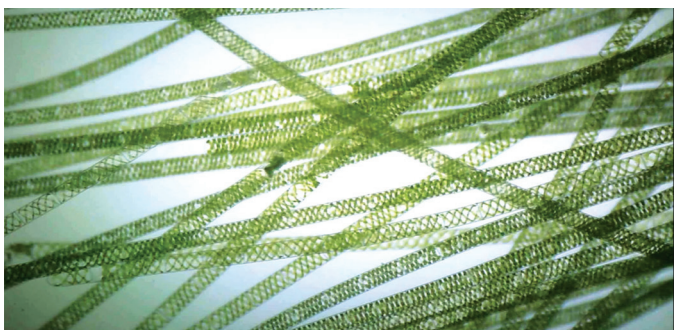


Figure 3. Spirogyras are filamentous green algae, named for their spiraling chloroplasts.

Spirogyra species can reproduce both sexually and asexually.

ACTIVITY 1

Drawing and labelling *Spirogyra.*
Draw and label the parts of *Spirogyra.*
Use this textbook, other books or internet.

Asexual Reproduction in *Spirogyra*

Spirogyra is a filamentous alga. It reproduces asexually by fragmentation. Under favorable conditions, vegetative reproduction is the preferred mode of reproduction.

- The vegetative filament after fragmentation develops into a new filament. Each fragment undergoes multiple division and elongates to form a new filament.

Fragmentation under ideal condition of food, sunlight and water a mature filament of spirogyra simply breaks into pieces. Each fragment forms a new filament (Figure 4).

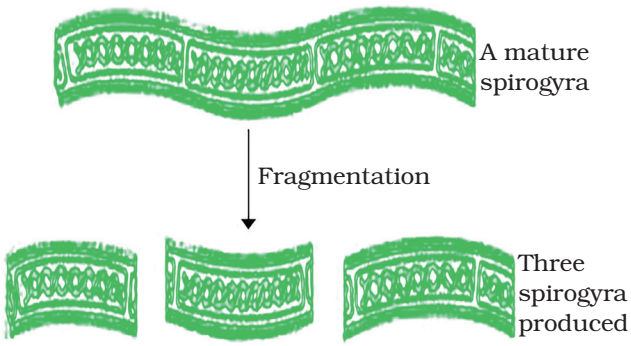


Figure 4. Asexual reproduction is found in few of the species of Spirogyra. Asexual reproduction is by the formation of a zygospores, akinetes or aplanospores.

Formation of aplanospores occurs under unfavorable conditions. The protoplast shrinks and forms a wall around it. This results in the formation of aplanospores

- Akinetes are also formed similarly, but they have a thicker cell wall of cellulose and pectin.
- Akinetes and aplanospores are non-motile spores, which develop into a new filament under favorable conditions after the decay of the parent filament.
- Azygospores are also known as parthenospores. These are the gametes, that failed to fuse during sexual reproduction and develop into a new filament asexually.

Sexual Reproduction in *Spirogyra*

Sexual reproduction in Spirogyra takes place by conjugation, i.e. the union of two non-motile gametes. Sexual reproduction in Spirogyra can be considered as isogamous type as there is no any differences in the shape of gametes resulting from the conjugation of non-flagellated gametes. However, one of the gametes can be regarded as male as it migrates and another as female as it remains stationary. So they can be regarded as morphologically isogamous but physiologically anisogamous.

ACTIVITY 2

Drawing and labelling sexual reproduction in *Spirogyra*.
Draw and label the stage of sexual reproduction in *Spirogyra*.
Use this textbook, other reference materials.

Conjugation is of two types, scalariform conjugation and lateral conjugation.

Scalariform Conjugation

Scalariform conjugation requires association of two or more different filaments lined side by side, either partially or throughout their length. Each cell from opposite lined filaments that emits tubular protuberances known as conjugation tubes. The conjugation tubes elongate and fuse to make a passage called the conjugation canal.

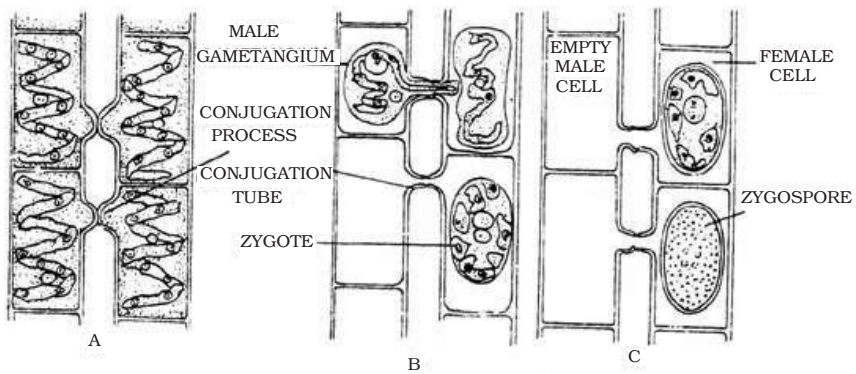


Figure 5. Stages in scalariform conjugation of Spirogyra

Scalariform conjugation is most common method of sexual reproduction in spirogyra that takes place in heterothallic or dioecious (having sexes that reside in different individuals) species (Figure 5).

During the time of conjugation both the filaments of different strains lie parallel facing each other. The close contact induces the secretion of more mucilage which holds the filament more firmly. All the cells of both filaments produce a small dome shaped protuberances in their longitudinal walls facing each other. These small tubular protuberances is known as transverse tubes or papillae.

The papillae grow in size and come in contact with each other through their anterior end. Upon their contact, the papillae get dissolved by an enzyme called cytase and forms a common tube-like passage known as conjugation tube. The cells of both filaments connected by conjugation tubes are called gametengia one of which function as male gametengium and other as female gametengium. Simultaneously, the protoplasmic content of gametengia contract from the cell wall by losing water and metamorphose into a naked, non-motile and non-ciliated gametes. The protoplast of male gamete moves towards the female gamete in another filament through conjugation tube. The protoplast of two gametes fuse to form a zygote. The zygote secrete a thick wall around itself and known as zygospores. As a result, the zygospores are formed in series in one filament and another filament remain empty.

In conjugating filaments each pair undergoes the same process as mentioned above. Hence the structure looks like ladder steps due to the presence of number of conjugation tubes between them. So, this process is named as scalariform conjugation.

Lateral Conjugation

In lateral conjugation, adjacent cells of a *Spirogyra* species function as male and female gametes. Conjugation tubes are formed between cells of the same filament (Figure 6).

Lateral conjugation is of two types:

Direct lateral conjugation: Passage is formed between two adjacent cells through the middle lamella. Male gametes fuse with female gametes. Zygotes are formed in alternate cells.

Indirect lateral conjugation: The conjugation canal is formed by the cell having male gamete and joins the adjacent cell having female gamete.

The zygote in *Spirogyra* is known as zygospores. Zygospores are diploid (2n) and formed by the fusion of male and female gametes. Zygospores are the only diploid stage in the life cycle of *Spirogyra*.

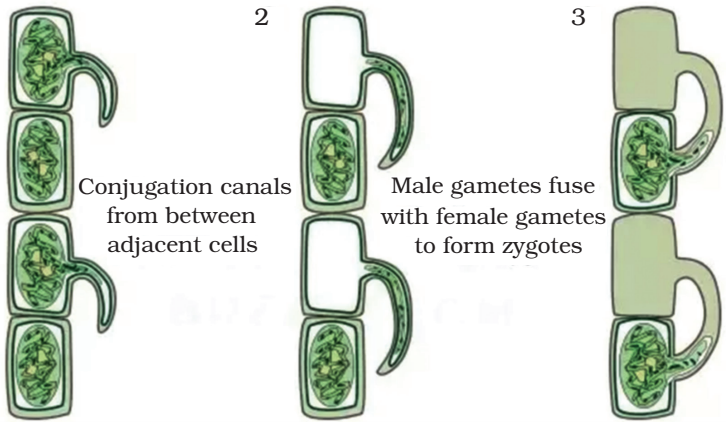


Figure 6. Stages in Lateral conjugation of Spirogyra

The zygospore remains dormant until favorable conditions are available. At the time of germination, the zygospore undergoes meiosis to form 4 haploid (n) nucleus, of which only one survives and others disintegrate. Developing zygospore burst open to form germ tube. The germ tube divides repeatedly by transverse division and develops into a new haploid filament of *Spirogyra*.

Economic Importance of Algae

Algae are economically important in a variety of ways. They can be used as a food source, a fodder, in fish farming, and as a fertilizer. It also plays a key role in alkaline reclaiming, can be used as a soil binding agent, and is used in a variety of commercial products. A brief account of the uses of algae is given below:

Algae Used as Food

Most species of marine algae (red, brown and green algae) are edible, such as *Porphyra*, *Sargassum* and *Laminaria*. *Chlorella* and *Spirulina* are protein-rich. They are thus used as food supplements. Ulva a green alga, commonly known as 'sea lettuce', is taken by man as a vegetable. These are a healthy source of carbohydrates, fats, proteins, and vitamins A, B, C, and E as well as the minerals like iron, potassium, magnesium, calcium, manganese and zinc.

Algae Used in Medicine

A large number of medicines are obtained from algae. The brown algae like *Laminaria*, *Sargassum*, etc., are good sources of iodine. These algae also yield medicines for treatment of goiter and gland diseases. Antibiotics are also prepared from some of these algae. *Chloranthus*, an antibiotic is obtained from Chlorella.

Algae used in Industry

The algae are used in various kinds of industries. These are as follows:

Agar Industry

Agar is a transparent substance obtained from the red algae, like *Gelidium*, *Gracillaria*. It is solid at normal temperature but becomes liquid above 95 C. Agar is used for the preparation of culture media for fungi and bacteria in the laboratory.

Algin Industry

Algin is a gelatinous or jelley like substance obtained from the cell-wall of some red algae. It is used in different commercial purposes, like the preparation of shampoos, cosmetics, hair dressings, shaving creams and other articles of toilet, shoe polishes, lubricating jellies, ice-creams and desserts. It is also used in paints and rubber industry.

Kelp Industry

The ash left behind, after burning the brown algae, like *Laminaria*, *Sargassum*, etc., is known as kelp. It chiefly contains potassium and iodine.

Diatomaceous Earth Industry

The diatomaceous earth is a kind of earth deposited at the bottom of the sea, after the death and decay of Diatoms.

The uses of diatomaceous earth are-much varied, viz., as a filtering material, as a substance used in insulation of boilers, blast furnaces, etc., as a cementing material, as a mild abrasive in metal polishes and tooth-pastes, as an absorbent for liquid nitroglycerine (the explosive material of the dynamite), as a material for painting the ship to protect it against the attack of sea-barnacles.

Iodine industry: is mainly depended upon algae. Algae belonging to Phaeophyceae, like *Laminaria*, *Ecklonia*, *Eisenia*, etc. are used in the industry to prepare Iodine.

Exercise

Choose the best answer from the given alternative provided

1. *Chlamydomonas* and Volvox are similar because
   (a) They are filamentous
   (b) They are colonial
   (c) They have diploid thallus
   (d) Both of them are motile
2. Plants which are not differentiated into roots, stem and leave are grouped under.
   (a) Gymnosperms
   (b) Pteridophytes
   (c) Thallophytes
   (d) Spermatophytes
3. Which are the most primitive group of algae
   (a) Blue green algae
   (b) Red algae
   (c) Brown algae
   (d) Green algae
4. Which one of the following is a colonial alga?
   (a) *Ulothrix*
   (b) *Spirogyra*
   (c) *Volvox*
   (d) *Chlorella*
5. Characteristics used to place algae into divisions include all of the following except
   (a) Form of storage material
   (b) Flagella number and location
   (c) Accessory pigments used in photosynthesis
   (d) All of the above.

5.2 Mosses

Mosses are flowerless small plants found under the division Bryophyta along with liverworts and hornworts. They do not possess any vascular system like xylem and phloem also lack true stem root and leaf. Mainly

absorb water and nutrients through their leaf like structure. They are mostly found in damp, shady locations as mats or clumps on the forest floor. They usually grow up only to a height of about 10cm, but have an exceptional genus Dawsonia which grows up to 50 cm (Figure 7).

Additionally, mosses are anchored to the substrate, whether it is soil, rock, or roof tiles, by multicellular rhizoids. These structures are precursors of roots. They originate from the base of the gametophyte, but are not the major route for the absorption of water and minerals.

Setae:

Figure 7. This photograph shows the long slender stems, called setae, connected to capsules of the moss Thamnobryum alopecurum.

General Characteristics of Mosses

The main characteristics of the Mosses are:

- The mosses are the plants which inhabit moist brick walls and they form a thick layer as a mat on forest floor as well as on the shaded trees.
- Mosses also require water as a medium for completing their life cycle.
- The gametophytic plant body has short stem and large number of whorls of leaves surrounding it.
- There is alternation of generation between the haploid gametophytic phase and the diploid sporophytic phase.

- The gametophytic phase produces the haploid gametes.
- The sperm is produced inside the antheridia and egg is produced inside the archegonia.
- Fertilization occurs resulting in the formation of the zygote which undergoes mitosis and forms the sporophyte.
- The gametophytic plant body anchor to the substratum by means of rhizoids.
- The sporophyte is attached to the gametophytic plant body. It lacks chlorophyll it depends on the photosynthetic gametophyte.
- The sporophyte consists of the foot, stalk and a capsule.
- By meiotic division the haploid spores are produced inside the capsule.
- As the spores matures the lid of the capsule get opened.

Reproduction: Alternation of Generation

Life Cycle

The life cycle of mosses alternates between the haploid gametophyte and the diploid sporophyte called alternation of generation. The male and female gametophyte produces haploid gametes, which fuse to form zygote and give rise to diploid sporophyte. The sporophyte then produces haploid spores which germinate to haploid gametophyte.

Gametophyte

- The gametophyte is structurally differentiated into stems and leaves, and forms the male and female sex organs at their tips.
- The female sex organ are known as archegonia which are shaped like bottle containers and only one cell thick. They are protected by modified leaves known as perichaetium.
- The male sex organ is known as antheridia and is a tiny, stalked and club shaped structure. They are protected by modified leaves known as perigonium.
- The antheridium mature to release antherozoids, which are biflagellate in structure. They swim in water and fertilise with the egg of the archegonium.

- The formation of diploid zygote leads to the second life phase of mosses, that is the sporophyte.
- The archegonium later goes on to divide to form calyptra which acts as a protective structure for the capsule in sporophyte.

Sporophyte

- The diploid zygote develops into a diploid sporophyte. A sporophyte consists of a foot, a long stalk called seta, a capsule which is capped by the operculum.
- The sporophyte remains attached to the gametophyte much like a parasite, dependent for food and water on the gametophyte, and divides by mitosis.
- The capsule has spore producing cells which undergo meiosis to form haploid spores.
- The capsule has teeth like structures called peristomes which prevents the falling off of spores in wet conditions.
- When the conditions are favorable, that is, the spores are ready to be dispersed, the operculum and peristome fall off and the spores are dispersed in the environment.

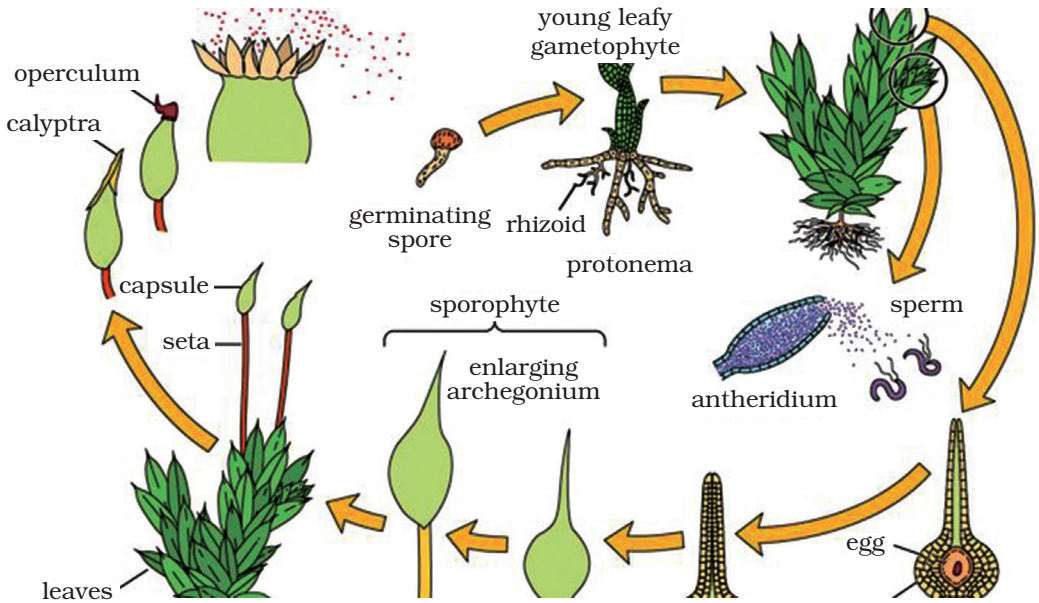


Figure 8. Life cycle of moss.

- The spores on falling on a wet damp ground germinate to form protonema, which are threadlike, filamentous structures. Protonema acts as a transitional structure which is later developed into a gametophyte, completing the life cycle (Figure 8).

Economic Importance of Mosses

Packing Material

Most of the mosses are used as packing material after being dried. They make a fairly good packing material in the case of glass ware and other fragile goods. Especially the dried peat mosses (Sphagnum spp.) are used to pack bulbs, cuttings and seedlings for shipment.

Used in Seed Beds

Since the peat mosses have remarkable power to absorb and hold water like a sponge, they are extensively used in seed beds and green houses to root cutting. The peat mosses (Sphagna) are also used to maintain high soil acidity required by certain plants.

As a Source of Fuel

The peat is also a potential source of coal. Dried peat may be used as fuel.

Absorbent Bandages

The *Sphagnum* plants are slightly antiseptic and possess superior absorptive power. On account of these properties they may be used for filling absorbent bandages in place of cotton, in the hospitals.

Protection from Soil Erosion

Mosses, form dense mats over the soil and prevent soil erosion by running water.

Soil Formation

Mosses are an important link in plant succession on rocky areas. They take part in binding soil in rock crevices formed by lichens. Growth of *Sphagnum* ultimately fills ponds and lakes with soil.

As Food

Mosses are good source of animal food in rocky and snow-clad areas. They are used by florists for home decoration.

Exercise

Choose the best answer from the given alternative provided

1. Bryophyte differ from pteridophyte in being
   (a) Non vasculature
   (b) Seeded
   (c) Vasculature
   (d) Sporophytic
2. A specialized organ of the sporophyte for attachment to the gametophyte Is called _____ .
   (a) Stalk
   (b) Foot
   (c) Apophysis
   (d) root
3. Which of the following is diploid in mosses.
   (a) Spore
   (b) Leaves
   (c) Spore mother cell
   (d) Gametes
4. Which is worng about bryophytes?
   (a) Water is essential for fertilization
   (b) Presence of archegonia
   (c) Presence of ciliated sperms
   (d) Presence of autotrophic independent sporophyte
5. A characteristic feature of bryophytes
   (a) They have chloroplasts
   (b) They have archegonia
   (c) They are thalloid
   (d) All of the above.

5.3 Ferns

Most of the ferns are small perennial herbs. Tree ferns with long pillar-like stem and a crown of leaves at the top are found only in tropical countries. The plant body is differentiated into stem, roots and leaves

with well-developed vascular bundles. The stem is usually a creeping underground rhizome bearing many adventitious roots.

It remains covered by a large number of persistent leaf-bases. Pinnately compound leaves, often called fronds, spring up from the rhizome. The leaves, when young, remain coiled inwards thus, exhibiting circinate vernation.

Figure 9. Ferns

General Characteristics of Ferns

The ferns are an extremely diverse group, and there is no single characteristic that defines them. The following features are present in most:

- Leaves, called fronds, are megaphylls. Most are compound with a rachis and numerous pinnae. Almost all have circinate vernation that are coiled (circinate) tightly in "shepherd's crook" or crozier fashion over the growing tips. These unroll as they mature. Stems, for the most part, are rhizomes that grow at, or just under, the ground surface. They have only primary tissues. "Tree" ferns have erect, thick trunks, the bulk coming from roots clustered around the small true stem. Roots are simple, uncomplicated and arise adventitiously along the rhizomes near the base of the fronds (Figure 9).
- Sporangia are located, for the most part, on the undersides of ordinary leaves in clusters called sori (singular, sorus). In many ferns a small leaf outgrowth called an indusium covers each sorus. Ferns have the highest number of chromosomes known in vascular plants (Figure 10).

- Most modern ferns are homosporous.

Reproduction of Ferns: Alternation of Generation

Unlike moss, the fern plant is the spore-bearing generation or sporophyte. The leaflets bear some brown kidney-shaped dots, called sori (sing, sorus), on the under surface. They are usually present directly on the veins or vein-endings.

Figure 10. Sori on the underside of Fern leaf

Life Cycle of Ferns

The following events occur in sexual phase or gametophyte generations:

Fern spore grows into a short green filament.

1. The filament becomes a heart-shaped prothalus that is anchored to the soil by means of root-like rhizoids.
2. The antheridium (male reproductive organ) and archegonium (female reproductive organ) grow on the upper surface of the prothalus.
3. The antheridium induces plenty of sperms and the archegonium induces a single egg. Since the prothalus gives rise to sperms and eggs it is called the gametophyte of the fern. The gametophytes are small, photosynthetic thalli that live anchored to the ground with rhizoids. Many are heart - shaped and only one - cell layer thick (Figure 11).

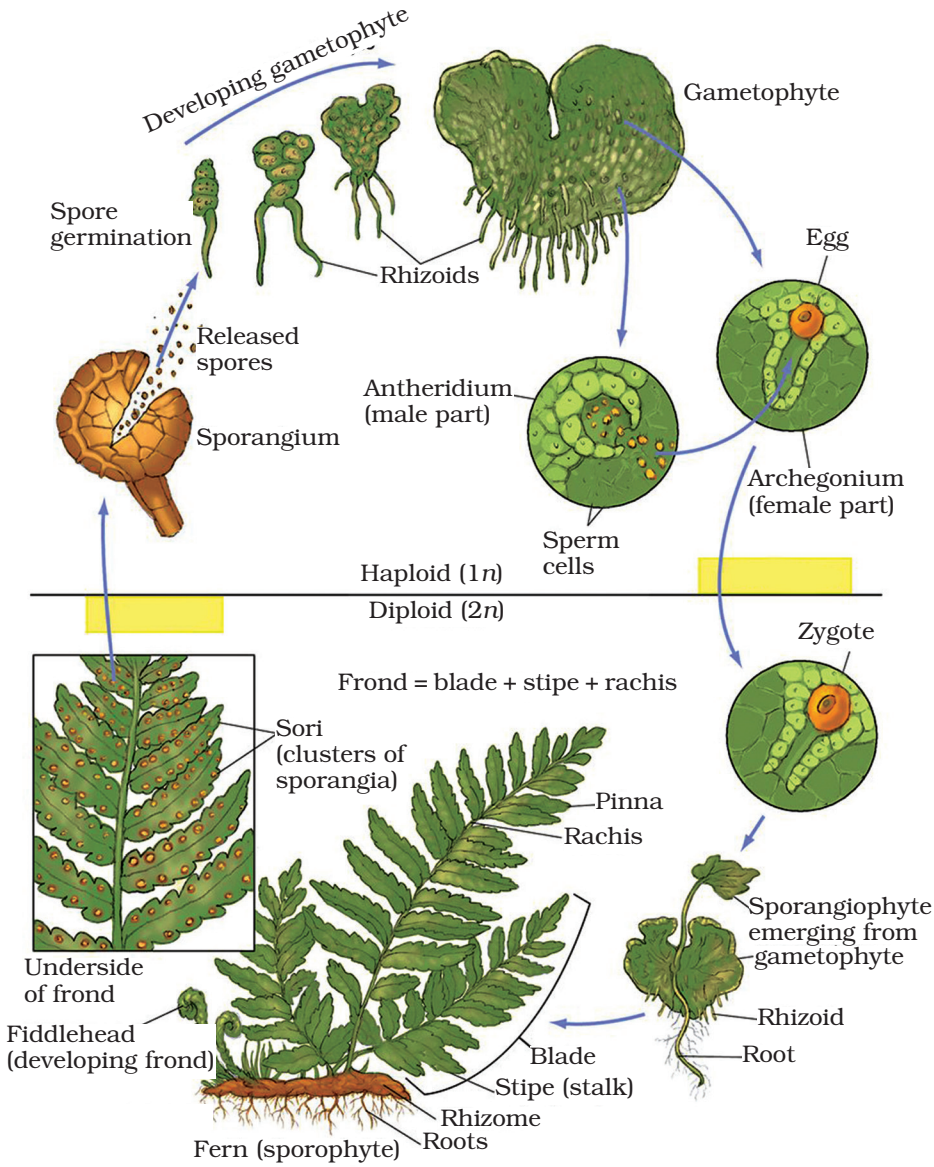


Figure 11. Fern structure and life cycle

The following events occur in asexual phase or sporophyte generation:

1. Through the process of fertilization; the egg inside the archegonium fuses with the sperm from the antheridium.
2. The fertilized egg or zygote develops into a young fern plant which sprouts to a mature size.

3. Sporangia produce spores on the lower surface of the fronds and released when mature. Sorus is a cluster of sporangia (plural for sori). Since the familiar leafy fern plants produces spores it is the sporophytes of the fern. The sporophytes of ferns are independent, divided into leaves, stems (rhizomes), and roots, and have vascular tissues.

ACTIVITY 3

Drawing and labelling the life cycle of mosses and ferns.
Draw the life cycles of Mosses and ferns.
Use reference materials, other than your textbook.

Economic Importance of Ferns

Importance of Ferns

Ferns commonly known as Vascular Cryptogams, are the seedless vascular plants that evolved after bryophytes. Besides being a lower plant, ferns are economically very important.

- Ferns are used by people for ornamental purposes.
- Fern is a source of food. In Philippines and in Asia the young fronds of certain fern leaves and rhizomes are used for food.
- Dry fronds of many ferns are used as a cattle feed.
- Pteridophytes are also used as a medicine. The fern, Dryopteris yield an anthelminthic drug.
- Made and used as binding and decorative purposes.
- Tropical species of ferns are used as pot plants.
- Pteridophytes are also used as an indicator plant. *Equisetum* accumulates minerals, especially gold, in their stem. Similarly, *Asplenium adulterinum* is an indicator of nickel and *Actinopteris australis* is a cobalt indicator.
- Several ferns have aesthetic values for their beautiful habit, graceful shape of the leaves, and beautiful soral arrangement.

5.4 FUNGI

Fungi: are achlorophyllous, heterotrophic, eukaryotic thallophytes. They are non-green in color with the capacity to live in all kinds of environments. They generally feed on dead and decaying organic matter. The structure of fungi can be explained in the following points:

- Almost all the fungi have a filamentous structure except the yeast cells.
- They can be either single-celled or multicellular organisms.
- Fungi consist of long thread-like structures known as hyphae. These hyphae together form a mesh-like structure called mycelium.
- Fungi possess a cell wall which is made up of chitin and polysaccharides.
- The cell wall comprises a protoplast, which is differentiated into other cell parts such as cell membrane, cytoplasm, cell organelles and nuclei.
- The nucleus is dense, clear, with chromatin threads. The nucleus is surrounded by a nuclear membrane.

Activity 4

Observing and identifying bread mold.

You need

A dropper, toothpick, bread with mold, glass slide, cover slip, Light microscope, water

Method

Using a dropper, place a drop of water at the center of a glass slide.

Using a toothpick scrap a little mold off the bread and introduce it into the drop of water in the glass slide.

Place a cover slip on the glass slide.

Place the slide on the microscope for viewing starting with lower to higher power.

Observe parts of the hyphae of *Rhizopus*.

Draw and label the parts of the hyphae of *Rhizopus*.

Activity 5

Illustrate life cycle of *Rhizopus*.

Illustrate the life cycle of *Rhizopus* with the aid of diagram or picture.

Use this textbook, internet, other books, or videos.

General characteristic of Fungi

Following are the important characteristics of fungi:

- Fungi are eukaryotic, non-vascular, non-motile and heterotrophic organisms.

