UNIT-I: CELL BIOLOGY
MODULE-1: CELL THEORY AND STRUCTURE OF PROKARYOTIC CELL

All living organisms are composed of cells. Anton Von Leeuwenhoek in late 1600s first saw and described a cell in a living organism. Robert Hooke observed for the first time the cells in a dead cork and named them as cells because they resembled the rooms of monastery. Robert Brown later discovered the nucleus.

The cell is defined as the smallest structural basic unit of an organism that is able to function independently.

All living organisms generally begin life as a single cell. This cell divides and redivides repeatedly until it forms into an organism. A mature plant or an animal usually consists of billions of cells. In the beginning, the cells formed from a single cell are alike in form and function. But later the cells modify into different types and perform different functions of the body.

CELL DOCTRINE

The **Cell Theory,** or cell doctrine, was proposed by Schleiden and Schwann in 1839 independently. They described the cell as a functional biological unit. It states that both the plants and animals posses almost the same internal organization, though they differ in their external forms. Both the plant and animal body is made of cells and each cell can be compared to a miniature organism in its function. This theory however, did not explain how new cells were formed.

Rudolf Virchow (1855) first explained that cells divide and new cells are formed from pre-existing cells.
The cell theory explains:

1) All living things are made up of cell (s).
2) The cell is structural and functional unit of all living organisms.
3) The cell retains a dual existence as a distinct entity and a building block in the construction of organisms.
4) Cells arise from preexisting ones and undergo multiplication.
5) Cells contain hereditary information which is passed from cell to cell during cell division.
6) All cells are basically the same in chemical composition.
7) All energy flow (metabolism & biochemistry) of life occurs within cells.

PROKARYOTIC CELL

Prokaryotes are microscopic unicellular organisms of universal occurrence. Prokaryotes are defined as the cells which do not contain a distinct nuclear membrane. The prokaryotes are the most primitive cells from morphological point of view because the cytoplasm is devoid of well defined organelles such as mitochondria, endoplasmic reticulum, golgibodies, centrioles etc but contain cell membrane and having organelles with single membrane. Bacteria, virus, blue green algae are the best examples for prokaryotes.

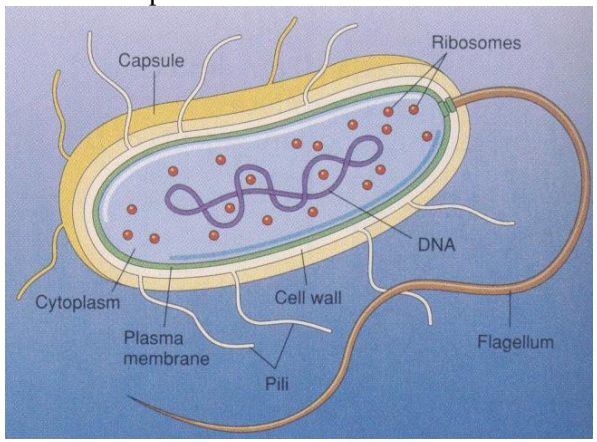
Some prokaryotic cells have external whip-like flagella for locomotion or hair like pili for adhesion. The Ultra structural details (details seen under electron microscope) of prokaryotes is presented below. A prokaryotic cell has three regions:

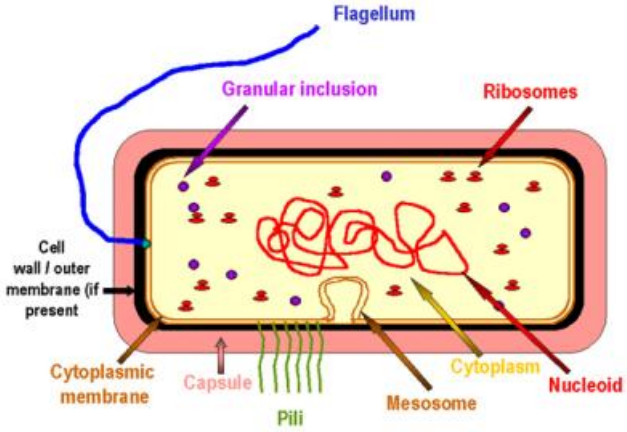
a) Cell envelope consisting of a capsule, cell wall and plasma membrane.
b) Appendages attached to the cell surface such as Flagella and Pili.
c) Cytoplasmic region that contains DNA, Ribosomes and other inclusions.