- They may be unicellular or filamentous.
- They reproduce by means of spores.
- Fungi exhibit the phenomenon of alternation of generation.
- Fungi lack chlorophyll and hence cannot perform photosynthesis.
- Fungi store their food in the form of starch.
- Biosynthesis of chitin occurs in fungi.
- The nuclei of the fungi are very small.
- The fungi have no embryonic stage. They develop from the spores.
- The mode of reproduction is sexual or asexual.
- Some fungi are parasitic and can infect the host.

Examples include mushrooms, molds and yeast

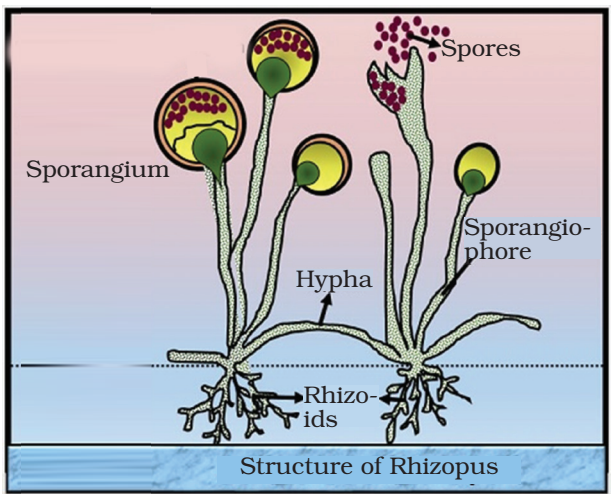


Figure 12. Structure of Rhizopus (Fungi)

Classification of Fungi

Kingdom Fungi are classified into the following based on the formation of spores:

Zygomycetes

These are formed by the fusion of two different cells. The Sexual reproduction is isogamous producing a thick-walled sexual resting

spore called a zygospores, while the asexual spores are known as sporangiospores. The hyphae are without the septa. Example – *Mucor*.

Ascomycetes

They are also called sac fungi because their sexual spores are produced in a sac or ascus. They can be coprophilous, decomposers, parasitic or saprophytic. The sexual spores are called ascospores. Asexual reproduction occurs by conidiospores. The hyphae are septate. Example – *Saccharomyces*.

Basidiomycetes

Mushrooms are the most commonly found basidiomycetes and mostly live as parasites. Sexual reproduction occurs by basidiospores that are produced by a club-shaped structure called a basidium. Asexual reproduction occurs by conidia, budding or fragmentation. Basidiomycetes also possess septate hyphae. Example- *Agaricus*.

Activity 6

Explaining the life cycle of club fungus
Explain the different stages of their lifecycle
Draw and label the lifecycle club fungus

Deutromycetes

They are otherwise called imperfect fungi as they do not follow the regular reproduction cycle as the other fungi. They do not reproduce sexually. Asexual reproduction occurs by conidia. Example – *Trichoderma*.

Nutrition in Fungi

Fungi are eukaryotic organisms that lack chlorophyll and depend on other organisms for their nutrition. Fungi secrete digestive enzymes that break down the food into simple molecules that can be absorbed through the cell wall. The absorbed molecules are used to produce energy and to build new cells.

Activity 7

Collecting and identifying bracket fungus and identifying annual rings
You need:
Camera and tripod, field note book, pocket knife, mirror, small towel, truffle, rake, paint brush, ruler, GPS, Tags for labeling and storage containers.

Method

1. Look for fruit bodies in good condition
2. Select fruit bodies
3. Your specimen collection will come from the same log trunk.
4. Use knife to dig out basal portion of the stipe keeping it intact, with some of mycelium
5. Never mix collections from different sites
6. Collect enough material.
7. Observe the structures of the fungus.
8. Identify the annual rings.

Draw and label the structures of the fungus.

Write a report.

Mode of life in Fungi

The fungi are achlorophyllous organisms. Hence, they cannot prepare their own food. They live as heterotrophs *i.e.*, as parasites and saprophytes.

Parasites: Parasitic fungi are those fungi that live in or on other organisms, usually plants, and derive their nutrients from them A parasite could be facultative or obligate. The obligate parasites survive and settle on a living host throughout their life. The facultative parasites are saprophytes that have turned parasitic. Many parasitic fungi are serious plant pathogens that can cause extensive damage to crops. Some parasitic fungi are also human pathogens, causing diseases such as histoplasmosis, blastomycosis, and coccidioidomycosis.

Saprophytes: procure their nutrition from dead and decaying organic matter. They break down the organic matter into simple molecules that they can absorb and use for energy and growth. Saprotrophic fungi can play an important role in the decomposition of organic matter and the recycling of nutrients back into the environment. The saprophytes are either obligate or facultative. An obligate saprophyte remains saprophytic during its entire lifetime. While a facultative saprophyte is nothing but a parasite that has secondarily become saprophytic.

Diseases that Affect Plant and Human

Blight spreads by fungal spores that are carried by insects, wind, water and animals from infected plants, and then deposited on soil. The disease requires moisture to progress, so when dew or rain comes in contact with fungal spores in the soil, they reproduce.

Late blight is a fungal disease that can infect tomato and potato plants. The disease spreads rapidly and will likely destroy the infected plant in a few days. Wind and water-borne fungal spores can quickly spread to other plants.

Figure 13. Blight infecting potato leaves

Symptoms: include sudden and severe yellowing, browning, spotting, withering, or dying of leaves, flowers, fruit, stems, or the entire plant.

Smut: Plan disease primarily affecting grasses, including corn (maize), wheat, sugarcane, and sorghum, caused by several species of fungi. Smut is characterized by fungal spores that accumulate in soot like masses called sori, which are formed within blisters in seeds, leaves, stems, flower parts, and bulbs. The sori usually break up into a black powder that is readily dispersed by the wind. Many smut fungi are Basidiomycetes and enter embryos or seedling plants, develop systemically, and appear externally only when the plants are near maturity. Other smuts are localized, infecting actively growing tissues (Figure 14).

Figure 14. Corn smut

Rust diseases: Are grouped based on the taxonomic classification of the pathogens. They are fungi in the phylum Basidiomycota, class Pucciniomycetes, and order Pucciniales. Rust fungi are obligate plant pathogens that only infect living plants. Infections begin when a spore lands on the plant surface, germinates, and invades its host. Infection is limited to plant parts such as leaves, petioles, tender shoots, stem, fruits, etc. Plants with severe rust infection may appear stunted, chlorotic (yellowed), or may display signs of infection such as rust fruiting bodies (Figure 15).

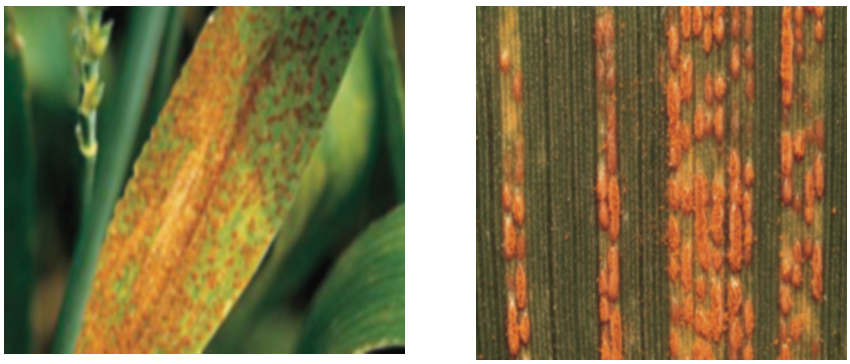


Figure 15. Leaf rust. Small circles represent rust pustules from which the spore will emerge.

Athlete's foot (Tinea pedis)

Tinea pedis is a foot infection due to a dermatophyte fungus. It is the most common dermatophyte infection and is particularly prevalent in hot, tropical, urban environments.

Figure 16. Tinea pedis infection

It is a contagious fungal infection that affects the skin on the feet and feed on keratin, a protein found in hair, nails, and skin. It can also spread to the toenails and the hands. Infection is usually acquired by direct contact with the causative organism, for example using a shared towel, or by walking barefoot in a public change room. The fungal infection is called athlete's foot because it's commonly seen in athletes (Figure 16).

Yeast Infection

Candidiasis is an infection caused by a yeast (a type of fungus called *Candida*. *Candida* normally lives inside the body (in places such as the mouth, throat, gut, and vagina) and on skin without causing any problems. Sometimes *Candida* can multiply and cause an infection if the environment inside the vagina changes in a way that encourages its growth. Candidiasis in the vagina is commonly called a "vaginal yeast infection." A vaginal yeast infection isn't considered a sexually transmitted infection. But, there's an increased risk of vaginal yeast infection at the time of first regular sexual activity. There is also some evidence that infections may be linked to mouth to genital contact (oral-genital sex).

Ring Worm

Ringworm is a skin infection that is caused by fungus. It can appear on any area of your skin and even your toenails and fingernails. It typically appears as a ring-shaped rash that may cause red skin that is scaly or itchy. It may also cause hair loss in the affected area. Ringworm often spreads by direct skin-to-skin contact with an infected person or animal. Ringworm, or *Tinea corporis*, refers to several types of contagious fungal infections of the top layer of the skin, scalp, and nails. It is called ringworm because the itchy, red rash has a ring-like appearance (Figure 17).

Eczema (atopic dermatitis) is caused by a combination of immune system activation, genetics, environmental triggers and stress. If you have eczema, your immune system overreacts to small irritants or allergens. This overreaction can inflame your skin. Eczema triggers include low humidity, skin exposure to solvents, over washing of the skin with soaps and detergents and/or lotions, rough wool clothing, food allergies, and repeated wetting. It also includes the overuse of antibiotics, occlusion

of skin (skin folds), and in skin areas that are often damp and subject to friction (diapers, tight-fitting clothes).

Figure 17. Sometimes the rash grows, spreads, or there's more than 1 rash.

ACTIVITY 8

Stating ways of preventing fungal infection.
State ways of preventing the spread of fungal infection.
Use reference material, i.e., internet, books.

Economic Importance of Fungi

In food

- Mushrooms and truffles are used as food due to their high protein content.
- Ascomycetes are used in food production like in bread-making by yeast, cheese ripening by *Penicillium roqueforti*.
- Yeast metabolites like ethanol impart flavor to the beer which are esters of higher alcohols (e.g. isobutanol).
- Many fungi are responsible for spoilage of food stuffs economic losses of stored food.

In medicine

The role of fungi in the medicine industry.

- They help in the production of different antibiotics against pathogenic bacteria or microorganisms.
- One most important antibiotic is produced from the fungi, called Penicillin from *P. notatum* and *P. chrysogenum*. It kills the gram-positive bacteria.

- The antibiotic Streptomycin also obtained from the fungi called *Streptomyces griseus*. It destroys the gram-negative organisms, which are not killed by penicillin.
- Many antibiotics such as Chloromycetin, Aureomycin, Terramycin, etc. are also obtained from *Actinomycetes.*
- Sclerotia is produced by the *Claviceps purpurea* in the ovaries of the flowers of grasses such as rye. The sclerotium is known as the ergot of rye. The derivative of ergot is known as the lysergic acid (LSD) used in experimental psychiatry and as a contrasceptive.

The anti-cancer substance Calvacin is obtained from the giant Puffball Clavatia.

In industry

- Fermentation of Alcohol.
- Preparations of Enzyme.
- Organic acid Preparation. The moulds are used to produce several organic acids such as oxalic acid, citric acid, gluconic acid, gallic acid, fumaric acid, etc.
- Gibberellins. The fungi *Gibberella fujikuroi* is responsible for the production of these hormones.
- Cheese Production. Some Fungi are used in the refining process of cheese, which are known as cheese moulds.

Reproduction in Fungi

Reproduction is the formation of new individuals having all the characteristics typical of a species. The fungi reproduce by means of asexual and sexual reproduction. Asexual reproduction is sometimes called somatic or vegetative and it does not involve union of nuclei, sex cells or sex organs. The union of two nuclei characterizes sexual reproduction.

Asexual Reproduction

In fungi, asexual reproduction is more important for the propagation of species. Asexual reproduction does not involve union of sex organs (gametangia) or sex cells (gametes) or nuclei. In fungi the following are the common methods of asexual reproduction.

1. Fragmentation of mycelium from any part of the thallus may grow into new individuals when suitable conditions are provided.
2. Fission of unicellular thalli (transverse cell division): Reproduction by the method of fission is are in fungi. Fission is simple splitting of cells into two daughter cells by constriction and the formation of a cell wall. It is observed in *Schizosaccharomyces spp.*
3. Budding is the production of a small outgrowth (bud) from a parent cell.As the bud is formed, the nucleus of the parent cell divides and one daughter nucleus migrates into the bud. The bud increases in size, while still attached to the parent cell and eventually breaks off and forms a new individual. It is common in yeasts (*Saccharomyces* sp.) (Figure 18).

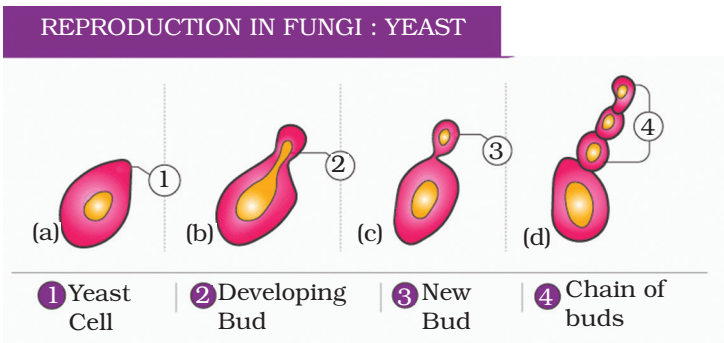


Figure 18. Budding in yeast

4. Production of asexual spores : Reproduction by the production of spores is very common in many fungi.

Spores: The term 'spore 'is applied to any small propagative, reproductive or survival unit, which separates from a hypha or sporogenous cell and can grow independently into a new individual.

Asexual Spores

The most common mode of asexual reproduction is through the formation of asexual spores, which are produced by one parent only (through mitosis) and are genetically identical to that parent. Spores allow fungi to expand their distribution and colonize new environments. They may be released from the parent thallus either outside or within

a special reproductive sac called a sporangium. The spores produced asexually are: a. Sporangiospores b. Conidia c. Chlamydospores

Sporangiospores

Sporangiospores may be motile (planospores)or nonmotile spores (aplanospores).

Sporangiospores are formed in sac-like structure called sporangium. Sporangium are produced at the end of special aerial hyphae called sporangiophore. e.g., *Rhizopus* (Figure 19)

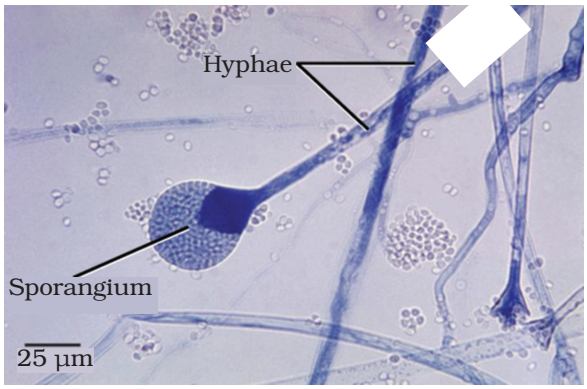


Figure 19. Release of spore from a sporangium

Zoospore: It is an asexually produced spore, which is motile by means of flagellum or flagella for its movement in the surrounding film of water. They are formed in a zoosporangium. Zoospore is naked. Normally, zoospores are uninucleate and haploid. The functions of zoospores include initiation of new generation and acting as gametes.

Conidiospores

Conidiospores or conidia (sing. Conidium) are asexual reproductive structures borne on special spore bearing hyphae conidiophores. Conidia are different from sporangiospore as these are not produced inside sporangium or any sac like structure. They are found in many different groups of fungi, but especially in Ascomycotina, Basidiomycotina and Deuteromycotina. In Deuteromycotina conidia are the only means of reproduction. Conidia may be borne singly or in chains or in cluster. Generally, the term 'conidia 'is used for any asexual spores other than sporangia and spores formed directly by hyphal cells. e.g. *Penicillium*, *Apergillus*.

Chlamydospores

Chlamydospores are usually formed during unfavorable condition and are thick walled single celled spore, which are highly resistant to adverse condition. Hyphal cell or portion of hyphae contracts, loose water, round up and develops into thick walled chalmydospore. When favorable condition returns, each chlamydospore give rise to a new individual fungus. e.g. Ascomycetes, Basidiomycetes, Zygomycetes, Candida albicans.

Arthrospore:

- Arthrospore are very primitive type of spore formed by the breaking up of fungal mycelium
- A spore is formed by separation followed by fragmentation of hyphae
- Examples: *Trichosporium, Geotrichum, Coccididious imitis*

Blastospore:

- It is a budding spores usually formed at the terminal end of hyphae.
- These spore may remain attached to hyphae and bud further to give branching chain of blastospores
- Examples: Ascomycetes, Basidiomycetes, Zygomycetes

Activity 9

Diagram showing reproduction in fungus.
Draw the asexual and sexual reproduction in fungus.
Use reference material including this textbook.

Sexual Reproduction In Fungi

The sexual stage in fungi is called the perfect state in contrast to the imperfect state which is the asexual stage. Sexual reproduction involves the fusion of two compatible sex cells or gametes of opposite strains. Fungal sex organs are called gametangia. They may be equal in size. In many higher ascomycetes morphologically different gametangia are formed. The male gametangia are called antheridia and the female ones ascogonia.

Sexual reproduction introduces genetic variation into a population of fungi. In fungi, sexual reproduction often occurs in response to adverse

environmental conditions. During sexual reproduction, two mating types are produced.

Homothallic or self-fertile- when both mating types are present in the same mycelium.

Heterothallic mycelia - require two different, but compatible, mycelia to reproduce sexually.

Although there are many variations in fungal sexual reproduction, all include the following three stages.

Plasmogamy two haploid cells fuse, leading to a dikaryotic stage where two haploid nuclei coexist in a single cell.

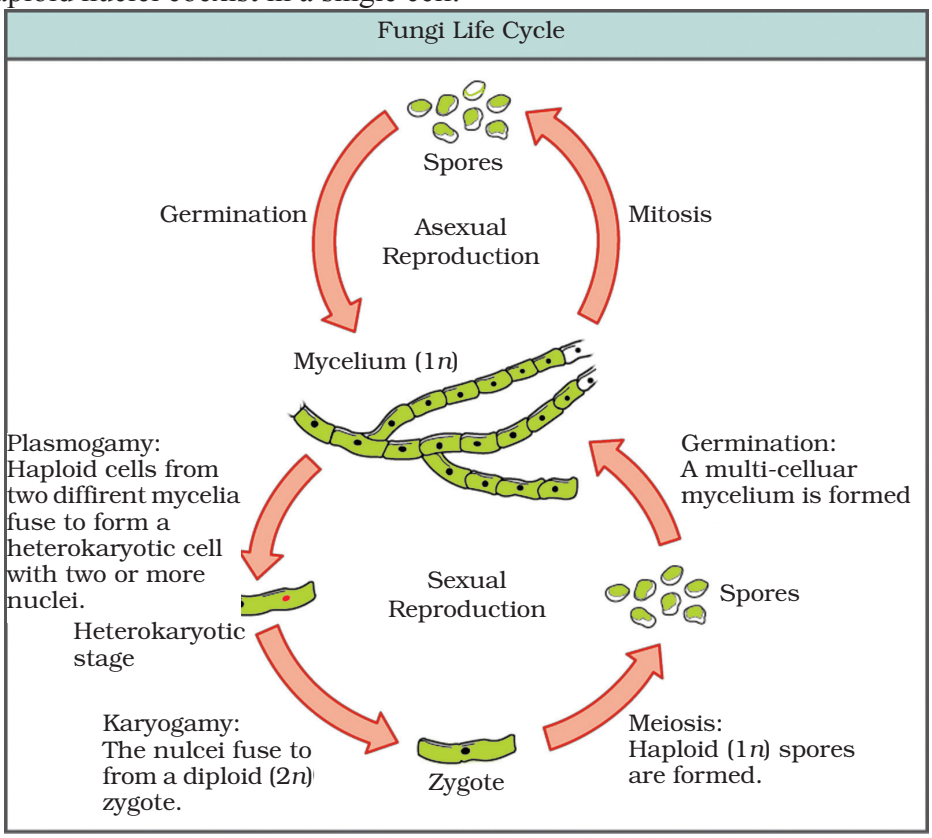


Figure 20. Life cycle of fungi

Karyogamy the haploid nuclei fuse to form a diploid zygote nucleus.

Meiosis takes place in the gametangia (singular, gametangium) organs, in which gametes of different mating types are generated. At this stage, spores are disseminated into the environment. These three processes

occur in a regular -sequence and at a specific time, during the sexual stage of each species.

Plasmogamy

It is the union of protoplasts of reproductive hyphae or cells, one from the male and the other from the female to bring about the nuclei of the two parents close together as a pair. However, the two nuclei do not fuse with each other. Such a cell is called a dikaryon. The dikaryotic condition is unique to fungi and may continue for several generations as the two nuclei (dikaryon) divide simultaneously during cell division. These are passed on to the daughter hypha.

Karyogamy: The fusion of the two nuclei which takes place in the next phase is called karyogamy. It may immediately follow plasmogamy as in lower fungi, or it may be delayed for a long time as in higher fungi.

Meiosis

Karyogamy which eventually occurs in all sexually reproducing fungi is sooner or later followed by meiosis producing four genetically different spores.

Exercise

Choose the best answer from the given alternative provided

1. All fungi are
   (a) Autotrophs
   (b) Saprophytes
   (c) Parasites
   (d) Heterotrophs
2. One of the common fungal diseases of man is
   (a) Cholera
   (b) Plague
   (c) Ringworm
   (d) Typhoid
3. Which of the following fungus is the most important in the wine industry?
   (a) Yeast
   (b) Mold
   (c) Mycorrhiza
   (d) Mushrooms

4. Spore bearing leaf is called
   (a) Sorus
   (b) Indusium
   (c) Ramentum
   (d) Sporophyll
5. The structure that produce gametes in the prothallus are
   (a) Anthers and archegonia
   (b) Ascogonium and anthers
   (c) Antheridia and archegonia
   (d) None of these
6. What happens to the spore of ferns?
   (a) It germinates to become a prothallus
   (b) It germinates to become another spore forming a fern plant
   (c) It joins with another spore forming seedling
   (d) It encysts and in devoured by snail
7. The dominant generation in pteridophyte is
   (a) Haploid
   (b) Gametophytic
   (c) Diploid
   (d) Triploid

5.5 Photosynthesis

Photosynthesis the process by which green plants and certain other organisms transform light energy into chemical energy. During photosynthesis in green plants, light energy is captured and used to convert water and carbon dioxide, into oxygen and energy-rich organic compounds. Photosynthesis takes place inside plant cells in small organelles called chloroplasts. Chloroplasts contain a green substance called chlorophyll. This absorbs sun light needed for photosynthesis. Plants and algae can only carry out photosynthesis in the light.

Plants get carbon dioxide from the air through their leaves, and water from the ground through their roots. Light energy comes from the sun.

The oxygen produced during photsynthesis is released into the air from the leaves. The glucose produced can be turned into other substances, such as starch and plant oils, which are used as an energy store. This energy can be released by respiration.

Conditions for Photosynthesis

Below are things that plants need for photosynthesis:

Water: Plants absorb water from the soil through their roots. The water is transported to all cells in the plants. Excess water is released through pores called stomata found in plant's leaves. When the air around the plant becomes saturated with water, the humidity rises. This prevents water vapor from evaporating from the stomata and water from being drawn up from the roots. This can cause a water deficit in the plant, causing the plant to close its stomata. With the stomata closed, carbon dioxide is blocked from entering the plant, slowing photosynthesis

Light: Plants get the energy they need for photosynthesis from light. Plants use only some of the wavelengths of light in sunlight to support the light-dependent reactions of photosynthesis.

Too little light, too much light, or the wrong kind of light, will affect photsynthesis in plants.

Chlorophyll: This is the green pigment found in the leaves of plants. Nutrients and minerals: Chemicals and organic compounds are absorbed from the soil by plant roots.

Glucose and oxygen are the products of photosynthesis.

Carbon dioxide + water (+light energy) → glucose + oxygen

$6CO_2 + 6H_2O$ (+Light energy) $C_6H_{12}O_6 + 6O_2$

Activity 10

Extraction of chlorophyll from plant leaves.

You need:

80% acetone (cooled)

Methanol (cooled)

Quartz sand

Method

1. Cool 80% acetone or methanol
2. Place a mortar and pestle on ice
3. Cut leaf material in pieces
4. Put the material in the mortar that was place on ice.
5. Keep the tubes and 80% acetone cooled on ice during the extraction
6. The flasks have to be kept in ice and dark
7. Add to mortar a bit of quartz sand and a few 80% acetone.
8. Grind until you have a homogenous suspension
9. Put the suspension in centrifugation tube

10. Centrifuge for 5 minutes
11. Extract the pellet with 5 ml of 80% acetone and centrifuge for 5 minutes.
12. Repeat the procedure until the green color of the pellet has gone.
13. Let the samples warm up by taking them out of the ice (Keep them in a dark)
14. The supernatant in the volumetric flask is made up to 25 ml with 80% acetone.
15. The chlorophyll extract is ready to be measured in the spectrophotometer.

Observe your results

Write a report

Temperature: Temperature, including air temperature and soil temperature, affects most processes of plant growth, photosynthesis, water intake, nutrient intake, and cell division. High temperatures can interfere with photosynthesis by causing the enzymes that regulate the process to "unravel." Cold temperatures can damage plant roots and even cause the plant to die. At temperatures below 7 C (about 45 F), the roots of a plant cannot take up water and nutrients (Figure 21).

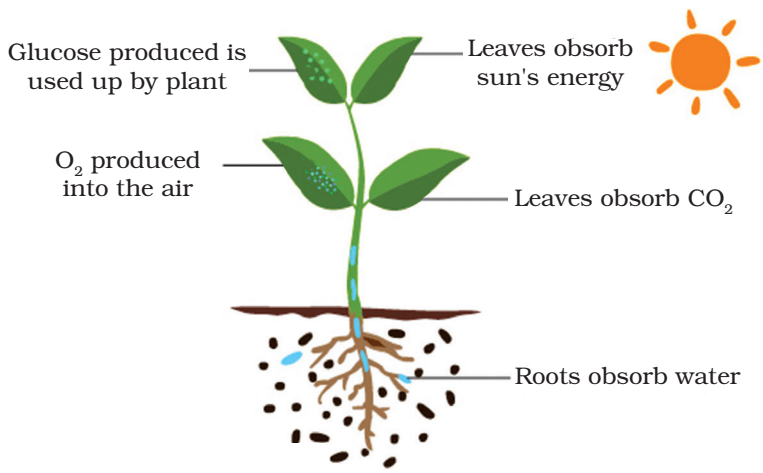


Figure 21. Sunlight in photosynthesis

Carbon Dioxide: Plants need carbon dioxide for photosynthesis. They take carbon dioxide in from the atmosphere through tiny holes in their leaves. But the increase in carbon dioxide could cause the temperature to rise to a point that is damaging to some plants.

Plants get CO_2 from the air through their leaves and water from the ground through their roots. Light energy comes from the sun.

The oxygen produced is released into the air from the leaves. The glucose produced can be turned into other substances, such as starch, used as a store of energy. This energy can be released by respiration.

Leaf Adaptation to Photosynthesis

Leaves are adapted for photosynthesis by having a large surface area, and contain openings, called stomata to allow carbon dioxide into the leaf and oxygen out. Although these design features are good for photosynthesis, they can result in the leaf losing a lot of water. The cells inside the leaf have water on their surface. Some of this water evaporates, and the water vapour can then escape from the leaf (Figure 22).

Functions of Leaves

The function of a leaf is photosynthesis to absorb light and carbon dioxide to produce glucose (food). The equation for photosynthesis is:

carbon dioxide and water → glucose and oxygen

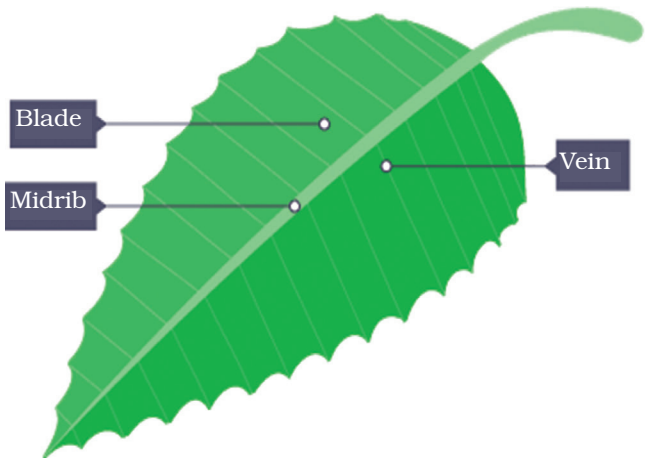


Figure 22. External structure of leaves

Leaves are also involved in gas exchange. Carbon dioxide enters the leaf and oxygen and water vapour leaves the plant through the stomata. Leaves are adapted in several ways to help them perform their functions.

Features of Leaves

Adaption	Purpose
Large surface area	To absorb more light
Thin	Short distance for carbon dioxide to diffuse into leaf cell
Chlorophyll	Absorbs sunlight to transfer energy into chemicals
Network of veins	To support the leaf and transport water, mineral ions and sucrose (sugar)
Stomata	Enable carbon dioxide to diffuse into the leaf and oxygen to diffuse out

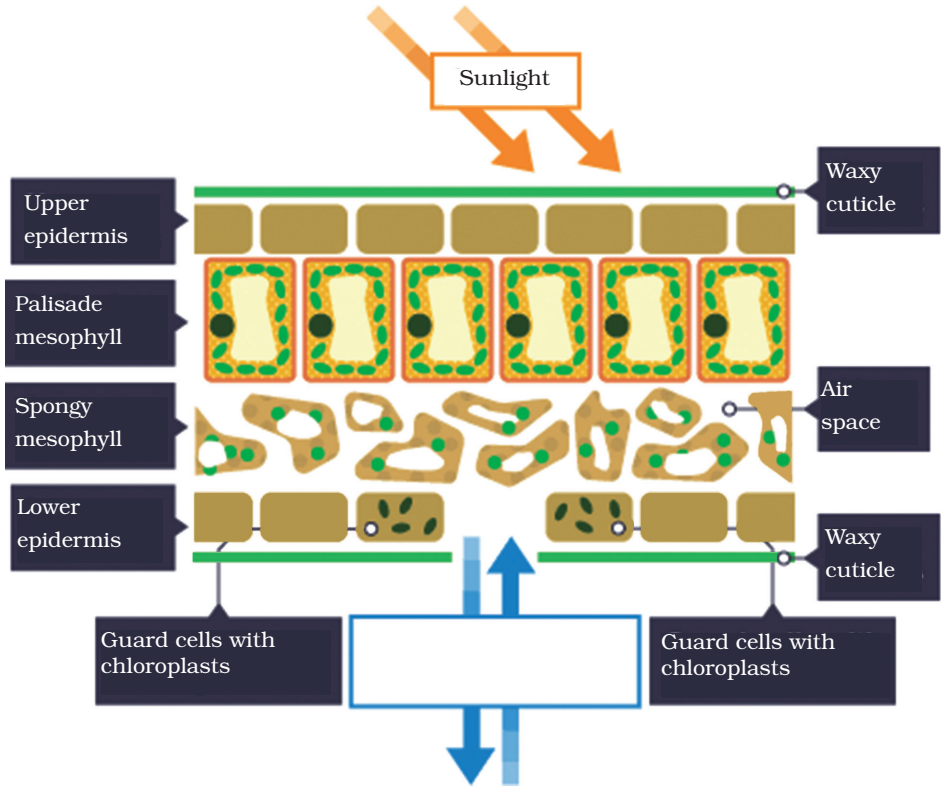


Figure 23. The internal structure of the leaf is also adapted to promote efficient photosynthesis.

Functions of Tissues of the Leaf

Adaption	Purpose
Epidermis is thin and transparent	To allow more light to reach the palisade cells
Thin cuticle made of wax	To protect the leaf from infection and prevent water loss without blocking out light
Palisade cell layer at top of leaf	To absorb more light and increase the rate of photosynthesis
Spongy layer	Air spaces allow gases to diffuse through the leaf
Palisade cells contain many chloroplasts	To absorb all the available light

Photosynthetic Structures

In Eukaryotes the photosynthetic apparatus is located in special intracellular organelle, chloroplasts. Chloroplasts similar to mitochondria, contain also DNA, RNA, and the apparatus for protein synthesis, i.e. potentially they are capable of self - reproduction. In size, chloroplasts are several times as large as mitochondria.

Chloroplasts are of spherical or oval shape. A chloroplast possesses two - outer and inner - membranes (Figure 23). Stacks of flattened vesicle - like disks extend from the inner membrane. These stacks are called the grana.

The number of grana per chloroplast in algae does not exceed 1 while in higher plants 50 grana link with each other through membranous bridges called lamellae. The aqueous medium of the chloroplast in which the grana are immersed is called the stroma.

The vesicle like structures, which the grana are composed of are referred to as thylakoids. One granum contains 10 to 20 thylakoids (Figure 24).

The elementary structural and functional photosynthetic unit of the thylakoid membrane which contains necessary light -

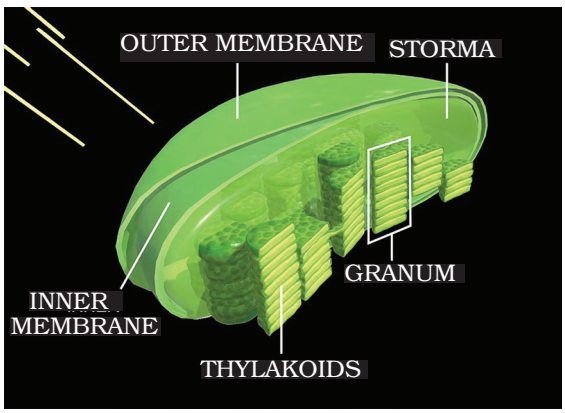


Figure 24. The structure of a granum

trapping pigments and components of the energy conversion apparatus is called the quantasome.

Activity 11

Experimenting to demonstrate the need for chlorophyll in photosynthesis

You need:

Potted plant, Alcohol, Iodine solution, distilled water, beaker, Petri dish

Method

1. Take a potted plant with variegate leaf.
2. Keep the plant facing the sunlight for 6 to 8 hours.
3. Plant carries out photosynthesis and produce starch.
4. Mark the green areas in leaf and trace them on a sheet of paper. Mark the regions as green and yellow.
5. The green areas contain chlorophyll which is absent in the yellow area.
6. Immerse the leaf in boiling alcohol to decolorize it.
7. Dip this decolorized leaf in iodine solution.

Remove the leaf from iodine solution & rinse in distilled water.

Remove the leaf from the distilled water and keep it on a peri-dish.

Observe the Dolor changes of the marked areas of the leaf

Give your conclusion

Write a report.

What is light?

Light is a form of the electromagnetic radiation produced by the sun. Visible light forms only a small fraction of the total electromagnetic radiation reaching the earth. Of the visible spectrum, of light certain wave lengths are absorbed by green plants, including the red and blue parts of the spectrum.

- Green light are mostly reflected or transmitted.
- the true nature of light is not fully understood.
- Blue light has a quite short wave length and has considerable energy.
- Red light has the longest wave length and less energy.

Activity 12

Experimenting by growing two plants in light and shade

You need:

- 6 bean seeds, pots, plant sprayer, potting soil, shelf, cupboard, ruler, notebook and pencil

Method:

1. Fill each pot with soil.
2. Plant bean seed in each pot.
3. Place three pots outside to receive sunshine.
4. Place the remaining three post in a shade.
5. Think about what you know of plants and light.
6. Spray all your planted seeds with the mister.
7. Observe your seeds for three weeks.
8. Take a close look of your pots at the end of each week.
9. Observe the experimental result.
10. Did the absence of light make any difference?
11. Write the result of your experiment.

Light and Chlorophyll

In solution, chlorophyll absorbs light energy but the energy cannot be used to carryout photosynthesis.

This is because the chlorophyll has been separated from the proteins and enzyme machinery of the chloroplast. When the pigments are in the chloroplast the light energy trapped is immediately passed to surrounding protein as chemical energy, which is used in photosynthesis.

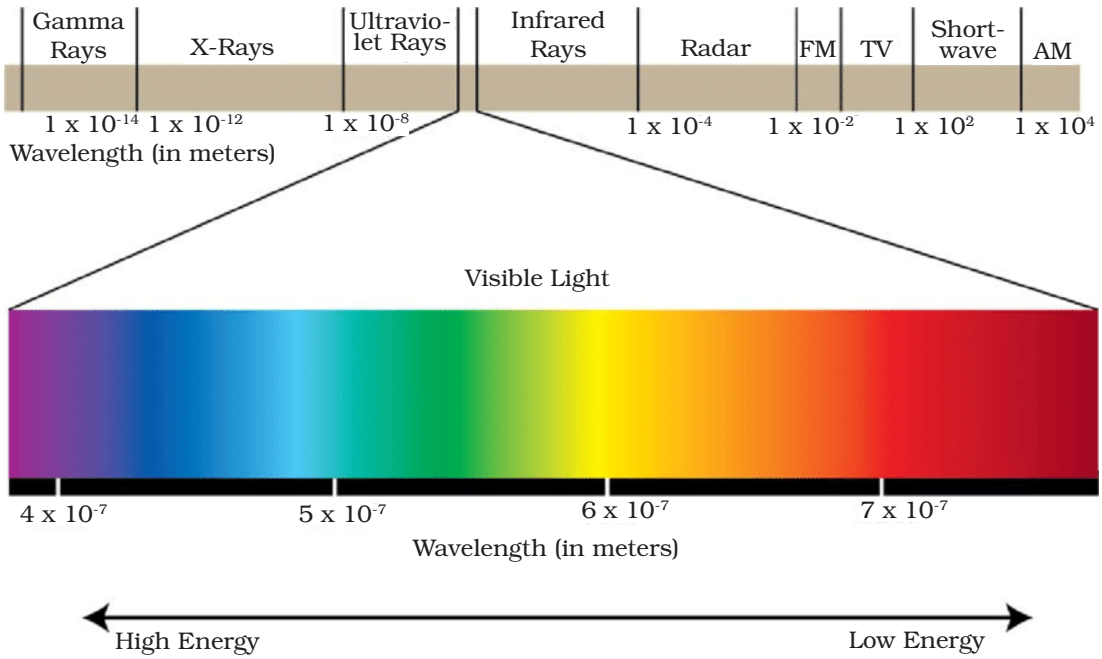


Figure 25. The light absorbed by chlorophyll

- A solution of chlorophyll, re - emits the energy of absorbed light as light of longer wavelength (red fluorescence) (Figure 25).
- Intact chloroplasts emit relatively little red fluorescence.

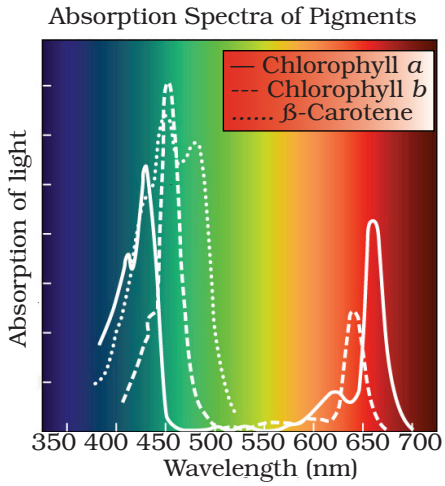


Figure 26. Absorbed spectrum measured using spectrometer

Absorption spectrum -a record ofthe amount of photosynthesis occuring at each wave length (Figure 26).

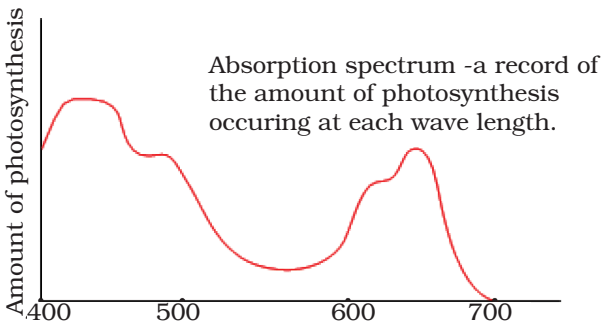


Figure 27. Chlorophyll the absorption spectrum and the action spectrum

- The absorption and action spectra for chlorophyll pigments namely red and blue light are very similar to the wave lengths that cause photosynthesis.
- The wave length absorbed provide most energy for photosynthesis.

- Both red and blue light are used by the green plant as the energy sourcefor photosynthesis (Figure 27).

ACTIVITY 13

Wrapping some leaves of growing plant with aluminum foil and comparing with other leaves of the same plants after four days.

1. Wrap the leaves of a growing plant with aluminum foil for four days.
2. Keep the leaves of the same plant without wrapping with aluminum foil.
3. Observe the leaves of the plant after four days.

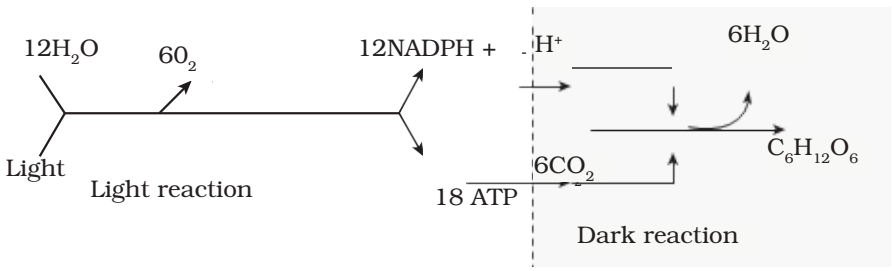
   Compare your results of the two leaves.

   Write your result.

Stages of Photosynthesis

Photosynthesis is the conversion of light energy to chemical energy with the subsequent use of chemical energy in the synthesis of carbohydrates from carbon dioxide. When energy is changed from one form to another, we say it has been transduced. Light energy is transduced to chemical energy in a chloroplast during photosynthesis. The chloroplast is a transducer organelle. This process is endergonic and requires much energy. Therefore, the overall process of photosynthesis is made up of two stages, commonly referred to as the light reaction and the dark reaction.

In chloroplasts the two stages are spatially separated: the light reaction is carried out in the thylakoid, while the dark reaction is accomplished in the stroma. The relationship between the light and dark reactions may be presented schematically as:



The light reaction proceeds in the light. At this stage, the sunlight energy is converted to the ATP chemical energy, and the energy - deficient water electrons are transferred to become the energy-rich NADPH electrons. The oxygen liberated during the light reaction is a by-product of this process.

The energy rich light reaction products, ATP and NADPH are used in the next stage which can proceed without light. The reductive synthesis of glucose from CO2 occurs during the dark reaction. The dark reaction cannot be accomplished independently of the light reaction.

The Light Reaction (Light Dependent Reaction)

In the thylakoid membrane, there are two photochemical centers or photosystems, commonly denoted as photosystem I and photosystem II (Figure 29). Either of the two photosystems cannot replace the other one, since functionally these photosystems are different. The photosystems consists of pigment molecules, together with various enzymes and electron acceptor molecules. Both photo systems I and II contain chlorophyll molecules organized so as to pass energy to a special pair of pigment at the reaction centers of the photosystems. This cluster of pigment molecule is called an antenna complex. Only the reaction center molecule is positioned to the electron transport chain. Energy absorbed by other molecules in the photosystem is transferred to the reaction molecule, where light dependent reactions begin.

The photosystems contain various pigments: green pigments, chlorophyll a and b; yellow pigments, carotenoids; and red or blue pigments. In this variety of pigments only chlorophyll a is photochemically active. The other pigments play a minor role and act merely as photon collectors (a kind of focusing lenses) or light guides to the photochemical center.

The function of the photochemical center is assigned to special forms of chlorophyll a which are: in the photosystem I, absorbing light at a wavelength of about 700 nm, and in the photosystem II, (P_{680}) absorbing light at a wave length of 680 nm.

Mechanisms of Light Dependent Reactions

- Occurs in the grana membrane.
- Splits water molecules and provides $2H_2$ atoms (4H) for reduction of CO_2.
- Leads to the synthesis of ATP and NADPH (reducing power).
- results in releasing of O_2 gas from the splitting water.

Steps:

The excitation of a chlorophyll electron.

- light energy absorbed by antenna chlorophyll cause the displacement of an "excited" (light energy) electron and the splitting of water.

The splitting of water

- the electron vacancy in the reaction center is powerful in energy terms to split water. The electrons replace those lost from the chlorophyll molecule.

Light energy becomes chemical energy.

- The excited electrons ejected from the reaction center are moped up by a powerful electron acceptor Q.
- Excited electrons are reduced and re - oxidized, until they reach the final electron acceptor $NADP^+$.

Reduced $NADP^+$ picks up hydrogen ions free floating in the thylakoid membrane and forms $NADPH_2$.

Formation of ATP

- The energy rich electrons ejected from the reaction center of photosystem II (PS II) is passed via Q to a vacant position in the reaction center in photosystem - I (PS I). As it passes, the electron progressively loses its excess energy.
- Some of this energy is used to form ATP from ADP + Pi. This is called photosynthetic phosphorylation or photophosphorylation.Photophosphorylation:-
- Integral part of photosynthesis.
- Occurs during the light step.
- Energy comes from the excited electron.
- Electron transport starts in chlorophyll but ends up in NADPH.

The formation of NADPH

- The excited electron from PS - I, trapped by an electron acceptor refered as R, is used to generate NADPH.

The photosystems

- The photosynthetic pigments are organized into two photosystems.

- Consists of pigment molecules, various enzymes and electron acceptor.
- PS - I and PS - II contain about 300 chlorophyll molecules.
- At each reaction center, as sufficient energy is funneled in, an electron is "boosted" to a higher energy level and immediately used to drive the chemical reaction of the formation of ATP and NADPH (Figure 28).

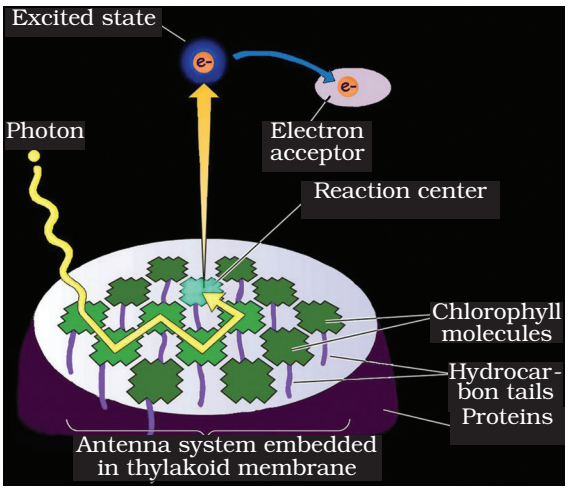


Figure 28. The excitation of a chlorophyll electron and the splitting of water

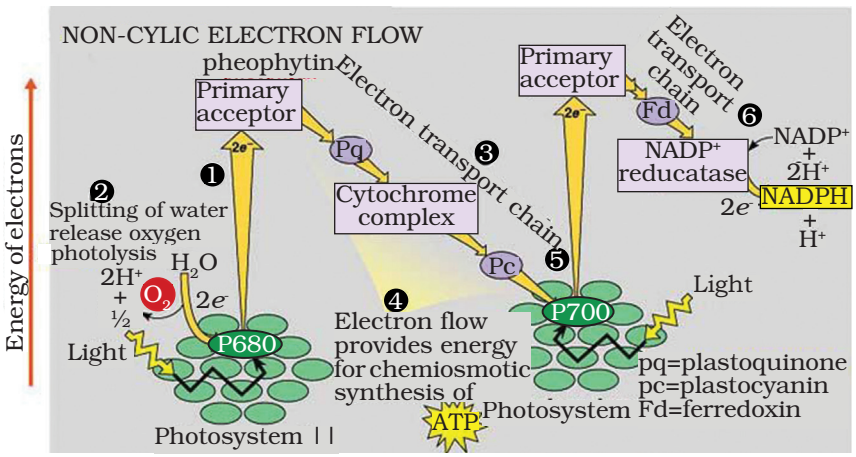


Figure 29. Cyclic and noncyclic electron transfer between photosystems I and II.

Absorption of photons (the particulate unit of light, carrying a quantum of energy) by the photosystem II leads to decomposition of water in

the photochemical center P_{680}. The electrons released from water molecules are boosted to a higher energy level from which they are transferred to an electron acceptor molecule. The electrons then pass downhill along an electron transport chain to photosystem I. As the electrons pass along this transport chain, ATP is formed from ADP, via the same mechanism by which ATP is formed along the electron transport chain of the mitochondrion. This process is known as non-cycle photophosphorylation. This is because:

- The phosphorylation is light-dependent
- The electrons lost from the chlorophyll are not recycled in any way.

Plants sometimes generate ATP by cyclic photophosphorylation because in this pathway the electrons take a cyclic path, falling back to the point of origin rather than flowing through to NADPH. It involves photosystem I but not photosystem II. ATP is formed but no $NADPH_2$.

When the electrons reach photosystem I, they have already expended their excitation energy in driving the proton pump and thus contain only the same amount of energy as the other electrons of this photosystem. Photosystem I now absorbs a photon, boosting one of its pigment electrons to a high - energy level. The electron is then channeled to ferredoxin and is used to generate reducing power. In plants and algae ferredoxin contributes two electrons to reduce $NADP^+$, nicotine adenine dinucleotide phosphate, generating NADPH. By using this molecule instead of the NAD^+ used in oxidative respiration, plants and algae keep the flow of electrons in the two processes separate.

In cyclic and non-cyclic photophosphorylation, ATP is produced because:

- A concentration difference in hydrogen ions (protons) develops across a membrane, creating a concentration gradient.
- Protons from photosystem I pass from the stroma into the interior of the thylakoid.
- Protons can then return to the stroma down a concentration gradient, via the enzyme complex (ATPase).

Thus, the energy produced in the first photo event is spent in ATP synthesis; the energy of the second photo event creates reducing power. These two processes together comprise the light reactions of eukaryotic photo centers.

Summary of the Light Step

The P_{680} chl having lost its electron seek replacement. It finds it from water molecule.

Light energy is trapped in the reactive chlorophyll molecule (P_{700}) of PS - I. The molecule is oxidized and electron is passed to electron acceptor (R) which goes to downhill to NAD^+.

The electron removed from P_{700} molecule is replaced by the electron from PS - II. There is a continuous flow of electrons from H_2O to PS–II to PS–I to–NAD^+.

$$2H_2O + 2NADP + (2ADP + 2Pi) \text{ --- } O_2 + 2NADPH + 2H+ + (2ATP + 2H_2O)$$

The Dark Reactions (Light Independent Reaction)

- Don't necessarily occur in the dark.
- Doesn't it self-require light.
- Occurs in the stroma of chloroplasts
- Requires the product of light step (ATP and NADPH) to reduce CO_2 to $C_6H_{12}O_6$.

The products of light reaction, ATP and NADPH which are formed in the chloroplast stroma, are immediately used in the reduction of CO_2 to glucose. Assimilation of CO_2 is a cyclic process commonly referred to as Calvin cycle. Three major phases are distinguished in the cycle:

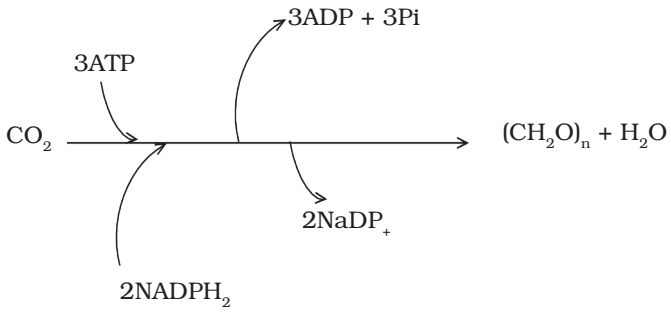
1. Fixation of CO_2 with ribulose bisphosphate (RuBP),
2. Production of triose phosphates by reduction of phosphoglycerate and
3. Regeneration of ribulose bisphosphate (RuBP).

There are two path ways.

The Calvin cycle (C_3 - pathway)

- C_3 - plants dominate the high altitude communities ex. average temperature below 25°C.
- Discovered by Melvin Calvin
- Referred to as C_3-plants because the first stable product of photosynthesis is glycerate-3-phage (GP), a 3-carbon compound.
- The starting and ending compound is a 5 - carbon sugar with 2-phosphates attached, ribulose bisphosphate (RuBP)

- CO_2 and H_2O from the environment combined with a 5 - carbon sugar molecule (RuBP) to generate 2 - molecules of 3 - phosphoglycerate (GP), a 3 - carbon intermediate.
- The 3 - GP is reduced to carbohydrate by use of ATP and $NADPH_2$.



- The cycle is completed by regeneration of RuBP. The Calvin cycle follows the following steps:

Step 1: Carboxylation of RuBP

- CO_2 diffuses into the stroma from the surrounding cytosol. An enzyme Rubisco combines a CO_2 molecule with a five
- Carbon carbohydrate called RuBP. The product is a six-carbon molecule that splits immediately into a pair of three carbon molecules known as PGA (phosphoglycerate).

Step 2: Reduction of GP

PGA is converted into another three - carbon molecule, PGAL (glycaraled hyde - 3 - phosphate), in a two - part process. First, each PGA molecule receives a phosphate group from a molecule of ATP. The resulting compound then receives a proton from NADPH and releases a phosphate group, producing PGAL. In addition to PGAL, these reactions produce ADP, $NADP^+$ and phosphate. These three products can be used again in the light reactions to synthesize additional molecules of ATP and NADPH.

Step 3 : Reduction of RuBP, the CO_2 acceptor

Most of the PGAL is converted back into RuBP in a complicated series of reactions. These reactions require a phosphate group from another molecule of ATP. However, some PGAL molecules are not converted into RuBP. Instead, they leave the Calvin

cycle and can be used by the plant cell to make other organic compounds (Figure 30).

For every three molecules of CO_2 that enter the cycle, one molecule of the 3-carbon compound glyceraldehyde phosphate is produced and 3 molecules of RuBP are regenerated.

- This reaction is catalyzed by the chloroplast enzyme ribulose bisphosphatecarboxylase/oxygenase, referred to by the name rubisco.
- The enzyme also has an oxygenase activity in which O_2 competes with CO_2 for the common substrate ribulose - 1,5 - bisphosphate (RuBP). Rubisco is very abundant, representing 40% of the total soluble protein of most leaves.

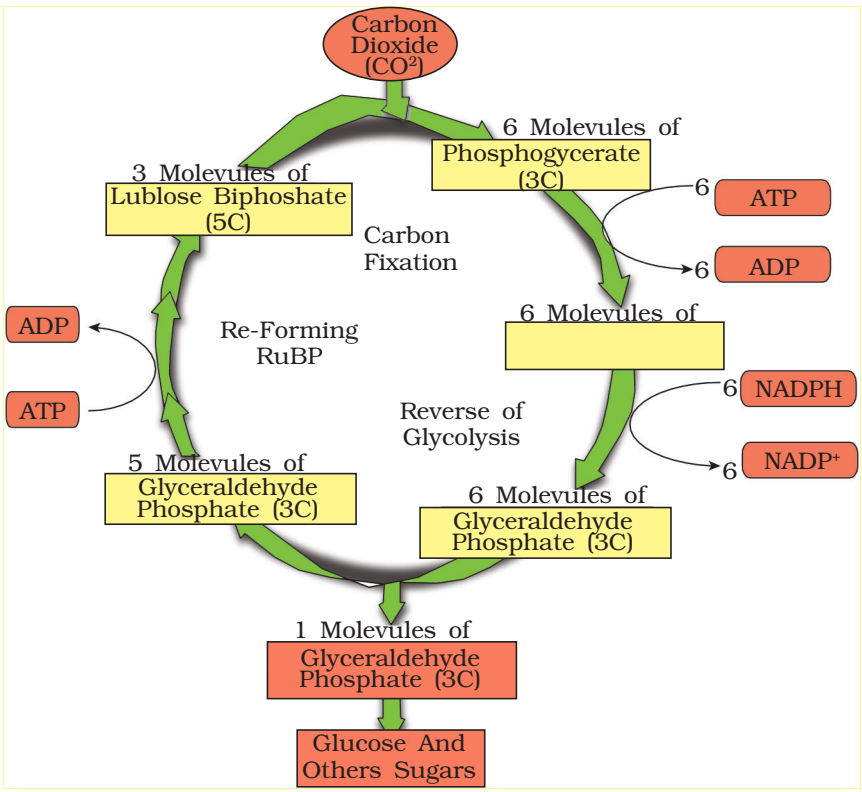


Figure 30. The Calvin cycle (the three - carbon photosynthetic path way).