STRUCTURE OF PROKARYOTIC CELL (BACTERIAL CELL)

CELL WALL

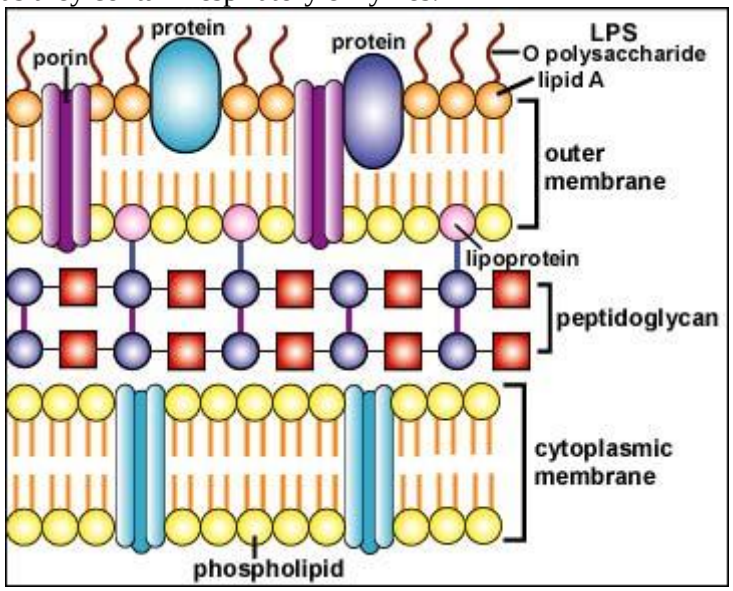
This rigid structure of prokaryotes contains peptidoglycan giving the cell shape and surrounding the cytoplasmic membrane. The cell wall provides the cell with protection from environment.





PLASMA MEMBRANE

A Phospholipid bilayer separates the cell from its environment. Phospholipid molecules are oriented so that hydrophilic (water-loving) heads are directed outward and hydrophobic (water-hating) tails are directed inward. The plasma membrane is selectively permeable to allow substances to pass into and out of the cell. The plasma membrane gives out certain infoldings called mesosomes. The mesosome plays an important role in generating energy for the cell as they contain respiratory enzymes.



LPS MEMBRANE:

Gram-negative bacteria have this outer membrane, i.e., outside the cell wall made up of Lipopolysaccharides (LPS) and that is similar to the plasma membrane, but less permeable. LPS is a harmful substance classified as an endotoxin which is toxic to animals.

GLYCOCALYX:

Some bacteria have an additional layer outside the cell wall called the glycocalyx. A **slime layer** consists of glycoproteins is loosely associated with the cell wall. Slime layers cause bacteria to adhere to solid surfaces.

A **capsule** is formed from polysaccharides and is firmly attached to the cell wall. The adhesive power of capsules is a major factor in the initiation of some bacterial diseases.

CYTOPLASM

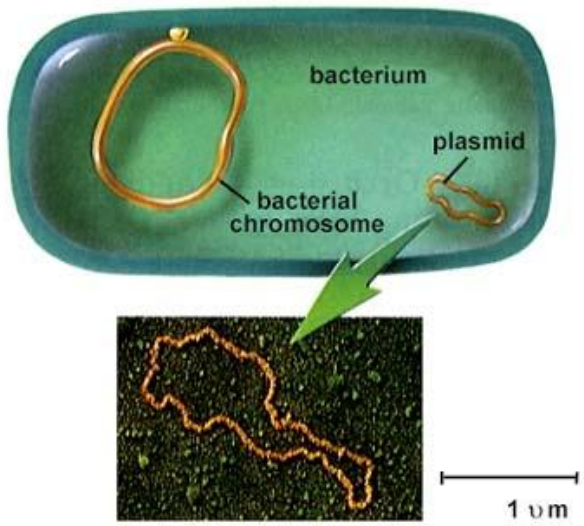
The cytoplasm consists of water, enzymes, nutrients, such as sugars and aminoacids wastes, gases and cell structures. The cytoplasmic region contains ribosomes, DNA, Plamids and inclusions.

NUCLEOID:

Prokaryotic cell does not contain an intact nucleus. It lacks nuclear membrane. Therefore the DNA and RNA molecules and their associated proteins are indirect contact with cytoplasmic ground substance. These substances are called as Prokaryon or Nucleoid. The cell usually have single chromosome with double stranded circular DNA.

PLASMIDS:

Plasmids are extra chromosomal genetic structures; plasmids are made of a circular piece of DNA. It has genetic instructions for initiating cell division or binary fission in Bacteria. Plasmids can provide "bonus" genetic information, such as antibiotic drug resistance, resistance to heavy metals, or can promote conjugation (transfer of genetic material between bacteria).