Dicarboxylic Acid Cycle (The C_4-Carbon Cycle)

- C_4 - plants are adapted to xerophytic environment.

- Can photosynthesize in the presence of very low CO_2 concentration.
- Can adapt to grow at low water content, high temperature and bright light intensities.
- C_4 - Carbon cycle was discovered in tropical grasses, ex:- Sugarcane, maize, sorghum (Figure 31).
- A typical C_4 - leaf has two distinct chloroplast containing cell types: mesophyll and bundle sheath.
- Operation of the C_4 - cycle requires the co - operative effort of both cell types.
- **Plasmodesmata:** Connects mesophyll and bundle sheath cell, thus providing the path way for the flow of metabolites between the cell types.
- The primary carboxylation in these leaves is catalysed not by rubisco, but by phosphoenol pyruvate (PEP) carboxylase.

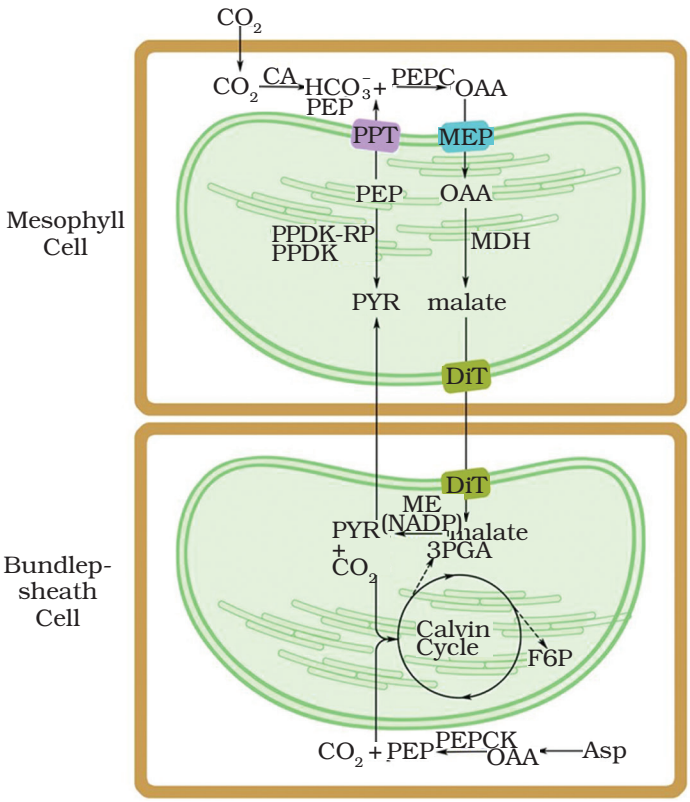


Figure 31. A pathway for carbon fixation in C4 plants

- PEP carboxylase is restricted to mesophyll cells, the decarboxylase and enzymes of the complete Calvin cycle are confined to the bundle sheath cells.

In some plants the first product of carbon dioxide fixation is not the three carbon molecule phosphoglycerate but the four - carbon compound oxaloacetic acid. Plants that utilize this path way are commonly called the C_4, or carbon four plants. The oxaloacetic acid is formed when carbon dioxide is bound to a compound known as phosphoenolpyruvate (PEP).

This reaction is catalyzed by PEP carboxylase. The oxaloacetic acid is then reduced to malic acid or converted (with the addition of an amino group) to aspartic acid. The malic acid (or aspartic acid depending on the species) is decarboxylated to yield CO_2 and pyruvic acid. The carbon dioxide then enters the Calvin cycle (Figure 32). The pyruvate is transported back to the chloroplast of mesophyll cells where it is reconverted into PEP by utilizing energy of ATP of light phase in the presence of enzyme pyruvate phosphate dikinase.

The C_4-cycle consists of 4-stages:

1. Fixation of CO_2 by the carboxylation of PEP in the mesophyll cell to form malate and or aspartate.
2. Transport of malic acid to the bundle sheath cells.
3. Decarboxylation of malic acid within the bundle sheath cells and generation of CO_2, which is then reduced to carbohydrate via the Calvin cycle; and
4. Transport of the pyruvic acid that is formed by decarboxylation step back to the mesophyll cell & regeneration of the CO_2 acceptor PEP.

Why C_4 plants evolved such energetically expensive method of providing CO_2 to the Calvin cycle?

C_4 plants evolved such energetically expensive method because CO_2 is not continuously available to the photosynthesizing cells. PEP carboxylase has a higher CO_2 affinity than does RuBP carboxylase, so it keeps the CO_2 concentration lower within the leaf. This maximizes the gradient of CO_2 between the cells and the outside air. A higher gradient means the leaf will trap a larger fraction of the passing stream of CO_2. If the stomata must be closed much of the time, as in hot, dry climate, the plant with C_4 metabolism will take up more CO_2 than the plant that

has only C_3 metabolism. Hence, it is a distinct advantage in drought-stricken areas. Sugar cane, corn, and sorghum are the best examples of C_4 plants.

Products of Photosynthesis

Chlorophyll in plant leaves converts carbon dioxide and water into the products glucose and oxygen.

Photosynthesis is the name given to the set of chemical reactions performed by plants to convert energy from the sun into chemical energy in the form of sugar. Specifically, plants use energy from sunlight to react carbon dioxide and water to produce sugar (glucose) and oxygen. Many reactions occur, but the overall chemical reaction for photosynthesis is:

- $6\ CO_2 + 6\ H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6\ O_2$
- Carbon Dioxide + Water + Light yields → Glucose + Oxygen

In a plant, the carbon dioxide enters via leaf stomatas by diffusion. Water is absorbed through the roots and is transported to leaves through the xylem. Solar energy is absorbed by chlorophyll in the leaves. The reactions of photosynthesis occur in the chloroplasts of plants. In photosynthetic bacteria, the process takes place where chlorophyll or a related pigment is embedded in the plasma membrane. The oxygen and water produced in photosynthesis exit through the stomata.

- In photosynthesis, energy from light is used to convert carbon dioxide and water into glucose and oxygen.
- For 6 carbon dioxide and 6 water molecules, 1 glucose molecule and 6 oxygen molecules are produced.

Actually, plants reserve very little of the glucose for immediate use. Glucose molecules are combined by dehydration synthesis to form cellulose, which is used as a structural material. Dehydration synthesis is also used to convert glucose to starch, which plants use to store energy.

Activity 14

Testing a leaf for starch

You need:

Bunsen burner, 250 ml beaker, boiling tube, Forceps, White tile, Test tube rack, a leaf to be tested, 90% ethanol, eye protection goggles, heat resistant gloves, Iodine solution, Dropping pipette.

Method:

1. Collect a leaf that has been recently expired to sunlight.
2. Boil 250 ml of water. Fill the beaker with halfway with water and allow it to come to a boil
3. Using a Bunsen burner or hot plate.
4. Use forceps to place your leaf in boiling water for 2 minutes.
5. Use forceps to remove your leaf from the boiling water.
6. Place the leaf into a boiling tube containing 90% ethanol.
7. Boil your leaf for 10 minutes, use water bath because ethanol is extremely flammable.
8. Remove your leaf from the boiling tube and rinse it with cold water.
9. Use forceps to spread your leaf into a white tile.
10. Soak your leaf in a few drops of iodine for 2 minutes.
11. Examine your leaf for a blue-black color, indicating starch.

Write your result

What is the purpose of boiling leaf?

What the purpose of place the leaf in 90% ethanol.

Intermediate Products of Photosynthesis

The overall chemical equation is a summary of a series of chemical reactions. These reactions occur in two stages. The light reactions require light (as you might imagine), while the dark reactions are controlled by enzymes. They don›t require darkness to occur they simply do not depend on light.

The light reactions absorb light and harness the energy to power electron transfers. Most photosynthetic organisms capture visible light, although there are some that use infrared light. Products of these reactions are adenosine triphosphate (ATP) and reduced nicotinamide adenine dinucleotide phosphate (NADPH). In plant cells, the light-dependent reactions occur in the chloroplast thylakoid membrane. The overall reaction for the light-dependent reactions is:

- $2H_2O + 2\ NADP^+ + 3ADP + 3P_i + light \rightarrow 2\ NADPH + 2H^+ + 3ATP + O_2$

In the dark stage, ATP and NADPH ultimately reduce carbon dioxide and other molecules. Carbon dioxide from the air is “fixed” into glucose. In plants, algae, and cyanobacteria, the dark reactions are termed the Calvin cycle. Bacteria may use different reactions, including a reverse Krebs cycle. The overall reaction for the light-independent reaction of a plant (Calvin cycle) is:

- $3CO_2 + 9ATP + 6NADPH + 6H^+ \rightarrow C_3H_6O_3$-phosphate + 9ADP + 8 P_i + 6 $NADP^+$ + 3 H_2O

During carbon fixation, the three-carbon product of the Calvin cycle is converted into the final carbohydrate product.

Fate of Photosynthesis Product

The sugar made in the chloroplasts supplies the entire plant with chemical energy and carbon skeletons for the synthesis of all the major organic molecules of plant cells. About 50% of the organic material produced by photosynthesis is consumed as fuel for cellular respiration in the mitochondria of the plant cells. Glucose is used in respiration to produce energy. Glucose is converted to more complex carbohydrates and stored, e.g. sucrose, starch. Oxygen is used in respiration or lost to air.

Technically, green cells are the only autotrophic parts of the plant. The rest of the plant depends on organic molecules exported from leaves via veins. In most plants, carbohydrate is transported out of the leaves in the form of sucrose, a disaccharide. They stockpile the extra sugar by synthesizing starch, storing some in the chloroplasts themselves and some in storage cells of roots, tubers, seeds, and fruits. Photosynthesis is the process that is responsible for the presence of oxygen in our atmosphere.

Activity 15

Testing to breakdown cell wall and stop the action of enzymes within a leaf

You need:

Ultrasonic homogenizer, (ultrasonicator) Leaf

Method:

1. Test to breakdown cell wall and stop enzyme action with a leaf use ultrasonic homogenizer
2. Use ultrasonic homogenizer and induce vibration in a titanium probe that is immersed in the leaf cell solution

Observe your results

Write your result.

Macronutrients and Micronutrients: Their Effects in Photosynthesis

Plants are able to produce their own food through a process called photosynthesis. They absorb nutrients through their roots from the

soil and is transported through the stem to the different parts that are above ground level. Plants are living organisms and they also require nutrients like us in order to survive, grow, reproduce and develop. They require two types of nutrients- macronutrients and micronutrients.

Macronutrients in Plants

Macronutrients in plants are nutrients that provide energy to the plants and are required in large amounts to maintain their development and growth. These are the most important elements required for crops and examples include nitrogen (N), Potassium (K), Calcium (Ca), Phosphorus (P), Magnesium (Mg), Sulphur (S), Oxygen (O), Carbon (C) and Hydrogen (H). Out of these the most important ones are nitrogen, phosphorus and potassium, which directly affect plant growth and actually create various parts of the plant.

All the essential elements perform several functions like they maintain the osmotic concentration of the cell sap, have buffering action, show enzymatic activity and act as a major constituent of macromolecules and coenzymes. Functions of some important elements are as follows:

Nitrogen: It is required by plants in large amounts. It is taken in the form of ions from the soil. It is required for the division of cells. It is the major constituent of proteins, vitamins, hormones etc. Also, nitrogen is an important component of chlorophyll that plays a vital role in photosynthesis.

Phosphorus: It is a constituent of cell membranes, proteins, and nucleic acids and is required for certain important reactions. Phosphorus plays a major role in energy storage and transfer as ADP and ATP (adenosine di- and triphosphate).It is important for plants for maintaining a good quality of flowering, fruiting and seed production.

Potassium: It is a mineral that is required in the growing parts of the plants in large amounts. It is also required for the opening and closing of stomata. It helps in the activation of enzymes and helps in maintaining the turgidity of the cell. In photosynthesis, potassium has the role of maintaining the balance of electrical charges at the site of ATP production. Potassium promotes the translocation of sugars for plant growth or storage in fruits or roots. It is important to plants for influencing water uptake.

Micronutrients in Plants

In addition to macronutrients, micronutrients are the other category of nutrients that are called trace elements or minerals required in a very small quantity that help in growth or metabolism. Some important nutrients include boron (B), iron (Fe), chlorine (Cl) manganese (M), copper (Cu), zinc (Zn), molybdenum (Mo) and nickel (Ni). Functions of some important elements are as follows:

Iron: It is required in larger amounts as compared to other micronutrients. It is an important constituent of protein and helps with the activation of enzymes. Iron is important for chlorophyll production and photosynthesis.

Manganese is important for metabolic processes, such as photosynthesis, respiration, amino-acid synthesis, and hormone activation. It has a role in the use of light to split water molecules during photosynthesis. It is important to plants for influencing chlorophyll production.

Zinc and copper are also involved in the activation of certain enzymes. Interstitial fluid helps in the uptake and utilization of calcium, functioning of the membrane, pollen germination, cell elongation, germination etc.

Boron is important to plants for sugar transport, amino acid production, cell wall formation, fruiting, flowering and improvement of crop quality.

Key Terms

- Phytoplankton
- Conjugation
- Fragmentation
- Gametophyte
- Sporophyte
- Frond
- Parasite
- Saprophyte
- Photosynthesis
- Stroma
- Thylakoids
- Photophosphorylation
- Plasmodesmata

SUMMARY

- Algae are defined as a group of predominantly aquatic, photosynthetic, and nucleus-bearing organisms that lack the true roots, stems, leaves, and specialized multicellular reproductive structures of plants. It is an important group of Thallophyta, the primitive and simplest division of the plant kingdom.
- In classification of algae various features that differentiate various types of algae are: organelle structure, flagellar apparatus, and cell division process.
- Cyanophyceae: simple unicellular, colonial or multicellular bodies, Principal pigments are chlorophyll-a, β-carotene, xanthophyll and phycobilins, c-phycoerythrin and cphycocyanin,
- Sexual reproduction in *Spirogyra* is isogamous, i.e. male and female gametes of similar size fuse together in the sexual reproduction. Sexual reproduction is by conjugation. Spirogyra asexually reproduces by fragmentation. Spirogyra breaks into two or more segments and each segment form new organism. Algae are used in medicine, as food and in industries.
- Moss plant is a gametophyte. It consists of an unbranched or branched shoot with spirally arranged small green leaves. At the base of shoot, numerous multicellular rhizoids are developed. These rhizoids functions as roots. Gametophytic generation reproduces sexually by gametes and is haploid. Sporophytic generation reproduces asexually by meiospores and is diploid. These two generations follow each other in alternate sequence. This phenomenon is termed alternation of generations.
- Ferns are flowerless green plants. They are usually easy to recognize by the feather like shape of their leaves, which are called fronds. Ferns reproduce by spores rather than by seeds.
- The fern life cycle requires two generations of plants to complete itself. This is called alternation of generations.
- Fungi are Eukaryotic organisms, non-vascular organisms, no embryonic stage for fungi and are typically non-motile. Fungi cannot prepare their food. They live as heterotrophs i.e., as parasites and saprophytes. Asexual reproduction, sometimes called somatic or vegetative, does not involve the union of nuclei or sex cells. Sexual reproduction is characterized by the union of two nuclei. Typically, fungi reproduce both asexually and sexually.
- Photosynthesis is the process through which green plants and other living things convert the energy of light into chemical. Leaves are adapted for photosynthesis by having a large surface area and

contain openings, called stomata to allow carbon dioxide into the leaf and oxygen out.

- The overall process of photosynthesis is made up of two stages, commonly referred to as the light reaction and the dark reaction. The light reaction proceeds in the light. The energy rich light reaction products, ATP and NADPH. It takes place in the thylakoid membranes of the chloroplast and includes photosynthetic pigments arranged into two light-harvesting complexes within photo system I and photo system II.
- Dark reaction is a light-independent process in which sugar molecules are formed from the carbon dioxide and water molecules. The dark reaction occurs in the stroma of the chloroplast, where they utilize the products of the light reaction.
- Macronutrients are the main nutrients needed for plant growth and development. The macronutrients include nitrogen, phosphorus, and potassium.
- A micronutrient is the small number of chemicals that is present in soil, water, or air that helps the plants to grow faster. They help to increase the strength of the roots and leaves of the plants

Exercise

Choose the best answer from the alternatives given

1. Which of the following is not true about C_4 plants such as (*Eragrostis tef*)
   (a) CO_2 is harvested during the nighttime.
   (b) The bundle sheath cells contain chloroplasts.
   (c) Light dependent reaction occurs in mesophyll cells.
   (d) Chloroplasts of bundle sheath cell lack thylakoids.
2. Which molecule in plant cells is responsible for captures the radiant energy from sunlight?
   (a) ATP
   (b) DNA
   (c) Chlorophyll
   (d) Carbon dioxide
3. Under what conditions do C_4 – plants have more photosynthetic efficiency than C_3 - plants?
   (a) Low water supply
   (b) Low temperatures
   (c) Low light intensity
   (d) Low CO_2 concertation

4. Which one of the following happens in both cyclic and non-cyclic photophosphorylation?
   (a) ATP is formed
   (b) Oxygen is generated
   (c) NADP is reduced
   (d) Water molecule splits
5. Which of the following stages of photosynthesis can take place in the dark?
   (a) Photolysis of water
   (b) Photosystem I
   (c) Photosystem II
   (d) Calvin cycle
6. The molecule of which pigment is located at the reaction center of a photosystem?
   (a) Chlorophyll b
   (b) Chlorophyll a
   (c) Carotenoid
   (d) Xanthophyll
7. Which of the following groups of plants carry out light dependent and independent reactions of photosynthesis in separate cells?
   (a) C_3 plants
   (b) C_4 plants
   (c) CAM plants
   (d) Plants without chlorophyll
8. Which of the following is not true about photosystem II
   (a) Its reaction center molecule is P_{680}
   (b) It passes its excited electrons to Photosystem I
   (c) The energy lost from its exited electrons reduces NADP
   (d) It replenishes its lost electrons from photolysis of water
9. Where does the light dependent reaction of photosynthesis occur in chloroplasts?
   (a) In the thylakoid membrane
   (b) In the fluid of the stoma
   (c) In all parts of the chloroplasts
   (d) In the stomatal opening
10. Which of the following process of photosynthesis does not require the presence of light to take place?
   (a) The splitting of water
   (b) ATP formation

(c) Reduction of NADP
(d) Carbon fixation

11. Which of the following is true about the first stage of photosynthesis?
(a) Light dependent
(b) Temperature dependent
(c) ATP driven
(d) Glucose-driven

12. Which of the following is the first to occur during photosynthesis?
(a) Splitting of water molecule
(b) Excitation of electrons from Photosystem II
(c) Excitation of electrons from photosystem I
(d) Fixation of carbon into glucose

13. Which of the following is not required to begin Calvin cycle in C3 plants?
(a) Atmospheric carbon dioxide
(b) FUDP carboxylase
(c) RUDP
(d) PEP carboxylase

14. When does Oxygen produced during photsynthesis?
(a) PGA is converted into PGAL
(b) CO_2 is fixed
(c) Water is split
(d) ATP is converted into ADP

15. The light reactions take place
(a) On the outer membrane of the chloroplast
(b) In the stroma
(c) In the cytosol
(d) On the thylakoid membrane

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CHAPTER 6

FLOWERING PLANTS

Chapter Contents

Chapter Outcomes

At the end of this chapter the learners should be able to:

- identify the characteristics of flowering plants and distinguish them.
- classify flowering plants into monocotyledonae(monocots) and dicotyledonae (dicots).
- distinguish the structural characteristics of monocots and dicots.
- describe the structures and functions of roots, stems, leaves and flowers in flowering plants.
- explain sexual and asexual reproduction in flowering plants.
- determine the floral formulae of flowers such as flamboyant (*Delonix*), pride of Barbados (*Caesalpinia*) and Rattle Box (*Crotalaria*).
- discuss types of pollination and list agents of pollination.
- explain the process of zygote and embryo formation in flowering plants.
- describe the conditions necessary for seed germination.
- list the types of fruits and explain fruit and seed dispersal.
- describe plant hormones and their functions.
- explain transport system in plants.
- discuss the process of excretion in plants.
- describe the process of plant growth and development.
- explain the process of gaseous exchange in plant.

Introduction

This unit deals with angiosperms that bears both flowers and fruits. These types of plants also contain ovules enclosed in an ovary. The ovule, once fertilized, develops into seeds, and mature into fruits. The flowers in plants of these species help in pollination and protect the ovaries and the embryos, whereas fruits aid in seed dispersal.

Angiosperms have evolved specialized cells and tissues that carry out these functions and have further evolved specialized vascular tissues (xylem and phloem) that translocate the water and nutrients to all areas of the plant body. The specialization of the plant body, which has evolved as an adaptation to a principally terrestrial habitat, includes extensive root systems that anchor the plant and absorb water and minerals from the soil; a stem that supports the growing plant body; and leaves, which are the principal sites of photosynthesis for most angiospermous plants.

In this unit you will also learn about the root pressure; how hydrostatic pressure generated in roots help in driving water and ions out of the soil and transpiration, the process in which water moves through the stem, leaves and flowers.

In **plants**, **growth hormones** determine every incident pertaining to the **plant**: when it flowers, when leaves form, the growth of stems and shoots, the development of fruits, the growth and maturing of the fruits, shedding leaves and ripening of fruits.

In this unit, you will learn, how seeds germinate in monocots and diocots, the structure and function of the stomata in gaseous exchange between the leaves and the atmosphere. Facultative aerobic and facultative anaerobic type of respiration will be discussed.

6.1 Flowering Plants

Angiosperms or flowering plants, the pollen grains and ovules are developed in specialised structures called flowers. Fruits enclose and protect the seeds. The angiosperms are a huge group of plants and occur in a wide range of habitats. Their size ranges from tiny, microscopic *Wolfia* to tall trees of *Eucalyptus*.

They are the plants that provide us with food, fodder, fuel, medicines and several other commercially important products. We can divide

them into two classes: the dicotyledons and the monocotyledons. The dicotyledons are those that have two cotyledons in their seeds. On the other hand, the monocotyledons have only one. Let us now look at the classification of flowering plants in more details.

Classification of Flowering Plants

The classification of flowering plants is done into two major groups: Dicotyledons and Monocotyledons.

Dicotyledons

They show the following distinguishing characteristics:

- They have tap roots.
- The leaves in members of this class, exhibit reticulate (net-like) venation.
- The flowers are tetramerous or pentamerous. They have four or five members in the various floral whorls, respectively.
- The vascular bundles in these plants are arranged in a ring. They are numbered 2-6, are open and with cambium.
- The seeds of dicotyledons are with two cotyledons.
- They exhibit epigeal germination.

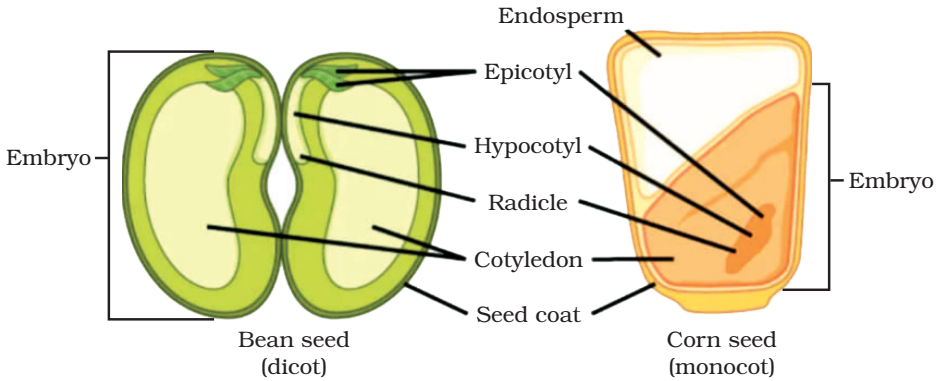


Figure 1. Dicot and monocot seeds

Monocotyledons

They show the following characteristics:

- They have adventitious roots (fibrous roots).
- The leaves are simple with parallel venation.
- The flowers are trimerous having three members in each floral whorl.

- The vascular bundles are scattered in the ground tissue, are many in number and without cambium.
- The seeds of monocotyledons are with one cotyledon. Examples include Cereals, bamboos, sugarcane, palms, banana, lilies and orchids.
- They exhibit hypoigeal germination.

Success of angiosperm

From their humble and still obscure beginning during the early Jurassic period (202–145.5 MYA), the angiosperms, or flowering plants, have successfully evolved to dominate most terrestrial ecosystems. The success of angiosperms is due to two novel reproductive structures: flowers and fruit. The function of the flower is to ensure pollination. Flowers also provide protection for the ovule and developing embryo inside a receptacle. The function of the fruit is seed dispersal. They also protect the developing seed. Different fruit structures or tissues on fruit such as sweet flesh, wings, parachutes, or spines that grab—reflect the dispersal strategies that help spread of seeds.

Figure 2. Flowering plants dominate terrestrial landscapes. The vivid colors of flowers are an adaptation to pollination by insects and birds.

6.2 Functions of Roots, Stems, Leaves and Flowers

Functions of root

Roots are the important underground part of all vascular plants. However, not all plants have their roots underground, some plants have their roots growing above the ground. These are called aerial roots.

Roots perform the following functions:

- Roots absorb water and dissolved nutrients from the soil.
- They anchor the plant firmly.
- They store food and nutrients.
- Roots transport water and dissolved minerals to the plant.
- Roots prevent soil erosion, provide sustenance and also habitat to various organisms.

Functions of stem

Stem, in **botany,** the **plant axis** that bears **buds** and shoots with **leaves** and, at its basal end, **roots.** The main function of a stem in plants is:

- It supports and holds leaves, flowers, and fruits.
- The stem allows the leaves to arrange in a way that they are able to receive direct sunlight in order to efficiently perform photosynthesis. The arrangement and position of leaves also allow for gas exchange.
- The xylem present in the vascular bundles of stems conduct water and nutrient minerals from the root across the plant.
- The movement of **synthesized** foods from the leaves to other plant organs occurs chiefly through other vascular tissues in the stem called **phloem**.
- Stems bear flowers and fruits in a position that facilitates the processes of pollination, fertilization, and dispersion of seeds.
- Some stems undergo modification to store food and water. Example: succulents.
- Few green stems contain chloroplasts and are capable of carrying out photosynthesis as well.
- Some stems are modified to carry out vegetative propagation which is a form of asexual reproduction seen in plants.

Functions of the leaf

In general, leaves are thin, flat organs responsible for the photosynthesis of the plant. Although photosynthesis typically occurs on the upper surface of the leaf, it can occur on both sides in some plant species. Leaves are typically comprised of a distinct upper and lower surface, stomata for gas exchange, waxy coating, hairs, and venation. As one of the most important constituents of plants, leaves have several essential functions:

- **Photosynthesis: The** primary function of the leaf is the conversion of carbon dioxide, water, and UV light into sugar (e.g., glucose) via photosynthesis.
- **Interchange of gases:** It takes place both for respiration and photosynthesis. The epidermis of the leaf contains guard cells that control and regulate the small pores on the undersurface of the leaves. These pores are called stomata. It is also responsible for gaseous exchange to takes place between the atmosphere and the plant body.
- **Transpiration:** Transpiration refers to the movement of water through the plant, and subsequent evaporation via the leaves. When the stomata open to accommodate the diffusion of carbon dioxide into the plant for photosynthesis, water flows out.
- This process also serves to cool the plant via evaporation of the water from the leaf, as well as regulate the plant's osmotic pressure. This process allows the plant to absorb water and minerals from the soil and conduct the same to the top of the plant.
- **Guttation:** Guttation refers to the excretion of water from the edges of leaves and other vascular plants due to increased levels of water in the soil at night, when the stomata are closed. The pressure caused at the roots, results in the leakage of water from the xylem out of specialized water glands at the edges of leaves.
- **Defense:** Some leaves have also evolved defense mechanisms to avoid being eaten or damaged. Some examples include the spines of cacti, cones of gymnosperms, respectively.