GRANULES

The cytoplasm contains glycogen and fat granules. The stored food materials are in the form of Granulose (a polymer of Glucose) and volutin granules.

RIBOSOMES

Ribosomes are the only organelles in the prokaryotic cells. These are made of rRNA and proteins and exist either free within cytoplasm or attached to the plasma membrane. Ribosomes translate genetic code into proteins. The Ribosomes are 70'S' type scattered freely in the cytoplasm.

CYTOSKELETON

This is the cellular "scaffolding" or "skeleton" within the cytoplasm previously thought to be a feature only of eukaryotic cells.

SURFACE APPENDAGES

Some prokaryotes have distinct appendages which includes

- **FLAGELLA:**
  Long, thin extensions that allow bacteria to move about freely in aqueous environments
- **AXIAL FILAMENTS OR ENDOFLAGELLA:**
  Wind around bacteria causing movement in waves
- **PILI OR FIMBRIAE:**
  Shorter, finer appendages that surround the cells of some gram-negative bacteria. They permit microbes to adhere to solid surfaces.

CHECK POINTS

1. The cell theory**,** or cell doctrine, proposed Schleiden and Schwann states that all organisms are composed of similar units of organization, called cells.
2. Rudolf Virchow (1855) first explained that cells divide and new cells are formed from pre-existing cells.
3. The cell is the unit of structure, physiology, and organization .
4. Cells that lack a membrane-bound nucleus are called prokaryotes.
5. The prokaryotic cell envelope consists of a capsule, a cell wall, and a cell membrane.
6. A cytoplasmic region that contains the cell genome (DNA), ribosomes, and various sorts of inclusions.
7. There are no chloroplasts. Photosynthesis usually takes place in infoldings or extensions derived from the cytoplasmic membrane.
8. Cell organelles such as mitochondria, endoplasmic reticulum, Golgi apparatus, vacuoles, and lysosomes are absent.
9. The appendages sometimes present are called flagella and pili.In a prokaryotic cell, most of the functions of cell organelles are taken over by the prokaryotic cell membrane.
10. Instead of going through elaborate replication processes like eukaryotes, bacterial cells divide by binary fission.

MULTIPLE CHOICE QUESTIONS

1. Cell doctrine was proposed by
   a) **Schleiden and Schwann** b) Robert Hooke
   c) Leeuwen hoek d) Robert Brown
2. Who is the first to explain that cells divide and new cells are formed from pre existing cells
   a) Schleiden and Schwann b) Robert Hooke
   c) Robert Brown **d) Rudolf Virchow**
3. According to cell theory one of the following statements is not correct
   a) All living things are made up of cells
   b) All cells form from pre existing cells by division
   c) The cell is the structural and functional unit of living organism
   d) All cells are basically not the same in chemical composition
4. The main difference between prokaryotic and eukaryotic cells is that the former is without
   a) Cell wall b) Genetic System
   c) Nuclear membrane d) Membrane System
5. DNA molecule of prokaryotic cell is
   a) Double Stranded Circular b) Single Stranded Circular
   c) Single Stranded Helix d) Double Helical Structure
6. The role of mesosomes in prokaryotic cell
   a) Function as mitochondria of Eukaryotes
   b) Contain respiratory enzymes
   c) They generate energy for the cel
   d) All the above
7. Some prokaryotic cell have hair like pili which help in
   a) Locomotion **b) Adhesion** c) Protection d) None

8. Nucleoid is
   a) Genetic material of prokaryotic cell
   b) Genetic material of Eukaryotic cell
   c) Nucleus of the prokaryotic cell
   d) Nucleus without nuclear membrane
9. Type of Ribosomes in prokaryotic cell
   a) "70S" type b) "80S" type
   c) "50S" type d) "30S" type
10. Cell organelle which is absent in prokaryotic cell is
    a) Mitochondria b) Golgi apparatus
    c) Endoplasmic reticulum **d) All**
11. The only organelle present in prokaryotic cells is
    a) Ribosomes b) Mitochondria c) Golgi d) Endoplasmic reticulum
12. Appendages present in prokaryotes
    a) Flagella b) Axial filaments c) Pili **d) All**
13. Extra chromosomal genetic structures present in prokaryotes
    a) Ribosomes **b) Plasmids** c) Nucleoid d) Pili

SHORT ANSWER QUESTIONS

1. What is a cell?
2. Give the salient features of cell doctrine as given by Schwann and Schleiden?
3. Where do you find prokaryotic cells?
4. Give an account of cell wall of prokaryotes.
5. What are plasmids? What is their role in biotechnology?
6. What is LPS membrane?
7. Give a brief account of cytoskeleton.
8. What is cyclosis? Explain.
9. Differentiate between flagella and pili.
10. Differentiate nucleus and nucleoid.
11. Give an account of Glycocalyx in bacteria.
12. What are the characters of Archae?
13. How archae are different from Bacteria?
14. What are the different appendages of prokaryotic cell?