- **Vegetative propagation:** Leaves of Bryophyllum, Begonia and Kalanchoe produce buds by means of which they give rise to new plants by vegetative propagation. In these cases when leaf lamina touches the ground, the leaf margin at point produces roots and form a bud that grows into a new plant.

ACTIVITY 1

Illustrating the types of vegetative propagation
Form peer groups in your class.
Discuss on the types of vegetative propagation, such as cutting, grafting, etc. and then present to your class.

Functions of Flowers

Flowers are modified leaves or sporophylls organized around a central stalk. Although they vary greatly in appearance, all flowers contain the same structures: sepals, petals, pistils, and stamens. The primary purpose of the flower is reproduction. Since the flowers are the reproductive organs of the plant, they mediate the joining of the sperm, contained within pollen, to the ovules contained in the ovary. Pollination is the movement of pollen from the anthers to the stigma.

Functions of flowers:

- Give protection to reproductive organs like stamen and stigma.
- Attract pollinators with their bright colors.
- Produce fruits and seeds after reproduction.
- In nature it is the key point for new generation to come.
- Can act as source of food.

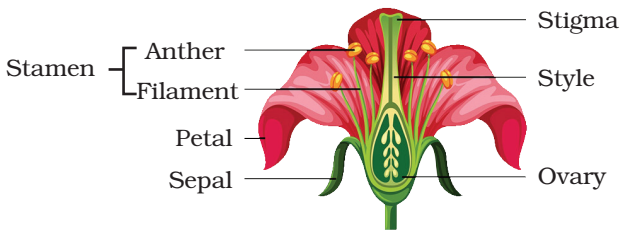


Figure 3. Parts of a complete flower

ACTIVITY 2

Drawing and labelling the pars of a complete flower
Draw a complete flower and label its parts
State the functions of each parts

6.3 Floral formulae of a flower

The floral formula uses discrete letters, signs and figures to represent the specific feature of the flower.

Letters used in floral formula

- K: This letter denotes the sepals that form an outermost whorl called the calyx.
- C: This letter represents the group of petals that constitute the second whorl called the corolla.
- P: It is used to denote the petals, which indicates the undifferentiated condition of the perianth members (sepals and petals).
- A: It specifies the male reproduction part or stamens (androecium).
- G: It denotes the female reproductive part, i.e. carpel, which includes the stigma, style and ovary (gynoecium).
- Br: It represents the bracteate condition of the flower.
- Ebr: It indicates the ebracteate condition, in which a flower lacks bract.
- Brl: It indicates the presence of bracteoles.
- Epik: It represents the presence of a secondary whorl surrounding the calyx called epicalyx.
- Ebrl: It is used to indicate the absence of bracteoles or to represent the ebracteolate condition.

Symbols used in Floral Formula

1. 0: It indicates the **absence** of a particular member in flower.
2. ∞ : It is generally used when the number of specific flower parts is more than **10**.
3. ⊕: It indicates an **actinomorphic** condition.
4. %: It denotes a **zygomorphic** condition.
5. ⚥: It represents the **bisexuality** of flowers.
6. ♂: It represents the unisexual, **staminate** flower.
7. ♀: This represents the unisexual, **pistillate** flower.

Combination of Letters, Symbols and Numbers

- **K5**: It shows the **aposepalous** condition, in which the five sepals are free.
- **K (5)**: It shows the **gamosepalous** condition, in which the five sepals are united.
- **C5**: It represents the **apopetalous** condition or the presence of the five free petals.
- **C (5)**: It represents the **gamopetalous** condition or the presence of five fused petals.
- **Cx**: It indicates corolla cruciform.
- A **curve** drawn over the letters **P** and **A**: It represents the **epiphyllous** stamens.
- A **curve** drawn over the letters **C** and **A**: It shows the **epipetalous** stamens.
- **A3**: It indicates the presence of three free stamens.
- **A2+2**: It indicates the presence of 4 free stamens, two in each whorl.
- **A (9) +1**: It represents the presence of diadelphous stamens (10 in number), in which nine stamens are fused in one whorl, and one stamen remains free.
- **A0**: Sterile stamen (staminode).
- **G0**: Sterile carpel (pistillode).
- **G-**: It represents the semi inferior ovary.
- A **line over** the letter **G**: It represents the **inferior** position of an ovary.
- The **line below** the letter **G**: It represents the **superior** position of an ovary.
- A **curve** over the letters **G** and **A**: It shows the **gynostagium** condition.

The floral formula can be used to describe the flowers of the particular family or the different species of flower. Let us take few examples of the floral formula to study the floral characteristics.

Floral Formula of Fabaceae Family:

%♀♂K(5) C1 + 2+(2) A(9) + 1G1

(%) shows that the symmetry of the flower is monosymmetric or **zygomorphic**. (♂) indicates that the flower is perfect or **hermaphrodite** (includes stamen plus pistil). A letter 'K' indicates the outermost whorl, i.e. **calyx** and (5) shows that the number of **sepals** is five that are **united** with each other.

'C' indicates the second floral whorl, i.e. **corolla** or petals and the number after this, i.e. 1+2+(2), represents **vexillary aestivation**. 'A' means the male reproductive part or **androecium**, and the number after it (9) +1 shows the presence of **diadelphous stamens** (includes 10 stamens).

In 10 stamens, 9 filaments unite to constitute one bundle, and the remaining one filament makes up another one. The line below the letter 'G' indicates the **superior position** of an ovary, and digit 1 shows the **monocarpellary** ovary.

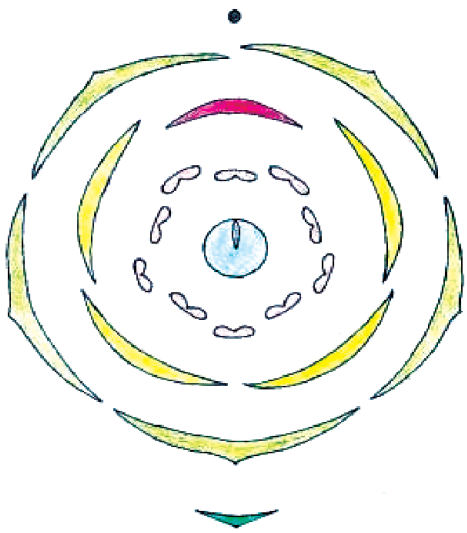


Figure 4. Floral formula of Delonix regia

6.4 Types of Plant Tissues

Plant Tissues

A collection of cells performing a specific function is called tissue. Plant tissues can be grouped into plant tissue systems each performing specialized functions. A plant tissue system is defined as a functional unit, connecting all organs of a plant. Plant tissue system is also

grouped into various tissues based on their functions. The plant tissues are differentiated into three main tissue types: **dermal, ground and vascular tissue**. Each plant organ (roots, stems, leaves) contains all three tissue types.

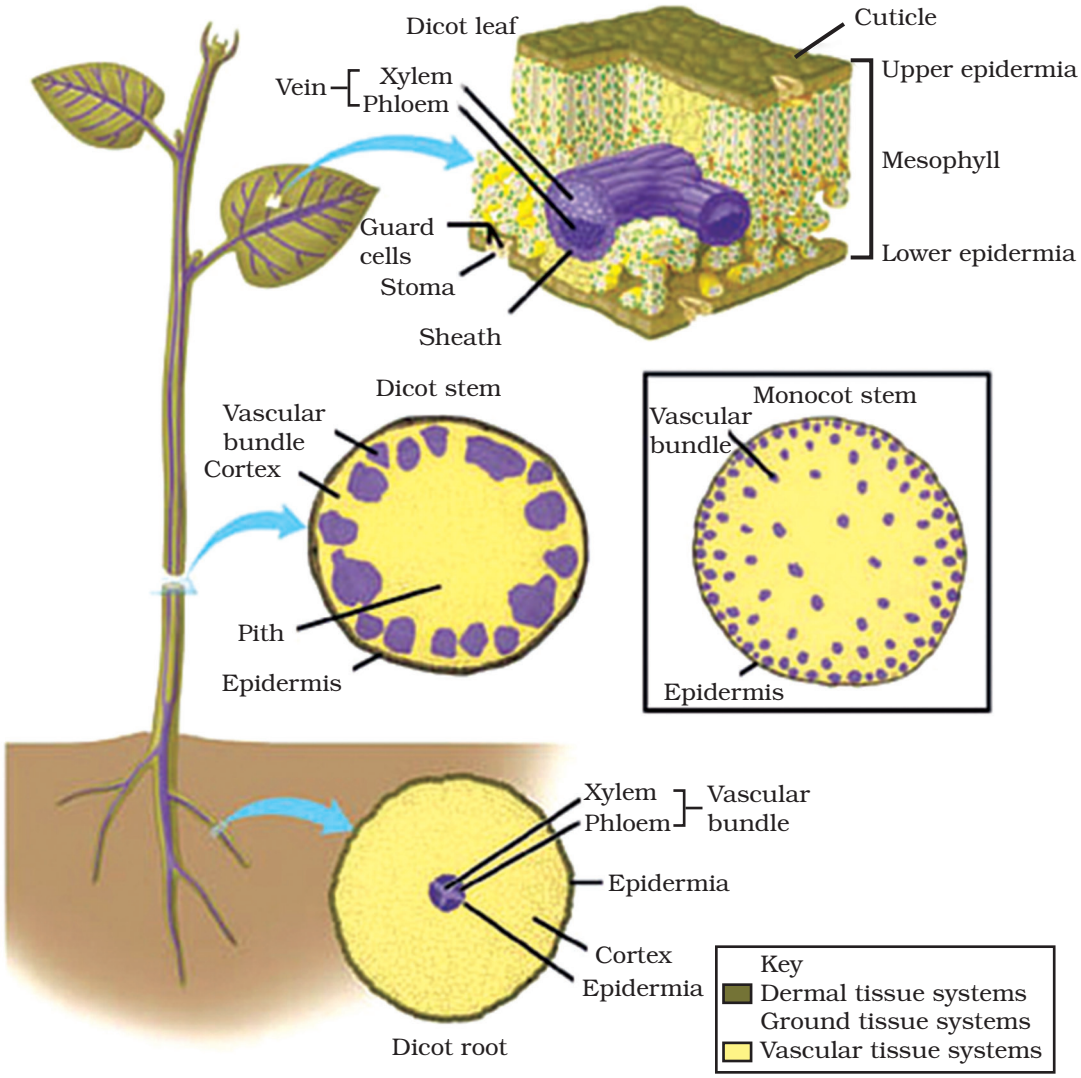


Figure 5. The three tissue types of plants

Three major types of plant tissues are:

Dermal Tissue

Dermal tissue covers the plant and can be found on the outer layer of roots, stems and leaves. Its main functions are transpiration, gas exchange and defense. The epidermis is an example of dermal tissue (Figure 7). It is composed of a single layer of epidermis cells. It may contains stomata and guard cells that allow gas exchange. It may contain root hairs that increase surface area or trichomes used in transpiration or defense. It may contain a waxy cuticle if found on the upper surface of leaves, to aid with lowering transpiration.

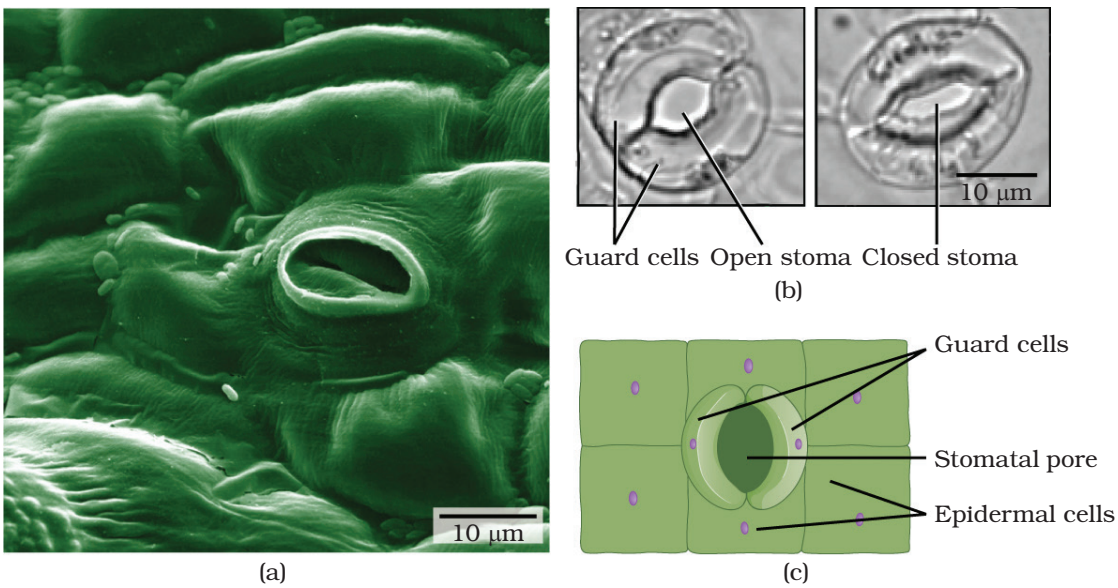


Figure 6. Openings called stomata (singular: stoma) allow a plant to take up carbon dioxide and release oxygen and water vapor. The (a) colorized scanning-electron micrograph shows a closed stoma of a eudicot. Each stoma is flanked by two guard cells that regulate its (b) opening and closing. The guard cells are more curved when the stoma is open compared to when it is closed. The (c) guard cells sit within the layer of epidermal cells

Ground Tissue

Ground tissue makes up much of the interior of a plant and carries out basic metabolic functions. Ground tissue in stems provides support and may store food or water. Ground tissues in roots may also store food. Ground tissue is often divided into three cell types:

(i) **Collenchyma** tissue is found chiefly in the cortex of stems and in leaves and is the primary supporting tissue for many herbaceous plants. Collenchyma (Figure 7) is living supportive tissue that has elongated cells and an unevenly thickened primary cell wall. It often constitutes the ridges and angles of stems and commonly borders the veins in eudicot leaves. Its main function is the mechanical support of young stems and leaves via turgor.

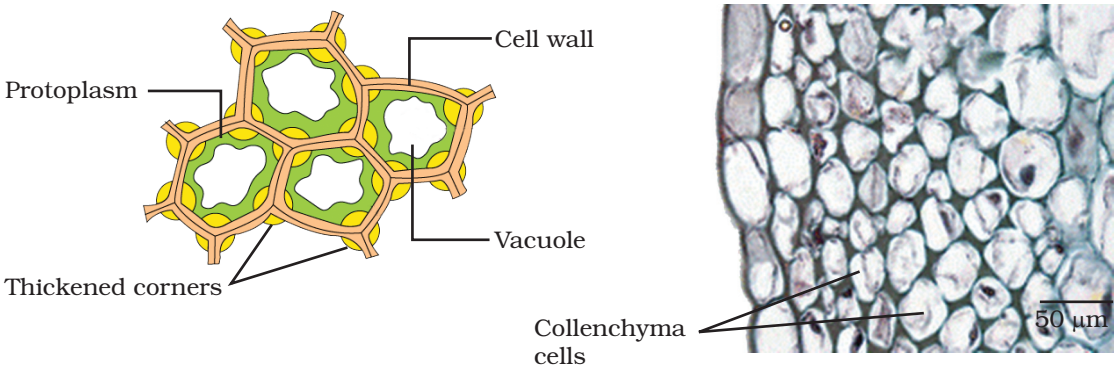


Figure 7. Collenchyma tissues

(ii) **Parenchyma** – These tissues are found in the soft parts of a plant such as the roots, stems, leaves, and flowers. Parenchyma tissues are typically composed of living cells that are thin-walled, unspecialized in structure, and therefore adaptable, with differentiation, to various functions. The cells of this tissue are loosely packed and contain large intercellular spaces between them. Each cell has a vacuole at the center. The functions of parenchyma tissues are secretion, food storage, photosynthesis, and other activities of plant life (Figure 8).

Leaf mesophyll composed of parenchyma tissue. The elongated palisade parenchyma contains the largest number of chloroplasts per cell and is the primary site of photosynthesis in many plants. The irregular spongy parenchyma also contains chloroplasts and facilitates the passage of gases through its many intercellular spaces.

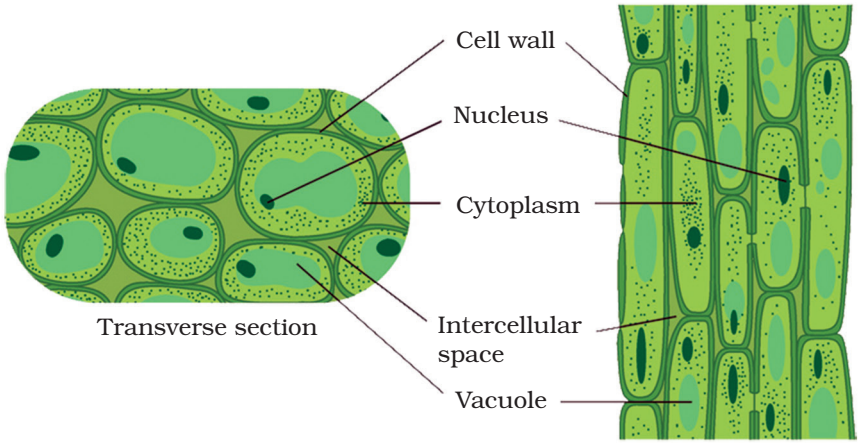


Figure 8. Parenchyma tissue

(iii) **Sclerenchyma**- The cells of this tissue are dead. They are rigid, contain thick and lignified secondary walls. The cells are rigid and non-stretchable and are usually found in non-growing regions of plant bodies, such as the bark or mature stems. Their main function is to provide strength and support to parts of the plant (Figure 9). Sclerenchyma cells occur in many different shapes and sizes, but two main types occur:

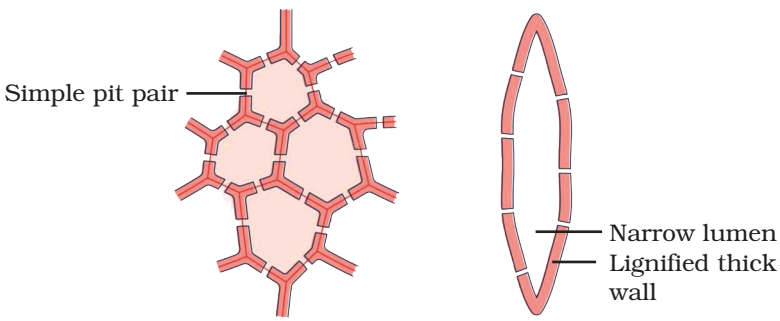


Figure 9. Sclerenchyma tissues

Fibers are greatly elongated cells whose long, tapering ends interlock, thus providing maximum support to a plant. They often occur in bundles or strands and can be found almost anywhere in the plant body, including the stem, the roots, and the vascular bundles in leaves.

Sclereids are extremely variable in shape and are present in various tissues of the plant, such as the periderm, cortex, pith, xylem,

and phloem. They also occur in leaves and fruits and constitute the hard shell of nuts and the outer hard coat of many seeds. Sometimes known as stone cells (Figure 10).

Figure 10. The hard shells of many nuts contain sclereids.

Vascular tissues

Vascular tissue is the plumbing system of the plant. It allows water, minerals, and dissolved sugars from photosynthesis to pass through roots, stems, leaves, and other parts of the plant. It is primary composed of two types of conducting tissue: xylem and phloem.

Xylem : It consists of tracheids, vessels, and xylem parenchyma and xylem fibers. Tracheids and vessels are hollow tube-like structures that help in conducting water and minerals. The xylem conducts only in one direction i.e. vertically. The conducting cells of the xylem are called tracheary elements. There are two type of tracheary elements: vessel elements and tracheids. The xylem parenchyma is responsible for storing the prepared food and assists in the conduction of water. Xylem fibers are supportive in function (Figure 11).

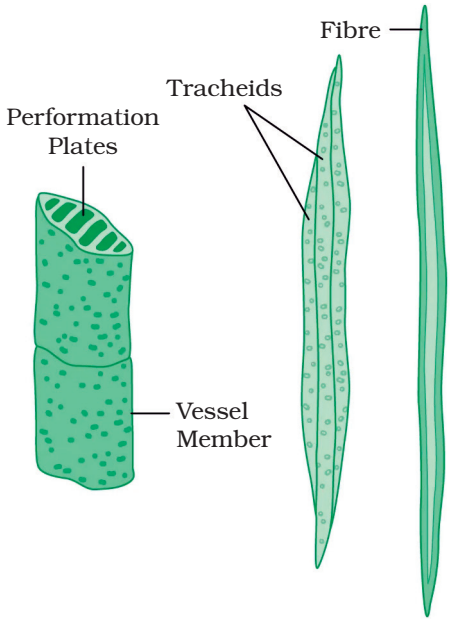


Figure 11. xylem tissues

Phloem tissue transports organic compounds such as sugars from the site of photosynthesis to the rest of the plant. It consists of four of elements: sieve tubes, companion cells, phloem fibers and the phloem parenchyma. Unlike the xylem, phloem conducts in both directions. The conducting cells of the phloem are called **sieve elements**. **Sieve-tube elements** are the sieve elements found only in angiosperms. **Companion cells** support sieve-tube elements in angiosperms. Because they lack essential organelles, sieve elements rely on specialized parenchyma cells to support them. Phloem contains living tissues except for fibers that are dead tissues (Figure 12).

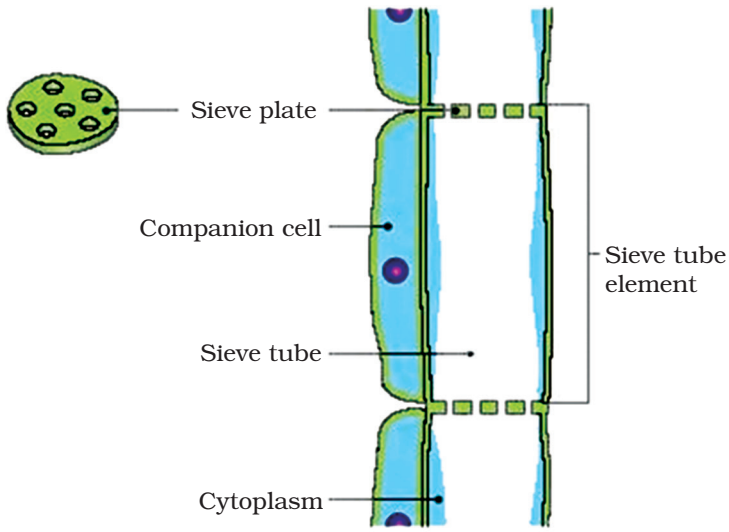


Figure 12. phloem tissue components

6.5 Root Systems

The root system is the descending (growing downwards) portion of the plant axis. When a seed germinates, radicle is the first organ to come out of it. It elongates to form primary or the tap root. It gives off lateral branches (secondary and tertiary roots) and thus forms the root system. Its branches penetrate through large and deep areas in the soil and anchor the plant very firmly. It also plays another vital role of absorbing water and mineral salts from the soil and transporting them upwards.

Types of Root System

Root systems are mainly of two types:

Tap root system - It is the root system that develops from the radicle and continues as the primary root (tap root) which gives off lateral roots. These provide very strong anchorage as they are able to reach very deep into the soil. It is the main root system of dicots e.g. neem, sunflower, mustard, carrot, mango, beetroot, parsley, china rose and all dicotyledons are examples of taproot systems (Figure 13b).

Fibrous root system - In this root system, the primary root is short-lived. A cluster of slender, fiber-like roots arises from the base of the radicle and plumule which constitute the fibrous root system. They do not branch profusely, are shallow and spread horizontally, hence cannot provide strong anchorage. Fibrous root system is the main root system of monocots, e.g. maize, grasses, wheat, rice and all monocotyledons are some examples of the fibrous root system (Figure 13a).

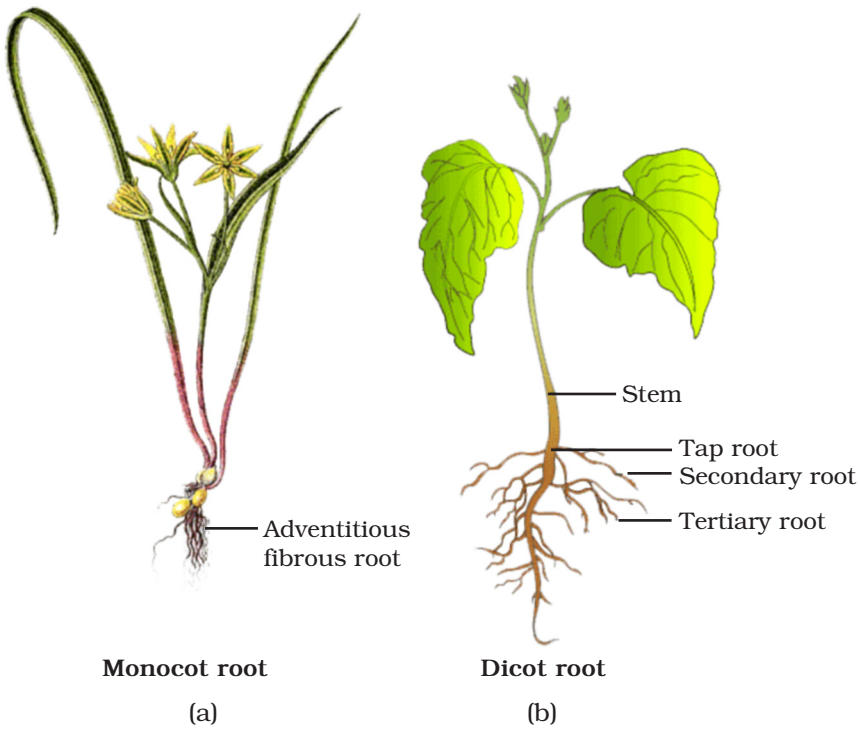


Figure 13. Monocot and dicot roots

Regions of Root Tip

When a seed is germinating, one of the first things to emerge through the seed coat is the root. This initial "root" is called a radicle and as it grows it gives origin to the root system. There are four root regions: the root cap, the region of cell division, the region of elongation and the region of maturation (Figure 14).

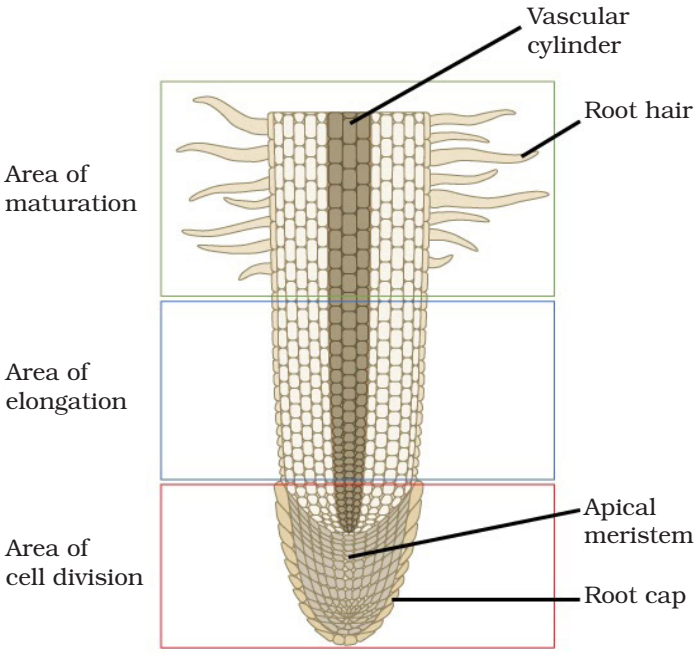


Figure 14. the regions of root tip

Root Cap

A root growing into the soil faces physical challenges, like friction and potential damage from rock particles present in the soil. The root cap is a mass of cells (parenchyma cells) located at the tip of the root. The root cap protects the apex of the root.