LONG ANSWER QUESTIONS

1. Describe the prokaryotic cell membrane and cell wall in detail
2. What are the features of the prokaryotic cell contents?
3. Draw a neat labeled diagram of prokaryotic cell and mention one important function of each part?

UNIT-I
CELL BIOLOGY
MODULE-2: STRUCTURE OF EUKARYOTIC CELL

Plants, animals, fungi and protista have eukaryotic cells. The eukaryotic cell is more complex in structure when compared to the prokaryotic cell. These cells are about 10 – 100 μm and have different shapes, sizes and functions.

A typical eukaryotic cell contains the following parts

1. Outer envelope (cell wall/ plasma membrane)
2. Cytoplasm and
3. Nucleus

Outer Envelope:

The outermost covering in certain protists, fungi and in all plants is the cell wall, while in animals it is the cell membrane or plasma membrane. Cell wall is thick, rigid, non elastic and non – living and it is absent in animal cells. Cell wall is made up of cellulose. The cell wall gives protection and support to the plasma membrane and the cytoplasm which lies beneath it.

In animal cells, the external covering is cell membrane or plasma membrane. It is living, thin, elastic, porous and semi permeable. It gives mechanical support and definite shape to the cell. It checks the entry or exit of undesirable substances and it allows the transmission of necessary materials to and from the cells.

Cytoplasm (Hyaloplasm):

It is the colloidal, transparent, colourless, homogeneous fluid present between plasma membrane and nucleus. The cytoplasm consists of various inorganic compounds (water, salts of Na, K etc and other metals) and various organic compounds such as carbohydrates, proteins, lipids, nucleoproteins, nucleic acids and enzymes. Cytoplasm also contains non – living and living structures. The non living structures are known as deutoplasm, paraplasm or inclusions and the living structures are called organelles which are membrane bound.

The peripheral layer of cytoplasmic matrix is called ectoplasm or plasma gel. It is a clear, non – granular viscous fluid. The inner part is called endoplasm or plasma sol which is granular, less viscous and semitransparent. The plasma gel and plasma sol are inter convertible. The cytoplasmic structures are found in the plasma sol. The plasma sol is always in motion and this movement is called cytoplasmic streaming or cyclosis.

Cytoplasmic Inclusions:

These includes oil drops, yolk granules, pigments, secretary granules, glycogen granules etc. and these are found suspended in the cytoplasm. The cytoplasmic inclusions are devoid of any membrane.

Cytoplasmic Organelles:

The living structures are called organelles or organoids. Most of them are membrane bounded. They perform several biosynthetic and metabolic activities such as secretion, storage, transport, respiration and reproduction etc. the cytoplasmic orgenelles includes ribosomes, mitochondria, golgi complex, endoplasmic reticulum, centrioles, lysosomes, microtubules, basal granules , plastids, cilia and flagella. Of these golgi complex and mitochondria are double unit membranes. While endoplasmic reticulum and lysosomes are single unit membranes. Ribosomes do not follow the membrane concept. Centrioles are without any limiting membrane. As eukaryotic cells can be either animal or plant, both these types of cell contain some

COMMON ORGANELLES:

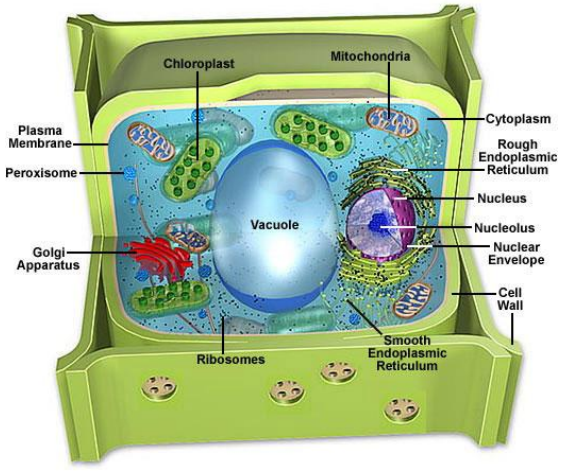
- Nucleus
- Mitochondria
- Endoplasmic reticulum
- Golgi apparatus
- Lysosomes
- Peroxisomes
- Cytoskeleton

THE PLANT CELL CONTAINS IS ADDITION

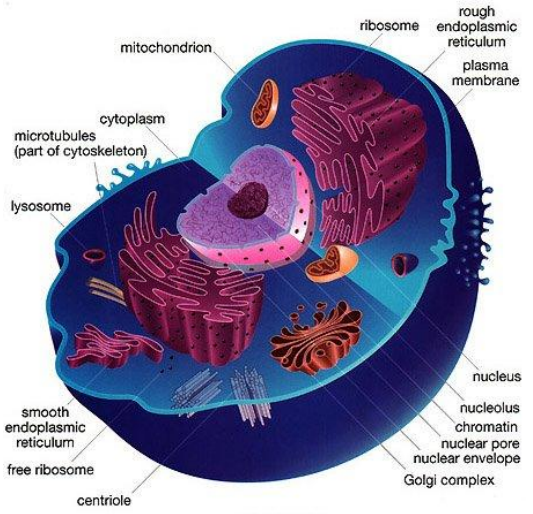
- Cell wall
- Plastids
- Vacuoles
- Flagella

THE ANIMAL CELL CONTAINS IN ADDITION TO THE COMMON ORGANELLES

- Centrioles
- Cilia or Flagella



ULTRA CELL STRUCTURE OF PLANT CELL



ULTRA CELL STRUCTURE OF ANIMAL CELL

Nucleus

Most conspicuous and lying usually in the centre of the cell is a rounded or ovoid body, called nucleus. It is found in all eukaryotic cells of both plants and animals except mammalian erythrocytes. It is delimited from the cytoplasm by its extremely thin nuclear membrane. The membrane has several pores which control transport of substances into and out of the nucleus. Embedded in the nucleoplasm of nucleus are chromatin, nucleolus, endosomes etc. Chromatin is the suspened network present in nucleoplasm and form chromosomes during cell division. Chromosomes contain hereditary material DNA and nucleoproteins. The number of chromosomes remain constant in a given species. Within the nucleoplasm also occurs a conspicuous spherical body, the nucleolus. It is concerned with protein synthesis and origin of ribosomes. Nucleus controls all the vital activities of the cytoplasm and it carries the hereditary material, the DNA.

Plant Cells Compared with Animal Cells

Animal cells do not have a cell wall. Instead of a cell wall, the plasma membrane (usually called cell membrane) is the outer boundary of animal cells. Frameworks of rigid cellulose fibrils thicken and strengthen the cell walls of higher plants. Plasmodesmata, the cytoplasmic bridges between adjacent cells of higher plant cells do not have a counterpart in the animal cell model. During telophase of mitosis, a cell plate is formed as the plant cell begins its division. In animal cells, the cell pinches in the center to form two cells; no cell plate is laid down. Centrioles are generally not found in higher plant cells, while they are found in animal cells. Animal cells do not have plastids, which are common in plant cells (chloroplasts). Both cell types have vacuoles, however, in animal cells vacuoles are very tiny or absent, while in plant cells vacuoles are generally quite large.

The cytoplasm consists of cell organelles and also vacuoles and ergastic substances. The details of cell organelles are given in subsequent modules.

Comparison of plant and animal cell

Character	Plant cell	Animal cell
Cell wall	Present	Absent
Plastids	Present	Absent
Flagella	Present	Present
Centrioles	Absent	Present
Centrosomes	Absent	Present
Cilia	Absent	Present
Ergastic substances	Present	Eliminated from cell

Check Points

1. Eukaryotic cells are found in organisms belonging to kingdom protista, fungi, plantae and animalia
2. Eukaryotic cells have different shapes, sizes and functions
3. Eukaryotic cells are typically made of outer enverelepe, cytoplasm and nucleus
4. All eukaryotic cells are covered by a cell membrane or plasma membrane. In plants there is an additional structure called the cell wall made up of cellulose.
5. Cytoplasm exhibits streaming movements, which is called cyclosis.
6. The non – living constituents of the cytoplasm are called paraplasm, deutoplasm or inclusions
7. The living structures of cytoplasm are called organelles, which are involved in various metabolic activities of the cell.
8. The vital part of the cell that controls all the activities is the nucleus. It is the dynamic centre of the cell.