The region of Cell Division (region of Meristematic Cells)

Region of meristematic cells is a small region of actively dividing cells called the apical meristem. Meristematic cells are found just a few millimeters over the root cap. The cells in this region are thin-walled with dense protoplasm. These cells divide actively.

Region of Elongation

- Enlargement of cells, allowing roots to grow lengthwise
- It lies next to the meristematic region.
- These are newly formed cells which lose the power of division, hence, they elongate rapidly.

Region of Maturation

- In this region, the cells differentiate into various tissues
- The zone behind the root hair known as the permanent zone produces lateral roots. It anchors the roots firmly in the soil and transports water and nutrients upwards.
- Also, it produces lateral roots.

Root makes the base of a plant which helps a plant to survive. It supplies water and minerals to the plants, thereby contributing to its growth and development.

Functions and Structures of Root Hairs

Structure of root hair cell

The root hair cell is roughly rectangular in shape with a cytoplasmic extension on its lateral end (the root hair). It has the following cellular components:

- A cell wall with intercellular spaces
- A semi-permeable cell membrane
- A large central Vacuole for maximum water and salt retention.
- A cornered nucleus
- Cytoplasm
- Mitochondria for energy production for active transport of nutrients.

Functions of root hair cells

Root hair cells are adapted for taking up water and mineral ions by having a large surface area to increase the rate of absorption. They also contain lots of mitochondria, which release energy from glucose during respiration in order to provide the energy needed for active transport. Root hair cells are specialized structures necessary for the maintenance, growth, and development of plants. They are responsible for the nutritional uptake within plants (Figure 15).

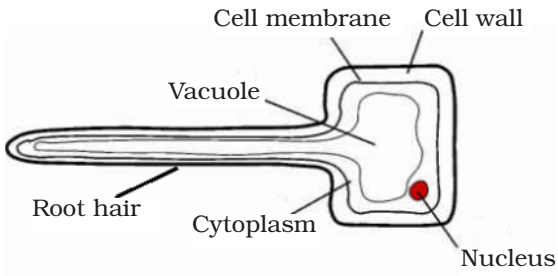


Figure 15. Root hair cell

Absorption: Their elongated, tubular, and pointy structures precisely aid in increasing the exchange of nutrients between the soil and plants' root systems. These cells primarily perform the absorption function. These small rectangular structures absorb the water and nutrients that are already present in the soil.

Storage; The components of food and water taken up by the root hair cells are then stored in vacuoles.

Preservation: At times of flood or when water or nutrients are present in abundance in the soil, they retain the internal storage and strive to strike an optimal balance within and outside the cells.

Supplement the surface area: Having a small diameter and greater length, root hair cells have a larger surface area for maximum storage of nutrients and essential fluids. Apart from sucking up the essential nutrients from within the soil, root hair cells also transfer or transport these to different parts of plants.

Modified Roots, Stems and leaves

Root modification

In some plants, the roots change their shape and get modified to absorb and transport water and minerals from the soil to different parts of the plant. They are also modified for support, food storage, and respiration.

Modifications of Tap Roots

For Food Storage: In some plants, the roots become fleshy due to the absorption of food material. The aerial parts of these plants are worn out due to unfavorable conditions. When the conditions are favorable again new buds emerge either from the fleshy root or from a small bit of stem above the taproots of carrot and turnip get swollen to store food.

For better Respiration: In some halophytes such as *Rhizophora* that grow in swampy areas, the roots emerge out of the ground and grow upwards to get oxygen for respiration. The root tips of these plants have minute pores called lenticels through which they respire.

Nodulated Roots

Roots of the leguminous plants are modified into root nodules which contain nitrogen-fixing bacteria such as *Rhizobium*. They help in fixing the atmospheric nitrogen into nitrates and make it available to the plant.

Modification of Adventitious Roots

(i) **For Food Storage:** Adventitious roots are modified into:
Simple Tuberous Roots are swollen and do not assume any shape. For e.g., sweet potato
Nodulose Roots are single beads. They become swollen at the apex and have a definite shape, e.g., ginger

(ii) For Support
Prop Roots: These roots develop from the branches of the tree, hang downwards, and penetrate into the ground thereby supporting the tree. e.g., roots of the banyan tree.
Stilt Roots: These roots grow obliquely from the basal node of the stem. e.g., roots of the sugarcane.
Climbing Roots: These roots arise from the nodes and attach themselves to some support to climb over it. Thus, they provide support to the plant. e.g. Money plant (Devil's ivy)
Clinging Roots: These roots enter the crevices of some support and fix the plant. e.g. epiphytes orchids

Stem modification

Stems of many plants are modified to perform different functions such as storage, protection, photosynthesis, support, propagation and perennation. Modifications help in better adaptation and survival. In some plants, stems are modified, which can be aerial, subaerial or underground modifications. They are modified to perform other functions, which are not normally associated with the stem (Figure 16).

Tubers are modified stems that may store starch, as seen in the potato. Tubers arise as swollen ends of stolons, and contain many adventitious or unusual buds.

Bulb which functions as an underground storage unit, is a modification of a stem that has the appearance of enlarged fleshy leaves emerging from the stem or surrounding the base of the stem, e.g. onion, garlic.

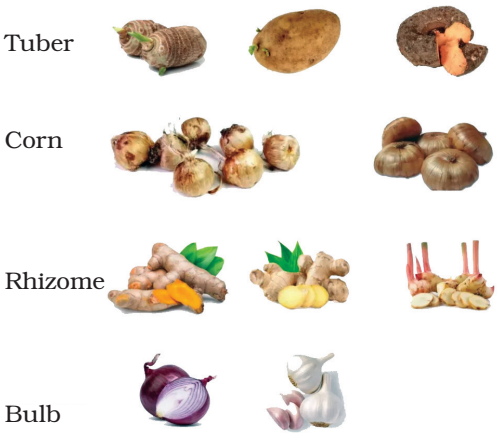


Figure 16. Stem modifications: Stem modifications enable plants to thrive in a variety of environments. Shown are (a) ginger (Zingiber officinalis) rhizomes, (b) a carrion flower (Amorphophallus titanum) corm (c) Rhodes grass (Chloris gayana) stolons, (d) strawberry (Fragaria ananassa) runners, (e) potato (Solanum tuberosum) tubers, and (f) red onion (Allium) bulbs.

Runner is a creeper that runs horizontally on the surface of the soil. The nodes have scale leaves, adventitious roots, and auxiliary buds. Runners arise from the auxiliary buds.

Modified leaves

A modified leaf is an adaptation of plant meant for its own survival due to its environmental stress. When a leaf performs functions other than photosynthesis and transpiration, structural changes may occur. Plants may change either the structure of the leaves, the color (to attract insects), or may add spines or thorns to protect itself. The plant pictured is an *Aloe vera* plant. The plant's leaves are covered in thorns to protect itself from potential predators and to preserve water (Figure 17).

Succulence: In a dry environment, leaves may either become reduced, like in cacti, or, else, become succulent. Succulent leaves not only retain lots of moisture but also have a lower surface area to volume ratio.

Spines for Defence: The non-photosynthetic leaves of cacti have become modified for defense.

Figure 17. Aloe vera modified leaf

Tendrils: In peas the terminal leaflet of the leaf has become modified into a tendril for climbing.

Leaves modified for Reproduction: Leaves grow, function and then die without sustaining new growth. But *Kalanchoe* has leaves that have become modified to generate new plants.

Movie of Venus Fly Trap: While both sundew and the venus fly trap respond actively to entrapped insects, the fly trap does so spectacularly!

Exercise

Choose the best answer from the given alternatives

1. Rhizome of ginger is a modification of stem because
   (a) It bears adventitious roots
   (b) It bears nodes and internodes.
   (c) It is underground
   (d) It stores food material.
2. Arrangement of leaves on a stem branch is
   (a) Venation
   (b) Vernation
   (c) Inflorescence
   (d) Phyllotaxy
3. The tissue which has dead cells in the functional state is
   (a) Collenchyma
   (b) Sclerenchyma
   (c) Parenchyma
   (d) Phloem

4. Most metabolism of the plants is carried in a tissue called _____.
   (a) Phloem
   (b) Meristem
   (c) Parenchyma
   (d) Collenchyma
5. Which tissue provides maximum mechanical strength to the plant?
   (a) Parenchyma
   (b) Xylem
   (c) Collenchyma
   (d) Phloem
6. Collenchyma are characterized by the presence of:
   (a) Elongated cells with deposits of cellulose and pectin all over the world
   (b) Isodiametric cells with deposits of cellulose and pectin at the corners
   (c) Elongated cells with thickening at the corners.
   (d) Isodiametric cells with thickening all over the wall.

6.6 Leaf Classification and arrangement on Stem

Leaf classification

A leaf is any usually flattened green outgrowth from the stem of a vascular plant. As the primary sites of photosynthesis, leaves manufacture food for plants, which in turn ultimately nourish and sustain all land animals. Leaves are an integral part of the stem system. They are attached by a continuous vascular system to the rest of the plant so that free exchange of nutrients, water, and end products of photosynthesis can be carried to its various parts. Leaves may be simple or compound.

Simple Leaf

A **simple leaf** is described as a single lamina attached to a stem by one petiole. There is no division in the lamina or leaf blade. Some examples of simple leaves include pear, oak, guava, and oregano. In a **simple leaf**, the blade is either completely undivided as in the banana leaf or it has lobes, but the separation does not reach the midrib, as in the maple leaf.

ACTIVITY 3

Examining the internal structure of leaf using the microscope

You need:

- Light microscope
- Leaf specimen
- Blank slide
- Cover slip

Method:

1. Take a very tiny specimen of the leaf.
2. Place on a blank microscope slide, then cap it with a cover slip.
3. Add a tiny drop of water under the cover slip.

Observe the internal structure of leaf cell under the microscope.

Draw the internal structure of the cell you have observed.

Compound Leaf

A **compound leaf** is a divided leaf blade where the divisions are called leaflets. Two or more leaflets are attached to the midrib or main vein, which is attached to the petiole.

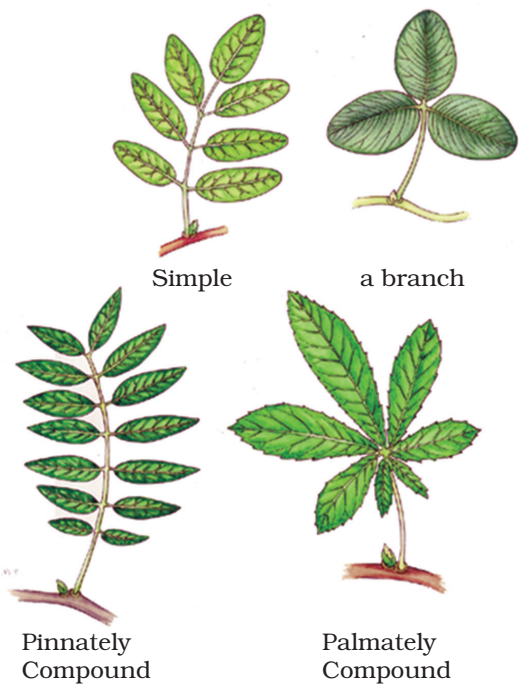


Figure 18. Simple and Compound Leaves

There are several types of compound leaves, depending upon how the leaves are arranged and divided (Figure 18).

Pinnately compound leaves: the leaflets are attached to the midrib, e.g. *Mimosa*, *Acacia* and pea.

In palmately compound leaves: the leaflets attach at the tip of the petiole, just like fingers attach to a palm, e.g., Citrus, Chestnut and *Oxalis* leaves.

It is advantageous for plants to have compound leaves rather than simple leaves. They flutter more easily in a breeze, aiding cooling as well as allowing them to capture more CO_2 from the air surrounding them because diffusion of gases is not great enough to replace that absorbed through the stomata.

Leaf arrangement

Phyllotaxy is the term used to describe the arrangement of leaves around the stem. The proper arrangement of leaves is important for providing sunlight and photosynthesis. Leaves arise from the node of the stem. They develop from the shoot apical meristems. Leaves have axillary buds that develop into branches.

The number and placement of a plant's leaves will vary depending on the species, with each species exhibiting a characteristic leaf arrangement.

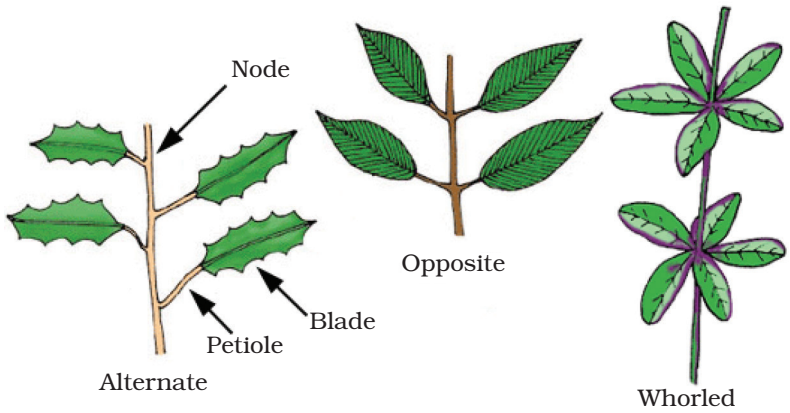


Figure 19. Different types of leaf arrangement

The three main types of leaf arrangement are:

1. **Alternate** – a single leaf originates at each node and leaves are arranged in an alternate fashion. E.g. mustard, china rose, sunflower, etc.

2. **Opposite** – two leaves arise at each node and they lie opposite each other. E.g. guava, *Calotropis*, etc.
3. **Whorled** – more than two leaves arise at each node and form a whorl, e.g., *Alstonia* (Figure 19).

ACTIVITY 4

Field trip collecting and classifying different kinds of leaves
From groups of 4-5 students will collect some leaves from the field.
Bring the leaves to the Laboratory
Classify the leaves
Use laboratory manual for your classification
Write a report

6.7 SEED GERMINATION

Seed germination is defined as the sum of events that begin with hydration of the seed and culminate in emergence of the embryonic axis (usually the radicle) from the seed coat. There are two types of germination:

Epigeal Germination:

Epigeal germination is the type of germination in which the cotyledons rise out of the soil due to the elongation of the hypocotyl. The hypocotyl is the part of the stem of an embryo plant beneath the stalks of the cotyledons. After emerging out of the soil, these cotyledons are called seed leaves, which become photosynthetic as well. The second leaves derived from the plumule become true leaves. This type of germination is very common in beans, gourds, castor, tamarind and onion etc.

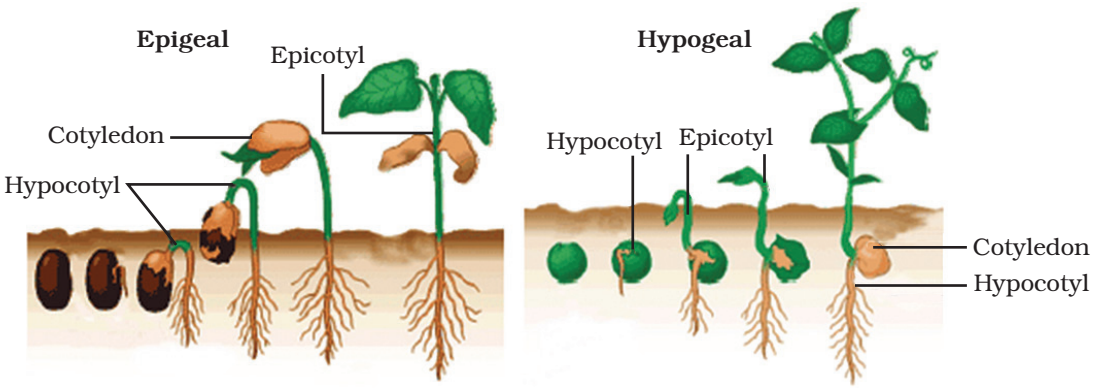


Figure 20. Epigeal and hypogeal germination

Hypogeal germination: Seed germination in dicots in which the cotyledons remain below the soil surface. In this type, the epicotyl elongates and the hypocotyl does not raise the cotyledons above ground. The epicotyl, which is the region of an embryo plant above the cotyledon, grows longer while pushing the plumule out of the soil. This type of germination is common in mango, custard apple, pea, gram, lotus and maize etc.

ACTIVITY 5

Setting up a laboratory experiment to demonstrate the two types of germination using a corn and bean seed.

You need:

- Bean seed
- Maize seeds
- Pots for sowing seeds

Method:

1. Prepare two pots with soil for sowing seeds
2. Collect maize and bean seeds
3. Direct students to sow few maize and bean seed in two separate pots.

Observe the seedlings as they emerge from the soil

Draw and label diagrams of maize and bean seedling and classify as epigeal and hypogeal Give conclusion.

Conditions Necessary for Germination

Seeds remain dormant or inactive until conditions are right for germination. All seeds need **water, oxygen, and proper temperature** in order to germinate. Some seeds require proper light also. Some germinate better in full light while others require darkness to germinate. Some of the major factors necessary for seed germination in plants are as follows:

1. **Water:** Germination cannot occur unless and until the seed is provided with an external supply of water. Water is absorbed by a dry seed through the micropyle and the seed coat.
2. **Oxygen:** Aeration of the soil is absolutely necessary for the germination of the seed because oxygen is necessary for the aerobic respiration by which the seeds get the requisite energy for the growth of the embryo.
3. **Temperature:** Seeds normally germinate within a wide temperature range. However, freshly harvested seeds of

several plants germinate only within a narrow temperature range which widens only when after-ripening has taken place.

4. **Light:** Plants differ as to the effect of light on their germination. Seeds of many plants are light indifferent i.e., they are not influenced in the germination by the presence or absence of light.

6.8 Reproduction in Flowering Plants

Flowering plants reproduce sexually through a process called pollination. The flowers contain male sex organs called stamens and female sex organs called pistils. The anther is the part of the stamen that contains pollen. This pollen needs to be moved to a part of the pistil called the stigma (Figure 21).

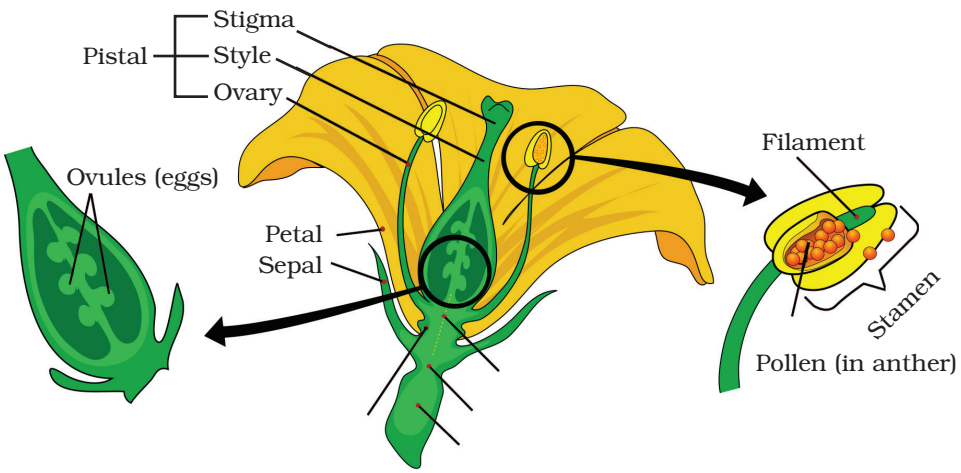


Figure 21. Floral parts of a complete flower

Reproductive Structure of a Flower

Androecium

It is the male reproductive part of a flower, comprising stamens and it is the third whorl. Each stamen comprises two parts, namely, anther and filament. The tip of the anther is supported by the filament. Here pollens are produced by meiosis and disappear eventually.

- **Anther**: is a four-lobed sac-like structure responsible for pollen formation. The transverse section of an anther is

microsporangia that further forms a pollen sac. The pollen sac contains pollen grains.

- **Filaments:** is a long stalk like structure that supports the anther.

Gynoecium

It is the female reproductive organ and the last whorl of the flower. The stigma, style, and ovary are the components of the pistil. The ovary produces ovules internally. Through meiosis, ovules produce megaspores which in turn develops into female gametophytes. As a result, egg cells are produced.

Pistil: each pistil has three parts:

- **Ovary**: is a chamber where ovules (eggs) are stored, waiting for fertilization.
- **Stigma:** is attached to the top of the carpel, where the pollen from other flowers lands.
- **Style**: is a tubular structure that connects the ovary and the stigma. It is responsible for the transportation of pollen from the stigma to the ovary.

Pollination

Pollination is an ecological process carried out by all flowering plants. In this process, the matured pollen grains are transferred from the anther to the stigma for the purpose of **sexual reproduction** in flowering plants.

There are two types of pollination:

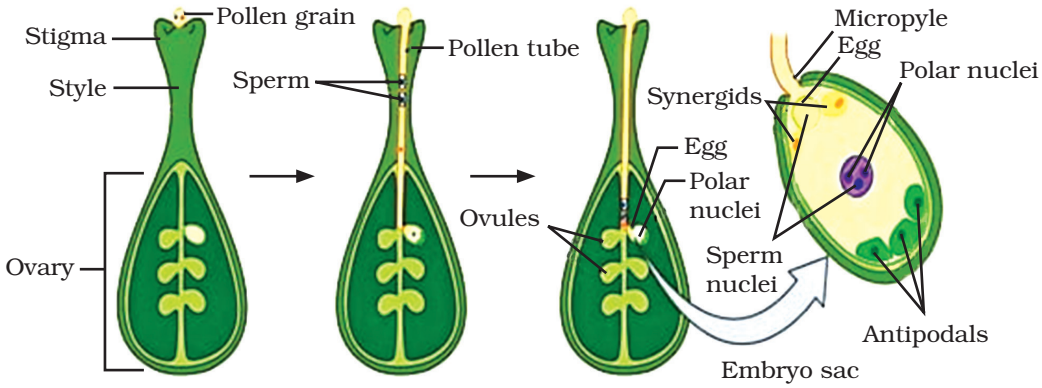
- **Self-Pollination:** This process occurs when the pollen grains from the anther is deposited on the stigma of the same flower, or another flower on the same plant.
- **Cross-Pollination:** This process occurs when the pollen grains are transferred from the anther of one flower into the stigma of another flower of different plants of the same species.

ACTIVITY 6

Explaining the types of pollination and listing agents of pollination
Explain self and cross pollination
List out the agents of pollination
Explain the agents of pollination
Write a report

Fertilization

After pollen is deposited on the stigma, it must germinate and grow through the style to reach the ovule. The microspores, or the pollen, contain two cells: the pollen tube cell and the generative cell. The pollen tube cell grows into a pollen tube through which the generative cell travels. As it travels through the style to reach the embryo sac, the pollen tube's growth is supported by the tissues of the style. The generative cell divides to form two sperm cells. The pollen tube is guided by the chemicals secreted by the synergids present in the embryo sac; it enters the ovule sac through the micropyle. Of the two sperm cells, one sperm fertilizes the egg cell, forming a diploid zygote; the other sperm fuses with the two polar nuclei, forming a triploid cell that develops into the endosperm. Together, these two fertilization events in angiosperms are known as double fertilization (Figure 22). After fertilization is complete, no other sperm can enter. The fertilized ovule forms the seed, whereas the tissues of the ovary become the fruit, usually enveloping the seed.



The pollen grain adheres to the stigma, which contains two cells; a generative cell and a tube cell

The pollen tube cell grows into the style. The generative cell travels inside the pollen tube. It divides to form two sperm

The pollen tube penetrates an opening in the ovule called a micropyle.

One of the sperm fertilizes the egg to form the diploid zygote. The other sperm fertilizes two polar nuclei to form the triploid endosperm, which will become a food source for the growing embryo.

Figure 22. Double fertilization process

6.9 Kinds of Fruits, Dispersal of Fruit and Seeds

Types of Fruits

Fruit is a matured ovary and its contents. The function of a fruit is to spread seeds. Scientists often categorize fruits based on their structure and seed type rather than just on the number of ovaries.

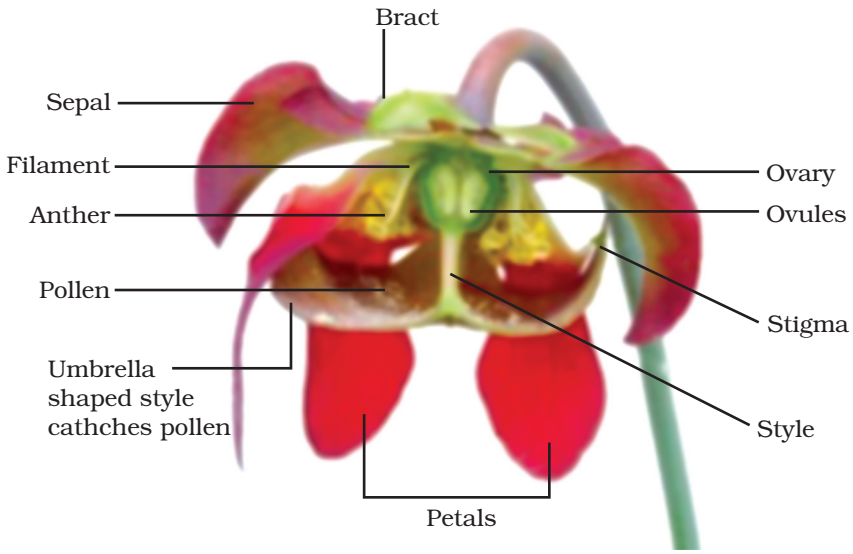


Figure 23. Parts of a Flower - the ovary and ovules are the fruit

The main types of fruits are drupes, pomes, berries, citrus fruits and pepo.

Drupes: are indehiscent fruits that has a hard pit with the seed inside fully surrounded by a soft, fleshy part. This is sometimes called a stone fruit, e.g. peaches, cherries, raspberries and blackberries.

Berries: are defined as fleshy fruits with many seeds inside and a covering on the outside that can be either soft or hard. They don't have a stone or a pit. 'True berry' is classified as a fleshy fruit formed from the ovary of one flower with a seed or seeds embedded in the flesh. e.g. blueberries, gooseberries and cranberries.

Pome: is a type of fruit that has a fleshy area surrounding a core containing seeds. Some examples of fruits that are pomes, apples and pears.

Hesperidia (citrus fruits) are fleshy fruits that have a thick tangy rind and sectioned pulp inside, such as lemons, oranges and limes.

Achene: is a dry indehiscent fruit with a thin closed wall around a single seed. These are all considered simple fruits.

Caryopsis: is a dry, single fruit with ovary walls joining the outer seed coating. This type of fruit is often seen in cereals and grasses.

Capsule: is a dry fruit which produces capsules to surround the seeds.

Legume: is a dry, dehiscent fruit that is long and contains many seeds. The seeds are only released if two seams are split vertically.

Activity 7

Collecting various fruits and seeds and classifying them into types.

You need:

A set of bag

Fruits and seeds

Methods:

1. Go in groups for collecting fruits and seeds.
2. You can collect fruits and seeds in either of the following methods.
   - Collected from standing trees.
   - Collected from fallen trees.
   - Collected from the ground.
   - Lopping of branches (selectively cutting branches).
   - Or from any other source.

Bring the fruits and seeds to the Lab and classify them.

Write a paragraph describing how the fruits and seeds can be classified.

Use classification chart and then present to the class.

Fruits and seed dispersal

Fruits play an important role in the seed dispersal of many plant species. In dehiscent fruits, such as poppy capsules, the seeds are usually dispersed directly from the fruits, which may remain on the plant. In fleshy or indehiscent fruits, the seeds and fruit are commonly moved away from the parent plant together.

Dispersal by ingestion

Many of the fleshy fruits that humans enjoy such as raspberries (*Rubus*) and cherries (*Prunus*) are adapted for dispersal by vertebrates. Some fleshy fruits are consumed with seeds intact. The seeds pass through the digestive tract of an animal and are deposited elsewhere; germination may be enhanced by weakening of the seed coat as it passes through the digestive tract.

Dispersal by adherence

A common method by which fruits are distributed in this way is to adhere to the fur or feet of a mammal. Fruits adapted for adherence are often covered with hook-like structures.