Multiple Choice Questions

1. Animal cell differs from plant cell as it possess
   a) Mitochondria **b) Centriole**
   c) Golgi Apparatus d) Endoplasmic reticulum
2. Which of the following found exclusively in animal cell
   a) Cell wall b) Lysosome **c) Centriols** d) Plastids
3. Ergastic substances are
   a) Organic Substances b) Inorganic Substances
   c) Products of Metabolism **d) All**
4. Cyclosis means
   a) Streaming Movements of the Cytoplasm
   b) Movement of the Vacuoles
   c) Both d) None
5. Cytoskeleton is composed of
   a) Microtubules b) Microfilaments
   c) Chromatin network **d) a & b**
6. Movement of cytoplasm within the cell is called_____(cyclosis)
7. In higher plants, the organelle responsible for photosynthesis is _____(chloroplasts)
8. Nuclear membrane separates nucleus from _____(cytoplasm)
9. Which of the following orgonells is not bound by two membrances
   a) Mitochondria b) Plastids
   c) Nucleus d) **Ribosomes**
10. The activities of all the living cells are controlled by
    a) Nucleus b) Hormones
    c) Chloroplasts d) Mitochondria

Short Answer Questions:

1. What are the common characters found in plant and animal cell?
2. What are the characters present only in plant cell?
3. How animal cell is different from the plant cell?
4. Give any 5 differences between a plant and animal cell.
5. How the plant cell is different from animal cell in its outer bounded structure?
6. What are the double membrane organelles?
7. Write about the cytoplasmic movements of the cell?
8. What is the cell organelle which helps in cell divisions that is present in animal cell? Describe it?

Long Answer Questions

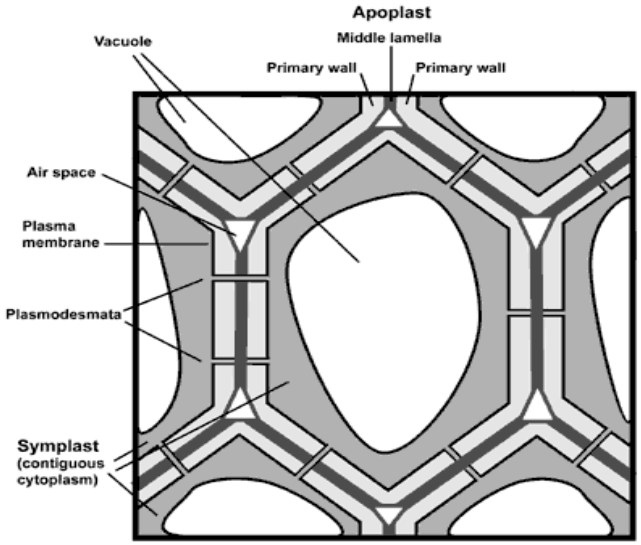
1. Describe briefly the ultra structure of Eukaryotic cell.
2. Discuss the major difference between plant and animal cells?
3. Draw and label the animal cell. Mention one important function of each part?

UNIT-I: CELL BIOLOGY
MODULE-3: CELL WALL AND CELL MEMBRANE STRUCTURE AND FUNCTION

Every cell is enclosed by a layer known as cell membrane. The cell membrane consists of either living or both living and non-living matters. In both the animal and plant-cells cell membranes are present. However, the membrane enclosing the cytoplasm is called plasma membrane. In many plants, in addition to plasma membrane, there is an outer most layer of non-living matter, the cell wall.

I. CELL WALL:

The cell wall is thick, non-living; rigid outer covering that surrounds all plant cells. It is absent in animal cells. It consists of three distinct regions 1.Middle Lamella 2. Primary Cell Wall and 3. Secondary Cell Wall



Details of Cell Walls of Plant in Front View

MIDDLE LAMELLA:

It is the outermost and the first formed layer of the cell wall. This layer joins the adjoining cells. It is made of calcium and magnesium pectates.

PRIMARY CELL WALL:

It lies next to middle lamella. It is thin and permeable layer made up of cellulose, hemi cellulose and other poly saccharides.

SECONDARY CELL WALL:

It lies inner to primary cell wall. It is thick and permeable made up of cellulose, lignin, suberin or cutin etc. This wall is responsible for providing mechanical support.

II. PLASMA MEMBRANE:

Plasma membrane is the term used for the cell membrane which is present in all the cells of the plants and animals. This membrane surrounds the cytoplasm. In animal cell, it is single and is the outer most limiting membrane. However in plant cells, it is followed by another layer of the cell wall.