Figure 24. The fruits above are dispersed by becoming caught in animal fur or on or in the feet of animals

Wind dispersal

Fruits and seeds that are wind-dispersed frequently have modifications that help slow their descent to the ground and increase the chances that they will be blown laterally by air currents, so that they do not land directly beneath or next to their parent plant. Seed modifications for wind dispersal can include small size and/or light weight, wings, hairs, and/or inflation (Figure 25).

Figure 25. Winged fruits.

Water dispersal

Plants that live in wetland environments may have buoyant, or floating, fruits or seeds. Some plants with floating fruits or seeds can disperse long distances over the ocean. e.g. of this is the coconut palm (*Cocos nucifera).*

Explosive dispersal

Seeds are dispersed through ballistic or explosive dispersal. In this method of dispersal, the fruit forcibly ejects the seed(s), scattering them for a short distance.

A spectacular example of explosive dehiscence comes from the tropical sandbox tree (*Hura*) (Figure 26).

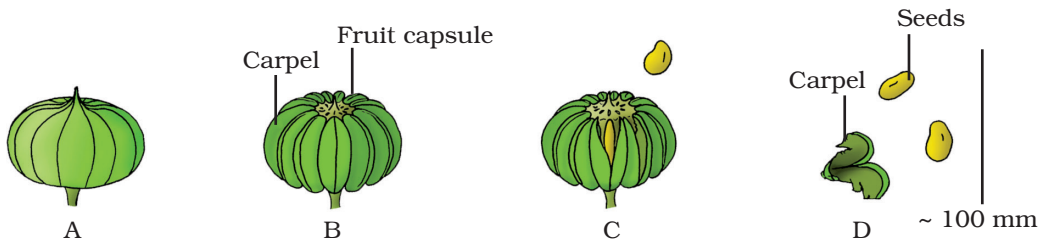


Figure 26. Diagram of the stages in the dehiscence of the sandbox tree fruit (Hura crepitans). A. Immature, dry fruit. B. More mature fruit showing multiple carpels. C. As the fruit dehydrates (loses water), the carpels split open, explosively discharging the seeds. D. An open carpel with seeds.

6.10 Plant growth hormones and plant growth

Growth in plants is influenced by chemical messengers called plant hormones. There are five types of plant hormones. These are Auxins, Cytokinins, Gibberellic acid, Ethylene and Abscisic acid.

Plant growth hormones

Auxins

There are two main types of auxins. These are synthetic auxins and natural auxins.

Synthetic auxins- are not naturally occurring but produced in Laboratories by man.They promote growth but also used as weed killers.

E.g. 2, 4-D (2, 4- dichlorophenoxyacetic acid), that kills dicot leaves.

Monocots are less sensitive to 2, 4-D. synthetic auxins prevent fruits from falling off (abscission) before they mature. This makes possible to harvest the fruit all at once. They also induce root initiation when applied to cuttings.

Natural auxins- are naturally found in plants.

e.g. IAA (Indole acetic acid):

- IAA major functions are promotion of elongation of stems and growth
- Formation of adventitious roots
- Inhibition of leaf abscission
- Promotion of cell division
- Inducement of ethylene production and
- Lateral bud dormancy.

Auxins stimulate formation of roots of stem cuttings.

Gibberellins

- Promotes **bolting,** i.e. sudden elongation of internodes, delays senescence.
- Induces parthenocarpy.
- Elongation of the stem and reverses dwarfism.
- Induces the formation of hydrolytic enzymes breaks seed dormancy.
- are found in root and shoot tips, young leaves and seeds.
- activate cell division and cell elongation.
- activate enzymes to break dormancy of seeds.

Cytokinins

- It promotes lateral and adventitious shoot growth and used to initiate shoot growth in culture.
- Helps in overcoming apical dominance induced by auxins.
- Stimulate the formation of chloroplast in leaves.
- Promotes nutrient mobilization and delay leaf senescence.

Ethylene

It acts as a growth promoter as well as an inhibitor. Occurs in gaseous form. It is synthesized in the ripening fruits and tissues undergoing senescence.

- It hastens the ripening of fruits.
- Controls epinasty of leaves.
- Breaks seed and bud dormancy.
- Stimulates rapid elongation of petioles and internodes.
- Promotes senescence and abscission of leaves and flowers.
- Induces root growth and root hair formation.

Abscisic acid

It is a growth-inhibiting hormone. ABAs act as an antagonist to GAs. It inhibits plant metabolism and regulates abscission and dormancy.

- Induces abscission of leaves and fruits.
- Inhibits seed germination.
- Induces senescence in leaves.
- Accelerates dormancy in seeds that is useful for storage purpose.
- Stimulates closure of stomata.

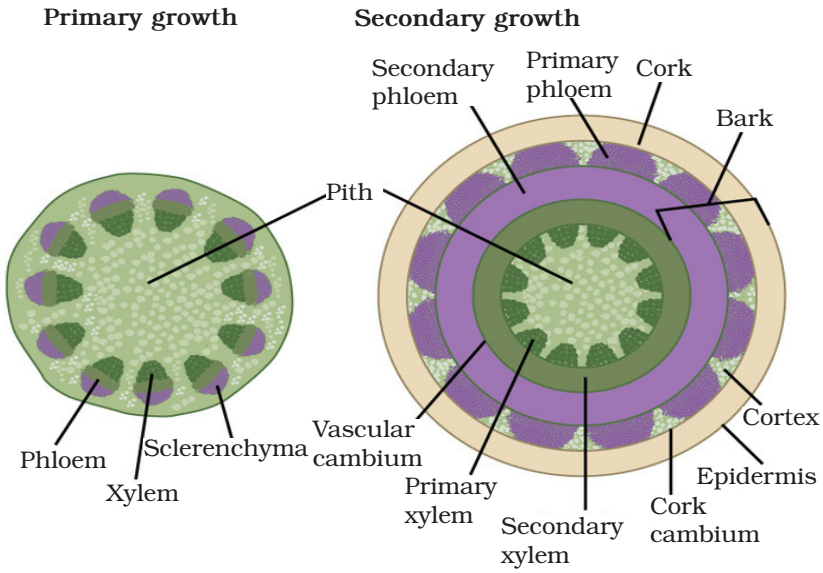


Figure 27. Primary and secondary growth

Primary and Secondary Growth in Plants

Growth in Stems

Growth in plants occurs as the stems and roots lengthen. Some plants, especially those that are woody, also increase in thickness

during their life span. The increase in length of the shoot and the root is referred to as primary growth. It is the result of cell division in the shoot apical meristem. Secondary growth is characterized by an increase in thickness or girth of the plant. It is caused by cell division in the lateral meristem.

Herbaceous plants mostly undergo primary growth, with little secondary growth or increase in thickness. Secondary growth, or "wood", is noticeable in woody plants; it occurs in some dicots, but occurs very rarely in monocots.

Activity 8

Drawing and labelling the cross section monocot and dicot stem & root
Draw and label the cross sections of a monocot and dicot stems and roots.
Use this textbook, other books or internet as a resource for your work

Primary Growth in Plants

Most primary growth occurs at the apices, or tips, of stems and roots. Primary growth is a result of rapidly-dividing cells in the apical meristems at the shoot tip and root tip. Subsequent cell elongation also contributes to primary growth. The growth of shoots and roots during primary growth enables plants to continuously seek water (roots) or sunlight (shoots).

Secondary Growth in Plants

The increase in stem thickness that results from secondary growth is due to the activity of the lateral meristems, which are lacking in herbaceous plants. Lateral meristems include the vascular cambium and, in woody plants, the cork cambium. The vascular cambium is located just outside the primary xylem and to the interior of the primary phloem. The cells of the vascular cambium divide and form secondary xylem (tracheids and vessel elements) to the inside and secondary phloem (sieve elements and companion cells) to the outside. The thickening of the stem that occurs in secondary growth is due to the formation of secondary phloem and secondary xylem by the vascular cambium, plus the action of cork cambium, which forms the tough outermost layer of the stem. The cells of the secondary xylem contain lignin, which provides hardiness and strength.

In woody plants, cork cambium is the outermost lateral meristem. It produces cork cells (bark) containing a waxy substance known

as suberin that can repel water. The bark protects the plant against physical damage and helps reduce water loss. The cork cambium also produces a layer of cells known as phelloderm, which grows inward from the cambium.

Measurement of Growth in Plants

You have already known that the growth in length of the plant is due to the activity of the apical region of shoot and root. So in any plant the growth in length can be measured in ordinary measuring scale at an interval of time. For precise measurement, an instrument called 'Lever Auxanometer' is used. It measures the rate of growth of plant in terms of short length. The auxanometer consists of a movable pointer attached to a pulley and a graduated arc fixed to a stand. A thread passes around the pulley. One end of the thread is tied to the growing tip of the potted plant. The other end is tied to a small weight. As the plant grows in length the pulley rotates and needle attached to the pulley moves down the scale. From this, growth in length of the plant can be measured at a given interval of time (Figure 28).

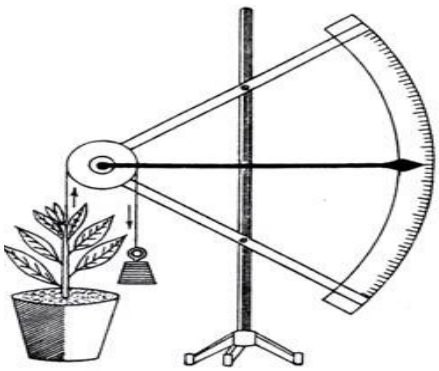


Figure 28. Arc Auxanometer

Activity 9

Class work, examining sections of stems, roots in different stages primary and secondary growth
Form groups of 4-5 students
Examine the sections of roots and stems
Evaluate your findings and then write a report.

Nastic and Tactic Movements in Plants

Nastic movements are non directional responses to stimuli (e.g. temperature, humidity, light irradiance), and are usually associated with plants. The movement can be due to changes in turgor or changes in growth. Decrease in turgor pressure causes shrinkage while increase in turgor pressure brings about swelling. The direction of nastic movements is independent of the stimulus's position. The rate or frequency of these responses increases as intensity of the stimulus

increases. An example of such a response is the opening and closing of flowers (photonastic response), movement of *Euglena*, *Chlamydomonas* towards the source of light.

Tactic movement is a type of movement in plants which is directed towards (positive) or away from (negative) a stimulus. For example, phototaxis is a plant's response to light. Positive phototaxis occurs when a plant moves or orients itself towards a light source. This type of movement may allow a plant to maximize its photosynthetic area which helps it grow. Phototaxis may also be negative which means the plant moves away from a light source in order to minimize light induced damage. Other stimuli that may induce tactic movement in plants include gravity and touch.

Exercise

Choose the best answer from the given alternatives.

1. The role of double fertilization in angiosperms is to produce
   (a) Endosperm
   (b) Cotyledons
   (c) Endocarp
   (d) Hormones
2. Male gametes in angiosperms are formed by the division of:
   (a) Microspore
   (b) Microspore mother cell
   (c) Generative cell
   (d) Vegetative cell
3. A fruit is
   (a) A product of the flower
   (b) A product of ovary
   (c) Post fertilization product of pistil
   (d) A body that contains seed
4. Seed dispersal is important because it:
   (a) Avoids competition
   (b) Produces mixed population
   (c) Promotes cores population
   (d) All of the above
5. Which of these is **not** a function of Auxin?
   (a) Inducing callus formation
   (b) Inducing dormancy

(c) Enhancing cell division
(d) Maintaining apical dominant

6. _____ is a gaseous plant hormone.
(a) IBA
(b) Ethylene
(c) Abscisic acid
(d) NAA

Transport system in vascular Plants

Vascular tissue is comprised of the xylem and the phloem, the main transport systems of plants. They typically occur together in vascular bundles in all plant organs. The two primary vascular tissues are xylem, which transports water and dissolved minerals from the roots to the leaves, and phloem, which conducts food from the leaves to all parts of the plant.

Xylem

- Water and minerals ascend from roots to shoots through the xylem
- Xylem sap flows upward to veins that branch throughout each leaf, providing each with water.
- Plants lose an astonishing amount of water by transpiration, the loss of water vapor from leaves and other aerial parts of the plant.
- The flow of water transported up from the xylem, replaces the water lost in transpiration and also carries minerals to the shoot system.

Phloem

- Organic nutrients are translocated through the phloem
- The phloem transports the organic products of photosynthesis throughout the plant via a process called translocation.
- In angiosperms, the specialized cells of the phloem that function in translocation are the sieve tube members.
- These are arranged end to end to form long sieve tubes with porous cross-walls between cells along the tube.
- Phloem sap is an aqueous solution in which sugar, primarily the disaccharide sucrose, is the most common solute.
- Sap may also contain minerals, amino acids, and hormones.

Movement of water and minerals through plants

The structure of plant roots, stems, and leaves facilitates the transport of water, nutrients, and photosynthates throughout the plant. The phloem and xylem are the main tissues responsible for this movement.

Movement of water through plants

Water potential: is a measure of the potential energy in water, specifically, water movement between two systems. Water potential can be defined as the difference in potential energy between any given water sample and *pure* water. Water potential is denoted by the Greek letter Ψ(*psi*) and is expressed in units of pressure called mega pascals (MPa). The potential of pure water ($\Psi^{pure}\ H_2O$) is designated a value of zero. Water potential values for the water in a plant root, stem, or leaf are expressed relative to $\Psi^{pure}\ H_2O$.

The water potential measurement combines the effects of **solute concentration (s)** and **pressure (p):**

$$\Psi_{system} = \Psi_s + \Psi_p$$

where Ψs = solute potential, and Ψp = pressure potential. Addition of more solutes will *decrease* the water potential, and removal of solutes will *increase* the water potential. Addition of pressure will *increase* the water potential, and removal of pressure (creation of a vacuum) will *decrease* the water potential.

Water always moves from a region of **high** water potential to an area of **low** water potential, until it equilibrates the water potential of the system. At equilibrium, there is no difference in water potential on either side of the system. In order for water to move through the plant from the soil to the air (a process called **transpiration**), Ψ^{soil} must be $> \Psi^{root} > \Psi^{stem} > \Psi^{leaf} > \Psi^{atmosphere}$.

Osmosis: A cell membrane and a cell wall surround the plant cell. The cell wall is freely permeable to water and substances in solution hence are not a barrier to movement, the diffusion of water across a differentially- or semipermeable membrane is known as Osmosis as shown in Figure 29. Osmosis occurs in response to a driving force. The net direction and rate of osmosis depends on both the pressure gradient and concentration gradient.

If the external solution balances the osmotic pressure of the cytoplasm, it is called isotonic. If the external solution is more dilute than the cytoplasm, it is called hypotonic and if the external solution is more concentrated, it is called hypertonic. Cells swell in hypotonic solutions and shrink in hypertonic ones.

Plasmolysis: This happens when the cell is placed in a solution that is hypertonic to the protoplasm. The process of plasmolysis is usually reversible. When the cells are placed in a hypotonic solution, water diffuses into the cell causing the cytoplasm to build up a pressure against the wall, which is called turgor pressure.

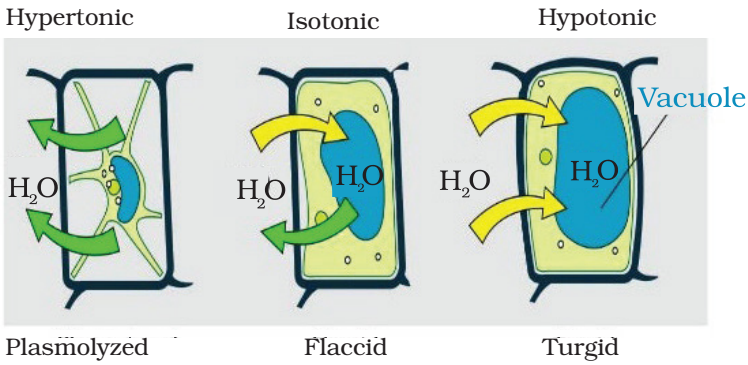


Figure 29. Osmosis in plant cells

When a plant cell is placed in a highly concentrated solution, water diffuses out of the cell, and turgor pressure is lost causing the cell to become flaccid. Further loss of water will result in plasmolysis, and finally to cytorrhysis, the complete collapse of cell wall.

Imbibition: is a special type of diffusion when water is absorbed by solids or colloids causing them to enormously increase in volume. Absorption of water by seeds and dry wood are examples of Imbibition.

Movement of minerals through plants

Diffusion: Diffusion is a free movement of ions in and out of the tissue. It helps in the movement of minerals from higher concentration to lower concentration without the help of any external metabolic energy.

Diffusion is passive. It may be from one part of the cell to the other or from cell to cell, or over short distances, for example from the intercellular spaces of the leaf to the outside. No energy loss takes place. Diffusion is a slow process. Diffusion rates are dependent on the

gradient of concentration, the permeability of the membrane separating them, temperature and pressure.

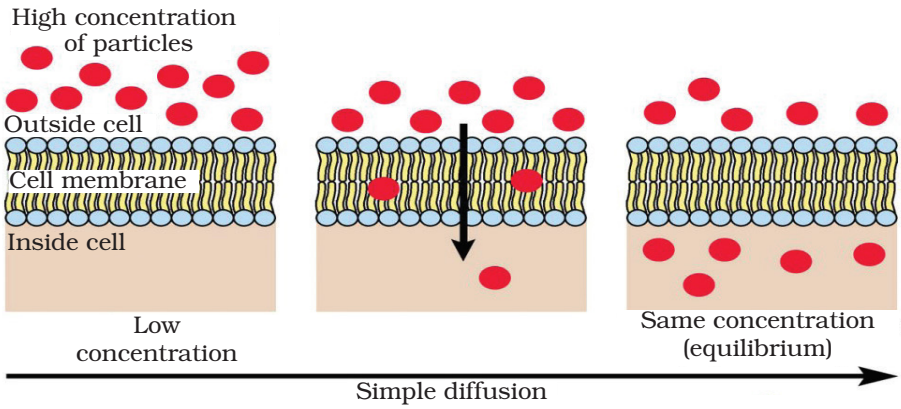


Figure 30. Simple diffusion

Facilitated Diffusion: Facilitated diffusion is **the passive movement of molecules along the concentration gradient assisted by a carrier.** It is a selective process, i.e., the membrane allows only selective molecules and ions to pass through it. It, however, prevents other molecules from passing through the membrane. Substances soluble in lipids diffuse through the membrane faster. Hydrophilic moiety substances, find it difficult to pass through the membrane. Their movement has to be facilitated. Membrane proteins provide sites at which such molecules cross the membrane. A concentration gradient must already be present for molecules to diffuse even if facilitated by the proteins (Figure 31).

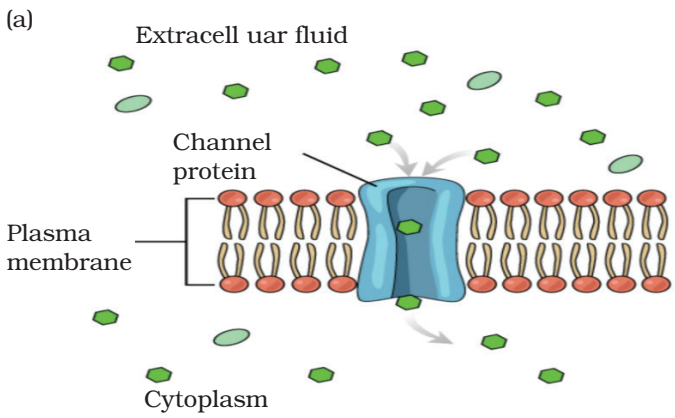


Figure 31. Facilitated diffusion

Active Transport: Uses energy to pump molecules against a concentration gradient. Active transport is carried out by membrane-proteins. Pumps are proteins that use energy to carry substances across the cell membrane. These pumps can transport substances from a low concentration to a high concentration. Active transport is a kind of transport wherein ions or molecules move against a concentration gradient.

Movement of Organic materials from Leaves to Roots

Phloem transports organic materials from sites of production (called a source) to a site of need (called a sink). Thus, the typical direction of transport is downward from the primary source (leaves) to the major sink (roots). The movement of sugar through the phloem of plants is known as Translocation. Sugar moves from the leaves, where it is produced, into the seive tubes of the phloem by active movement. The increase in solute concentration in the seive tube cells causes water to enter into it as a result of osmosis.

Translocation of organic solutes is essential in higher plants because:-

In higher plants, only the green parts can manufacture food and it must be supplied to other non-green parts i.e., the stem and roots for consumption and also for storage.

During the germination of the seeds, the insoluble reserve food material of the seed is converted into soluble form and is supplied to the growing regions of young seedling till it has developed its own photosynthetic system i.e., leaves.

Translocation of organic solutes always takes place from the region of higher concentration of soluble form i.e., the supply end (source) to the region of lower concentration of its soluble form i.e., the consumption end (sink).

Excretion in Plants

Carbon dioxide, excess water produced during respiration and nitrogenous compounds produced during protein metabolism are the major excretory products in plants. Plants produce two gaseous waste products i.e. oxygen during photosynthesis and carbon dioxide during respiration.

6.11 Excretory products of plants

The cellular respiration, photosynthesis, and other metabolic reactions produce a lot of excretory products in plants. Carbon dioxide, excess water produced during respiration and nitrogenous compounds produced during protein metabolism are the major excretory products in plants.

Excretion of gaseous waste, in plants takes place through, stomatal pores on leaves. Oxygen, released during photosynthesis is used for respiration while carbon dioxide, released during respiration is used for photosynthesis.

Excess of water is also excreted from the plant body through the stomatal pores and from the surfaces of fruits and stems. Plants can get rid of excess water by transpiration and guttation.

Other than gaseous wastes, metabolism in plants also generates organic by-products. These wastes are stored in different forms in different parts. The gums, oils, latex, resins, etc. are some waste products stored in plant parts like barks, stems, leaves, etc.

The main excretory materials formed in plants are:

1. **Alkaloids:** These are nitrogenous excretory matters made up of C.H, O and N. These are insoluble in water, soluble in alcohol, sour in taste, many of them are poisonous and some used as medicines are found in storage organs of the plant such as seeds, leaves, bark etc.

   e.g. are: Morphine, Cocaine, Caffeine, and Nicotine

2. **Tannins:** These are related with glucosides are bitter and sour taste. These are found in cell sap, cell wall, leaves, barks etc. These are more present in un-ripened fruits and decrease as the fruit ripens. These are mostly used in manufacturing medicines, ink and hardening leather. e.g. Haematoxylin, Katha.
3. **Resins:** These are formed by the oxidation of essential oils. These are insoluble in water and soluble in alcohol and ether, present in special types of glands or in canals either in group or alone with gums and essential oils. These are used in manufacturing paints and varnish.e.g. Heeng, Ferula.

4. **Gums:** This is formed due to disintegration of cellulose cell wall & soluble in water. This excretes in the form of mucilaginous substance which acts as sticking substance. It is also used in manufacturing of medicines.
5. **Organic Acids:** These are commonly found in leaves and fruits of plants. Citric acid is found in Citrus, Oxalic acid in Oxalis, Tartaric acid in fruits of Imli, malic acid in cacti, Opuntia and especially in CAM plants where stomata remain open in night and closed in day time.

6.12 Munch's Mass Flow or Pressure Flow Hypothesis

According to this hypothesis put forward by Munch (1930) and elaborated by Craft (1938) and others, the translocation of organic solutes takes place in mass through phloem along a gradient of turgor pressure from the region of higher concentration of soluble solutes i.e., supply end to the region of lower concentration i.e., consumption end. The principle involved in this hypothesis can be explained by a simple physical system as shown in the Figure 32.

Two membranes X and Y permeable only to water and dipping in water are connected by a tube T to form a closed system. Membrane X contains more concentrated sugar solution than in membrane Y. Due to higher osmotic pressure of the concentrated sugar solution in membrane X, water enters into it so that its turgor pressure is increased. The increase in the turgor pressure results in mass flow of sugar solution to membrane Y through the tube T till the concentration of sugar solution in both the membranes is equal.

According to Munch's hypothesis, a similar analogous system for the translocation of organic solutes exists in plants. As a result of photosynthesis, the mesophyll cells in the leaves contain higher concentration of organic food material in them in soluble form and correspond to membrane X or supply end. The cells of stem and roots where the food material is utilized or converted into insoluble form correspond to membrane Y or consumption end. While the sieve tubes in phloem, which are placed end to end correspond to the tube T.

Mesophyll, cells draw water from the xylem of the leaf due to higher osmotic pressure and suction pressure of their sap so that their turgor pressure is increased. The turgor pressure in the cells of stem and

the roots is comparatively low and hence, the soluble organic solutes begin to flow in mass from mesophyll through phloem down to the cells of stem and the roots under the gradient of turgor pressure. In the cells of stem and the roots the organic solutes are either consumed or converted into insoluble form and the excess water is released into xylem through cambium.

Cytoplasmic Streaming

Cytoplasmic streaming, also called protoplasmic streaming and cyclosis, is the flow of the cytoplasm inside the cell, driven by forces from the cytoskeleton. It is likely that its function is, at least in part, to speed up the transport of nutrients, proteins and organelles within cells. It is usually observed in large plant and animal cells, greater than approximately 0.1 mm. In smaller cells, the diffusion of molecules is more rapid, but diffusion slows as the size of the cell increases, so larger cells may need cytoplasmic streaming for efficient function (Figure 33).

In plant cells, chloroplasts may be moved around with the stream, possibly to a position of optimum light absorption for photosynthesis. The rate of motion is usually affected by light exposure, temperature, and pH levels. The optimal pH at which cytoplasmic streaming is highest, is achieved at neutral pH and decreases at both low and high pH.

Although the mechanism of cytoplasmic streaming is not completely understood, it is thought to be mediated by "motor" proteins molecules made up of two proteins that use adenosine triphosphate (ATP) to move one protein in relation to the other. If one of the proteins remains fixed on a substrate, such as a microfilament or a microtubule, the motor proteins can move organelles and other molecules through the cytoplasm.

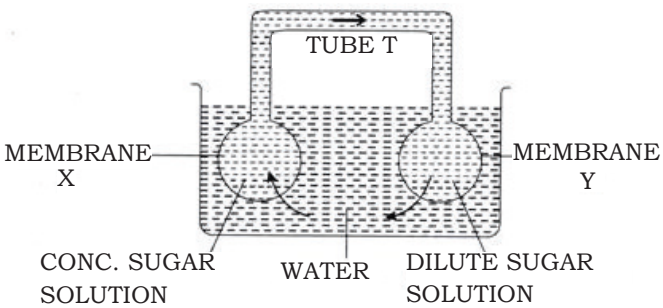


Figure 32. A model demonstrating the munch mass flow hypothesis

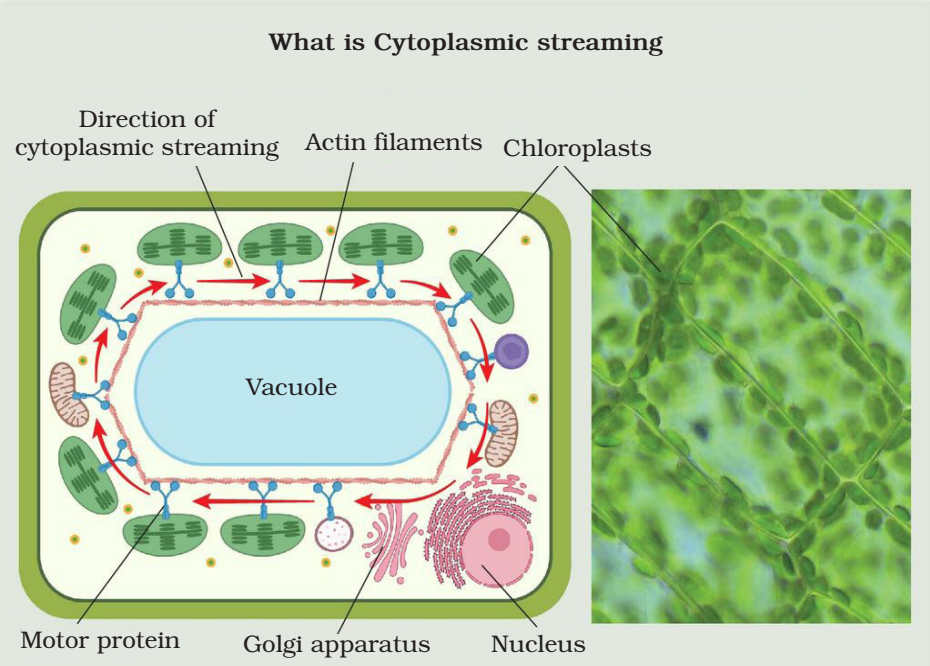


Figure 33. Cytoplasm streaming in eelgrass

Translocation

During photosynthesis, plants produce glucose from simple inorganic molecules carbon dioxide and water using light energy. Some of the glucose produced by photosynthesis is used for respiration. Translocation is the movement of sugar produced in photosynthesis to all other parts of the plant for respiration. This occurs in phloem cells.