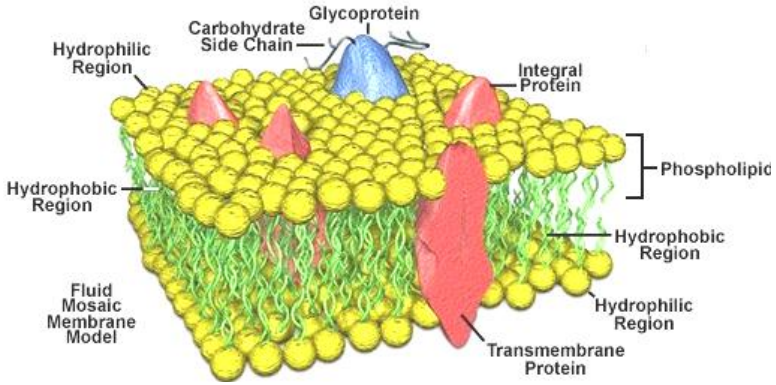
Plasma membrane is living, thin, elastic and porous, semi permeable membrane. It is also found around the cell organelles. It is composed of a double layer of phospholipids and proteins.

STRUCTURE OF PLASMA MEMBRANE:

Many theories and models are proposed to explain the molecular structure of plasma membrane. Out of which Fluid Mosaic model proposed by Singer and Nicolson (1972) is the most widely accepted theory at present.

FLUID MOSAIC MODEL:

According to this theory the biological membranes are semi fluid in nature. The plasma membrane is made of a phospholipid bilayer, with their hydrophobic fatty acid tails are attracted to each other and oriented away from the water or aqueous environment while the hydrophilic phosphate groups are on the outside and are attracted to the watery environment of the cytoplasm or the outside of the cell. Protein molecules occur as separate particles asymmetrically arranged in a mosaic pattern. The proteins molecules are arranged in two ways. Some are floating like icebergs between the phospholipids molecules. These are called integral proteins or intrinsic proteins.



Fluid Mosaic Model Showing Hydrophilic and Hydrophobic Layers

These molecules and phospholipids molecules cannot move freely within the membrane. Some protein molecules are arranged on the outside. These are called as extrinsic or peripheral proteins. Thus lipids are not capped with a solid protein coating so leaving many portions of the lipid bare and exposed to the extra and intra cellular environments. It is through these bare areas that lipid soluble molecules pass. This arrangement of protein and lipid molecules help the membrane to regulate the entry and exit of substances through it. A part from proteins, a small quantity of glycolipids, cholesterol and carbohydrates are also found in the fluid matrix.

FUNCTIONS OF PLASMA MEMBRANE:

1. It provides mechanical support, provides stability and maintains its shape.
2. The main function of plasma membrane is to regulate flow of ions and molecules of various substances into and out of the cell. Different methods of transport are a) osmosis b) diffusion c) facilitated diffusion d) active transport e) exocytosis etc.

CHECK POINTS

- Cell membrane is present both in plants and animals .Cell membrane is covered by cell wall in plants.
- Cell wall is absent in animals.
- The main structural component of cell wall is cellulose. It also contains hemi cellulose, pectin and glyco protein.
- Middle lamella joins the adjacent cells.
- Plasma membrane is living, porous and semi permeable membrane.
- Fluid mosaic model proposed by Singer and Nicolson is the accepted theory at present, which explain the structure of plasma membrane.

MULTIPLE CHOICE QUESTIONS

1. This cell structure separates the interior of the cell from its surroundings, and regulates the movement of particles in and out of the cell.
   a) Cytoplasm **Cell membrane** C. Lysosome D. Cell wall
2. The cell wall is best described as a tough, rigid structure found in

a) Plant cells that surrounds the cell membrane.
b) Animal cells that surrounds the cell membrane.
c) Animal cells located just inside the cell membrane.
d) Plant cells located just inside the cell membrane.