Phloem: moves food substances that the plant has produced by photosynthesis to where they are needed for processes such as:

- Growing parts of the plant for immediate use
- Storage organs such as bulbs and tubers
- Developing seeds

Transport in the phloem, therefore takes place both up and down the stem - in contrast to transport in the xylem, which is just upwards. Transport of substances in the phloem is called translocation.

The parts of the plant which make these substances are referred to as sources (e.g. the leaves) and the parts of the plant, which store or use the substances are called sinks (examples include bulbs and roots). When

sucrose reaches a sink, it is converted into starch for carbohydrate storage. This maintains a concentration gradient between the source and the sink, so that more sucrose moves into the source.

6.13 Transpiration

Thus, transpiration can be defined as the process by which the plant body releases water in the form of vapors through its aerial parts. It is an important process in plants that facilitates other processes and keeps a balance of water and nutrients.

Advantages of transpiration to the plant:

- Transpiration controls the rate of absorption of water from the soil.
- Transpiration is responsible for Ascent of Sap because it exerts tension or pulls on water column in the xylem.
- Movement of water and minerals absorbed by the roots is also controlled by transpiration in the plants.
- Transpiration is responsible for the cooling of leaves and protects leaves from heat injury during high-temperature and intense sunlight.
- Osmotic balance of the cell is maintained by the process of transpiration.
- Transpiration helps in the exchange of gases.

Disadvantages of transpiration

- Water stress produces abscisic acid which promotes abscission of leaves and fruits.
- Less yield: Transpiration allows less water inside the plant. Hence, lesser yield
- Transpiration often results in water deficit (capillary water) which causes injury to the plants by desiccation.
- Rapid transpiration causes mid-day leaf water deficit (temporary wilting). If such condition continues for some time, permanent water deficit (permanent wilting) may develop, which may be fatal to the plants.
- Many xerophytes have to develop structural modifications to reduce transpiration. These modifications are extra burden on the plants.

Excessive rate of transpiration leads to stunted growth of plants.

Since approximately 97-99 percent of absorbed water is lost through transpiration, the energy used in absorption and conduction of water goes waste.

Activity 10

Observing the process of transpiration through experiments

You need:

- Well-watered potted plant
- A polythene bag or a bell jar
- Greasy substance

Method:

1. A well-watered plotted plant is taken, and the plant is covered with a transparent polythene bag
   - The bag is tied up to make the set up airtight.
   - The Vaseline or grease can be used to make the experiment airtight.
   - The covered plant is placed in the sunlight for about two or three hours.

Observe your experiment

Give conclusions of your experimental result

Write as report.

6.14 Environmental factors affecting transpiration

Some environmental conditions create the driving force for movement of water out of the plant. Others alter the plant's ability to control water loss.

1. **Atmospheric humidity**
   - When the atmosphere is humid, the rate of transpiration is reduced.
   - It is because atmosphere is more saturated with moisture and retards the diffusion of water vapor from the intercellular spaces of the leaves to the outer atmosphere through stomata.
   - In dry atmosphere, the RH (relative humidity) is low and the air is not saturated with moisture and hence, the rate of transpiration increases.

2. **Temperature**
   - An increase in temperature brings about an increase in the rate of transpiration by lowering the relative humidity and wider opening of stomata.
3. **Wind**
   - When wind is stagnant (not blowing), the rate of transpiration remains normal.
   - When the wind is blowing gently, the rate of transpiration increases. as it removes moisture from the vicinity of the transpiring parts of the plant thus facilitating the diffusion of water vapor from the intercellular spaces of the leaves to the outer atmosphere though stomata.
   - When the wind is blowing violently, the rate of transpiration decreases as it creates hindrance in the outward diffusion of water vapors from the transpiring part and it may also close the stomata.
4. **Light**
   - Light increases the rate of transpiration as stomata remain open under light conditions coupled with increased temperature.
   - In dark, due to closure of stomata, the stomatal transpiration is almost stopped.
5. **Available soil water**
   - The rate of transpiration will decrease if the available soil water is not sufficient enough for easy absorption by the roots.
6. **CO_2**
   - An increase in the atmospheric CO_2 concentration and the concentration inside the leaf causes stomatal closure and reduced transpiration.

6.15 Physiological factors affecting the rise of water in Xylem

Root pressure is caused by active distribution of mineral nutrient ions into the root xylem. Without transpiration to carry the ions up the stem, they accumulate in the root xylem and lower the water potential. Water

then diffuses from the soil into the root xylem due to osmosis. Root pressure is caused by this accumulation of water in the xylem pushing on the rigid cells. Root pressure provides a force, which pushes water up the stem, but it is not enough to account for the movement of water to leaves at the top of the tallest trees. The maximum root pressure measured in some plants can raise water only to 6.87 meters, and the tallest trees are over 100 meters tall.

Transpiration

Transpiration is the evaporative loss of water by plants. Besides the loss of water vapor in transpiration, exchange of oxygen and carbon dioxide in the leaf also occurs through pores called stomata. Generally, stomata are open in the day time and close during the night (Figure 34).

Plant factors that affect transpiration include number and distribution of stomata, number of stomata open, water status of the plant, canopy structure etc. As water evaporates through the stomata, since the thin film of water over the cells is continuous, it results in pulling of water, molecule by molecule, into the leaf from the xylem. Also, because of lower concentration of water vapor in the atmosphere as compared to the sub stomatal cavity and intercellular spaces, water diffuses into the surrounding air.

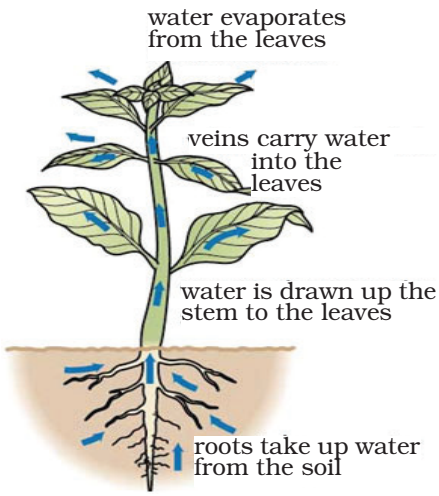


Figure 34. Transpiration in leaves

Cohesion Tension Mechanism

This theory however describes the movement of water from roots to the leaves of a plant. Because of osmosis water from soil reach to the xylem of roots of a plant. Water to molecules are bonded to each other by hydrogen bonding, hence water form a string of molecules during its movement toward xylem. The water molecules stick together and get pulled up by the force called tension. This force is exerted because of the evaporation at the surface of the leaf.

Xylem vessels are tubular structures extending from roots to the top of the plants. Cells are placed one above the other, with their end walls perforated forming a continuous tube. These are supported by xylem tracheids which are characterised by having pores in their walls. One end of xylem tube is connected with the root hairs via pericycle, endodermis and cortex and another end is connected with the sub stomatal cavity in the leaves via mesophyll cells. This tube is filled with water. The water is filled inside the xylem capillaries and due to cohesion and adhesion properties of water, it forms a continuous water column. The water column cannot be broken or pulled away from the xylem walls because of cohesion and adhesion of water.

Adhesion

Adhesion is the name of force of attraction between two unlike molecules. It enables water to move upward in the plant with the help of a capillary action. For instance, adhesion enables water to "climb" upwards through thin glass tubes (called capillary tubes) placed in a beaker of water. This upward motion against gravity, known as capillary action, depends on the attraction between water molecules and the glass walls of the tube (adhesion).

Water potential gradient

Water potential is a measure of the potential energy in water, specifically, water movement between two systems. Water potential can be defined as the difference in potential energy between any given water sample and *pure* water.

Water always moves from a region of **high** water potential to an area of **low** water potential, until it equilibrates the water potential of the system. In order for water to move through the plant from the soil to the

air (a process called **transpiration**), Ψ^{soil} must be > Ψ_{root} > Ψ_{stem} > Ψ_{leaf} > $\Psi_{atmosphere}$.

Solute potential (Ψ_s), also called osmotic potential, is negative in a plant cell and zero in distilled water, because solutes reduce water potential to a negative Ψ_s. The internal water potential of a plant cell is more negative than pure water because of the cytoplasm's high solute content. Because of this difference in water potential, water will move from the soil into a plant's root cells via the process of osmosis.

Pressure potential (Ψ_p), also called turgor potential, may be positive or negative. Positive pressure (compression) increases Ψ_p, and negative pressure (vacuum) decreases Ψ_p. Positive pressure inside cells is contained by the rigid cell wall, producing turgor pressure.

6.16 Gaseous Exchange

It occurs by diffusion across a concentration gradient and includes the exchange of oxygen and carbon dioxide in respiration and photosynthesis. Successful gaseous exchange requires a large surface area, as is provided by the alveoli of the lungs and the leaves of plants.

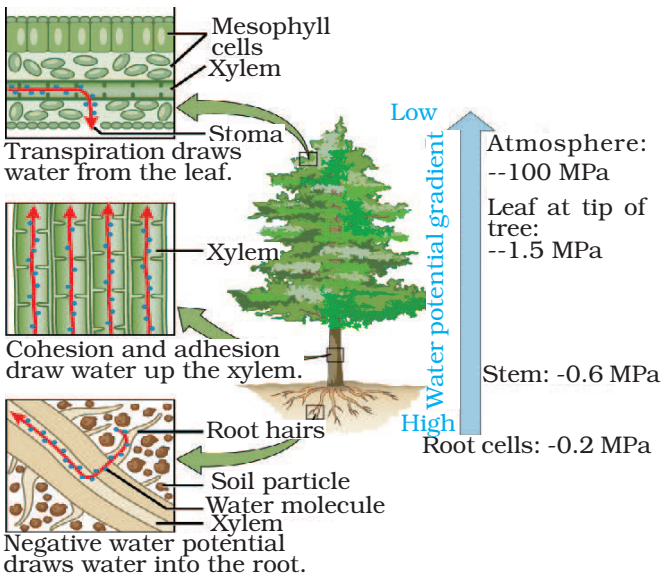


Figure 35. The transpiration pull in plants

Concentration gradient

Gaseous exchange occurs in the root hair of young terrestrial plants. Oxygen in the air spaces in the soil dissolves in the film of moisture surrounding soil particles and diffuses into the root hair along a concentration gradient. It diffuses from root hair cells into the cortex where it is used for respiration.

Structure and Function of Stomata

Some minute pores which are usually, found in leaf for the exchange of gas and transpiration are known as stomata (singular stoma).

Structure of stomata

- Stomata are present in leaf epidermis.
- The stomatal pores are very minute and are covered with crescent-shaped guard cells.
- The outer wall of guard cells are thin and the inner wall is thick. Each guard cell contains cytoplasm, a nucleus and plenty of chloroplasts.
- There is a single large air chamber below the stomatal pore.
- They control the procedure of transpiration and gaseous exchange.
- They are enclosed by two bean-shaped guard cells
- The guard cells organize the opening and closing of stomata.
- The wall of the guard cell surrounding the pore is thickened and inelastic due to the rest of the walls is thin, elastic and semi-permeable.
- The expansion and contraction of the guard cells are caused due to the accomplishment of turgid and flaccid situation correspondingly (Figure 36).

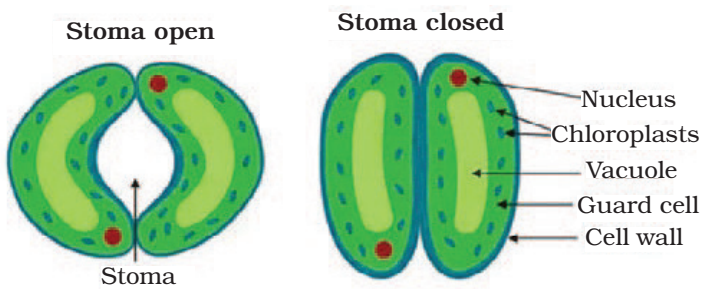


Figure 36. The structure of stomata

Functions of stomata

The two main functions of stomata are to allow for the uptake of carbon dioxide and to limit the loss of water due to evaporation.

- The gaseous exchange (CO_2 and O_2) between the intercellular spaces of plant cell and the outer air takes place through stomata during photosynthesis
- During respiration, plants receive O_2 and release CO_2 through stomata.
- Stomata allow the ingress of carbon dioxide and release of oxygen i.e. gaseous exchange takes place through stomata. These gas molecules are really the source of the carbon atoms used by plants to create sugars, proteins, and other vital materials for life.
- Stomata help in loss of excess water from the surface of leaves in the form of water vapor in plants.

Structure and function of lenticels

Structure of lenticel

Lenticels are found as raised circular, oval, or elongated areas on stems and roots. In woody plants, lenticels commonly appear as rough, cork-like structures on young branches. Underneath them, porous tissue creates a number of large intercellular spaces between cells. This tissue fills the lenticel and arises from cell division in the phellogen or sub stomatal ground tissue.

Functions

- The lenticels help in allowing the oxygen into and carbon dioxide out.
- Often, transpiration in a small scale may take place through lenticels.
- They allow for the exchange of gases between the internal tissues and the atmosphere.

6.17 Explanation of Metabolic Equations

The equation $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + H_2O$ + energy depicts the process of cellular respiration. This is a process in which living organisms combine food (glucose) with oxygen into energy while producing carbon dioxide and water as waste products. Since organisms can't use the energy from food directly, cellular respiration is necessary to convert the energy into a form they can use known as adenosine triphosphate (ATP).

Stage 1 of Cellular Respiration: Glycolysis

The first stage of cellular respiration is known as glycolysis or glucose splitting. Enzymes split glucose into two molecules of pyruvate. Two molecules of ATP are needed to perform glycolysis, but the process produces four molecules of ATP. That means that there is a net gain of two ATP molecules. It also produces energy-carrying molecules that are needed in later steps of the cellular respiration process.

Stage 2 of Cellular Respiration: The Krebs cycle

The Krebs Cycle is also known as the citric acid cycle because it forms citric acid. The series of reactions that take place in the Krebs Cycle release energy and produce carbon dioxide as a waste product. Glucose is completely broken down, and all of the energy is stored in the bonds of four ATP molecules, 10 Nicotinamide adenine dinucleotide (NADH) molecules, and two Flavin adenine dinucleotide (FADH2) molecules.

Stage 3 of Cellular Respiration: Electron Transport

In the final stage of cellular respiration, the high-energy electrons from NADH and FADH2 move along the electron transport chains. Some of this energy is used to pump hydrogen ions across the inner membrane of the mitochondrion from the matrix into the intermembrane space. They flow back into the matrix to form ATP synthase, which produces ATP. This process can only occur in the presence of oxygen. The hydrogen ions that pass through the electron transport chain combine with oxygen to form water.

Producing ATP

The final stage of cellular respiration produces the most ATP. While two molecules of ATP are produced in each of the first two stages, the final stage produces as many as 34 more molecules of ATP. That's just from a single molecule of glucose. Not all energy produced from this process is in the form of ATP as much of the energy is released in the form of heat.

Glucose is first converted to pyruvate by glycolysis, and the pyruvate is converted to ethanol and COA_2 in a two-step process.

In ethanol fermentation, the pyruvate produced through glycolysis is converted to ethanol and carbon dioxide in two steps. First, the pyruvate releases carbon dioxide to form a two-carbon compound called acetaldehyde. Next, acetaldehyde is reduced by NADH to ethanol, thereby regenerating the NAD^+ for use in glycolysis. Overall, one molecule

of glucose is converted into two molecules of carbon dioxide and two molecules of ethanol (Figure 37).

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$$

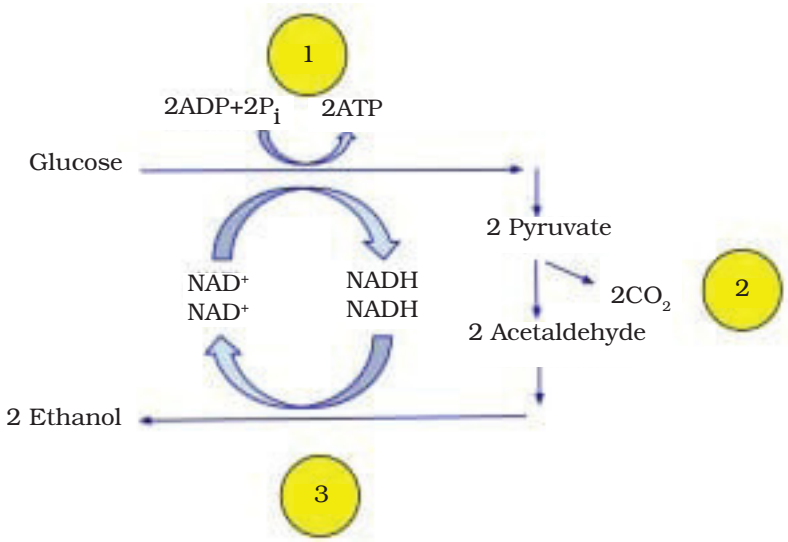


Figure 37. The processes of glycolysis and ethanol fermentation.

6.18 Types of Respiration

The method by which cells get chemical energy by the consumption of oxygen and the liberating of carbon dioxide is called respiration. In order to carry on respiration, plant cells require oxygen and a means of disposing of carbon dioxide just as animal cells do. In plants, every part such as root, stem executes respiration as plants do not possess any particular organs like animals for the exchange of gases.

Facultative aerobic

Aerobic respiration is the process of breaking down glucose in the presence of oxygen in order to generate energy in the form of compounds like ATP. The method entails the movement of electrons between compounds that serve as a source of the substrate, such as glucose, to oxygen, which serves as the terminal electron acceptor. Aerobic respiration is the most important mechanism for generating energy.

Facultative anaerobic

Anaerobes are microorganisms that can survive in the lack of free oxygen; obligatory, also known as stringent microbes are anaerobes that can only survive in the anaerobic environment. Facultative anaerobe, a microbe that can produce energy via aerobic respiration but then shift to anaerobic respiration based on the quantity of oxygen and fermentable content present in the environment.

Exercise

Choose the best answer from the given alternatives

1. Plants lose water mainly by the process of
   (a) Guttation
   (b) Exudation
   (c) Transpiration
   (d) Evaporation
2. Water entering roots through diffusion is
   (a) Endosmosis
   (b) Osmosis
   (c) Passive absorption
   (d) Active absorption
3. Auxanometer is used to demonstrate
   (a) Movements
   (b) Growth
   (c) Auxin concentration
   (d) Respiration
4. Nastic movements differ from tropic movements by:
   (a) Movement of variation
   (b) Non-directional
   (c) Directional
   (d) Stimulated by chemicals
5. Water potential of a cell is lowered by the
   (a) Addition of solutes
   (b) Addition of water
   (c) Addition of heat
   (d) Removal of solutes
6. According to transpiration-cohesion theory water is pulled through the xylem. The cause of the pull is
   (a) Guttation
   (b) Root pressure

(c) Transpiration
(d) Condensation

7. During fruit development, photosynthesizing leaves are _____ and the fruit is _____
(a) Sink, sink
(b) Source, source
(c) Sink, source
(d) Source, sink

8. Absorbtion of minerals from a region of low concentration to region of higher concentration by the rexpenditure of energy is called _____ .
(a) Passive absorption
(b) Vacillated diffusion
(c) Active absorption
(d) Osmosis

9. The process by which water is absorbed by solids like colloids causing them to increase in volume is called
(a) Osmosis
(b) Plasmolysis
(c) Imbibition
(d) Diffusion

10. A cell swells up when kept in
(a) Hypotonic solution
(b) Hypertonic solution
(c) Isotonic solution
(d) Any of the three

SUMMARY

Angiosperms are commonly known as group of **"flowering plants"**. The angiosperms is one of the most highly evolved group of Spermatophyta. They are vascular seed bearing plants in which ovules are enclosed in the ovary wall.

Classification of Angiosperms is based on the types of cotyledon present, angiosperms are divided into two classes. They are **monocotyledons and dicotyledons**. The dicotyledonous angiosperms have two cotyledons in their seeds and the monocotyledonous angiosperms have one cotyledon.

The success of angiosperms is due to two novel reproductive structures: **flowers and fruits**. The function of the flower is to ensure pollination, often by arthropods, as well as to protect a developing embryo.

Plant tissues can be grouped into plant tissue systems each performing specialized functions. The plant tissues are differentiated into three main tissue types: dermal, ground and vascular tissue. Ground tissue is often divided into Collenchyma, sclerenchyma, and parenchyma. The vascular tissue consists of xylem and phloem.

A typical plant body consists of three basic organs: roots, stems, and leaves. A root is the underground part of a plant and the organ that anchors a plant to the ground. A root **absorbs water and minerals**. Roots are also modified to perform different functions.

The main function of the stem is to **bear branches and leaves** and to give them proper exposure to sunlight. The leaves help the plants to absorb sunlight and carbon dioxide for manufacture of food. Leaves of certain plants become wholly or partially modified for **defensive purpose** into sharp, pointed structures known as spines - to protect plants from grazing animals.

The arrangement of leaves on a stem is known as phyllotaxy. Leaves are classified as either alternate, whorled or opposite. Seed germination is a process where a seed develops and grow into new plants.

Double fertilization, in flowering plant reproduction, the fusion of the egg and sperm and the simultaneous fusion of a second sperm and two polar nuclei that ultimately results in the formation of the endosperm of the seed. This is called double fertilization and is unique to flowering plants.

Fruit is a mature ovary and its contents. Fruits and seeds dispersal is the process whereby fruits and seeds are scattered from their origin.

Plant hormones control all the growth and development activities like cell division, enlargement, flowering, seed formation, dormancy and abscission.

An instrument called 'Lever Auxanometer measures the rate of growth of plant in terms of short length.

Vascular plants transport systems consist of two main systems which are the xylem and phloem.

Carbon dioxide, excess water produced during respiration and nitrogenous compounds produced during protein metabolism are the major excretory products in plants. The main excretory materials formed in plants are: alkaloids, tannins, resins, gums, and organic acids.

The pressure flow hypothesis helps explain how dissolved sugars move from sugar sources to sugar sinks. When sinks need sugar, the pressure difference between the source and sink causes dissolved sugars to move to the area of need. Excess sugars can be stored in areas such as roots to be used later.

Cytoplasmic streaming is the cells transport system which moves a cells content around as required. This occurs in the cytoplasm of the cell, the fluid which fills the space between organelles and contains cell solutes. Movement in the cytoplasm is thought to be facilitated by actin-myosin motors.

Oxygen in the air spaces in the soil dissolves in the film of moisture surrounding soil particles and diffuses into the root hair along a concentration gradient. It diffuses from root hair cells into the cortex where it is used for respiration.

Some minute pores which are usually, found in leaf for the exchange of gas and transpiration are known as stomata. They are typically found in plant leaves and can also be found in stems and other parts of plants.

Lenticels are specialized structures located in the felodermis, whose function is to guarantee the entry of oxygen and gas exchange.

A facultative anaerobe is a microorganism that is capable of switching between both aerobic and anaerobic respiration for producing energy depending on the presence or absence of oxygen in the surrounding environment.

A facultative aerobe is an organism that makes ATP by aerobic respiration if oxygen is present, but is capable of switching to fermentation or anaerobic respiration if oxygen is absent.

Exercise

1. Which type of tissue has lignified cell walls?
   (a) Parenchyma
   (b) Collenchyma
   (c) Sclerenchyma
   (d) Cambium
2. Which of the following is **not** a simple tissue
   (a) Xylem
   (b) Parenchyma
   (c) Collenchyma
   (d) Sclerenchyma
3. Which of the following floral parts the greatest potential impact on fertilization?
   (a) Sepal
   (b) Petal
   (c) Stamen
   (d) Carpel
   (e) Either C or D

4. Which of the following is the correct order of floral organs from the outside to the inside of a complete flower?
   (a) Petals-sepals-stamens-carpels
   (b) Sepals-stamens-petals-carpels
   (c) Spores-gametes-zygote-embryo
   (d) Sepals-petals-stamens- carpels
   (e) Male gametophyte-female gametophyte-sepals-petals
5. All of the following are primary functions of flowers except:
   (a) Pollen production.
   (b) Photosynthesis.
   (c) Meiosis.
   (d) Egg production.
   (e) Sexual reproduction

Health Related Caution

What are the ways to avoid dengue and malaria fever?

- Time your outings.
- Reduce mosquito habitat.
- Sleep under mosquito-net.
- Put screens on windows and doors.
- Keep your house airy and well-lit.
- Do not let water stagnate anywhere.
- Wear long pants and long sleeves to cover your body.
- Apply mosquito repellent with DEET (diethyltoluamide) to exposed skin.
- Treat clothing, mosquito nets, tents, sleeping bags and other fabrics with an insect repellent called permethrin.

How can a person reduce the risk of getting HIV?

- Get tested for HIV.
- Do not inject drugs.
- Choose less risky sexual behaviors.
- Use condoms every time you have sex.
- Limit your number of sexual partners.
- Get tested and treated for STDs.
- Talk to your health care provider about pre-exposure prophylaxis (PrEP).

What is Bullying?

Any unwanted written, verbal, graphic, or physical act by an individual or group toward another person(s) that causes harm or distress.

Types of Bullying

- Physical
- Verbal
- Social
- Emotional
- Cyber

Signs of Bullying

- Headaches
- Depression
- Loss of friends
- School absenteeism
- Academic problems

What You Can Do

PREVENT

- Be a role model for positive communication, healthy relationships, and self-care.
- Reinforce acts of kindness, respect, and inclusion.
- Set policies and rules about bullying.

RECOGNIZE

- Know the definition of bullying and its many forms.
- Talk with and actively listen to the youth who confide in you.
- Watch for warning signs of bullying.

INTERVENE

- If you witness bullying behavior
- Respond quickly and consistently to send the message that it is not acceptable.
- Separate the students involved.
- Meet any immediate medical or mental health needs.
- Stay calm and model respectful behavior.

Source: Teacher's Diary on *Cyber-Crime Awareness* by UNODC, Cybercrime and MoE, Republic of Liberia

What is Cybercrime?

Cybercrime is criminal activity that either targets or uses a computer, a computer network or a networked device. Most cybercrime is committed by cybercriminals or hackers who want to make money or take advantage of a person.

Types of Cybercrime

- Email and internet fraud.
- Identity fraud (where personal information is stolen and used).
- Theft of financial or card payment data.
- Theft and sale of corporate data.
- Cyber extortion (demanding money to prevent a threatened attack).
- Ransomware attacks (a type of cyberextortion).
- Cryptojacking (where hackers mine cryptocurrency using resources they do not own).
- Cyberespionage (where hackers access government or company data).
- Interfering with systems in a way that compromises a network.
- Infringing copyright.
- Illegal gambling.
- Selling illegal items online.
- Soliciting, producing, or possessing child pornography.

How to Prevent Cyber Crimes?

- Enforce concrete security and keep it up-to-date.
- Never give out personal information to a stranger.
- Check security settings to prevent cybercrime.
- Using an antivirus software helps to recognize any threat or malware before it infects the computer system.
- When visiting unauthorized websites, keep your information secure.
- Restriction on access to your most valuable data.
- Backup all data, system, and considerations.
- Don't use free USB sticks.

Source: Teacher's Diary on *Cyber-Crime Awareness* by UNODC, Cybercrime and MoE, Republic of Liberia

REPUBLIC OF LIBERIA
MINISTRY OF EDUCATION

TEXTBOOK MANAGEMENT
Student Textbook Assignment Form

School : _____

District : _____Country: _____

Teacher : _____Subject: _____

Grade : _____

No.	Name of the Student	Name of the Textbook	Barcode Number	Condition of the TB when received	Date Received	Date Returned	Condition of TB when returned	Signature of Student
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								