3. Fluid mosaic model proposed by Singer and Nicholson explains about:
a) Plasma membrane with proteins floating in bilipid layer
b) Plasma membrane with bilipid layer sandwiched between proteins
c) LPS layer of bacteria
d) Structure of cell wall
4. The main function of plasma membrane is to
a) Regulate the flow of materials into and outside the cell
b) Provide support
c) Maintain shape and size
d) All the above
5. Plasma membrane is mainly made of
a) Lipids and Carbohydrates b) Proteins and Starch
c) Fats and Starch d) **Proteins and Phospholipids**
6. Which one of the following layers is responsible for holding the adjoining cells together?
a) Middle Lamella b) Primary Cell Wall
c). Secondary cell wall d) All
7. One of the following functions of primary cell wall
a) Mechanical support b) Maintain cell shape
c) Protect against pathogens d) **All**
8. Fluid mosaic model to explain the structure of plasma membrane is proposed by
a) Davson and Danielli **b) Singer and Nicholson**
c) Robert Brown d) Schwann and Schledien
9. The rigidity (support) of a plant cell is primarily due to the presence of the
a) Cytoskeleton b) Cell Sap
c) Cell membrane **d) Cell wall**
10. Which structure permits the entry and exit of dissolved materials of an animal cell?
a) Tonoplast b) Nuclear membrane
c) Cell wall **d) Cell membrane**
11. This is not the function of plasma membrane
a) Is a boundary layer of cell to hold the cytoplasm?
b) Regulate the flow of ions.
c) Selective permeability **d) Intercellular transport**

SHORT ANSWER QUESTIONS

1. Give an account of fluid mosaic model for the structure of membranes?
2. Explain briefly the functions of cell wall?
3. Explain the functions of plasma membrane?

LONG ANSWER QUESTIONS

1. Describe the structure and functions of cell wall?
2. Explain the Fluid Mosaic model to describe the structure of plasma membrane?

UNIT-I: CELL BIOLOGY
MODULE-4: CELL ORGANELLES: CHLOROPLAST AND MITOCHONDRIA

MITOCHONDRIA:

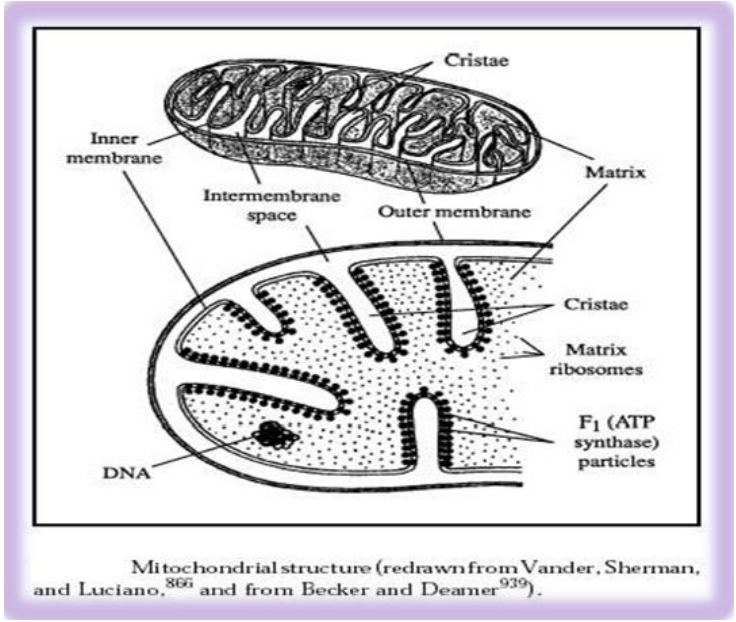
Mitochondria are filamentous or granular structures present in the cytoplasm of the cell. They are absent in prokaryotes and in mature RBC cells of eukaryotes. They are the centres of aerobic respiration and produce a large amount of energy in the form of ATP. Hence, they are described as power houses of the cell.

OCCURRENCE AND SHAPE:

The mitochondria may be variously shaped they may be cylindrical, spherical, granular, rod like, thread like, or sausage shaped structures. They are present in large numbers in those cells which are concerned with secretion of enzymes and the function of respiration.

STRUCTURE:

The mitochondria are about 1.5 to 10µm long and 0.25-1.00µm wide. Each mitochondrion is made of a double unit membrane like a thermos flask. Each membrane is $60A^0$ in thickness. The space between the two membranes is peri mitochondrial space. The inner membrane encloses a chamber filled with matrix rich in proteins and lipids. The inner membrane of mitochondria which is towards the matrix is called M-face and its outer surface which is towards perichondrial space is called C-face. The composition of each membrane is similar to that of plasma membrane. The inner membrane is thrown into numerous prejections into the matrix called cristae. On the cristae are found numerous minute projection called elementary particles or F_1 particles. They are also called as oxysomes. These particles are concerned with electron transport system. Each F_1 particles is made of a base, stalk and a head. The head of these particles contain ATP synthetase enzyme. The outer membrane of mitochondria is smooth and it separates the mitochondria from cytosol. The elementary particles functionally are associated with the the enzymes of the electron transport system and oxidative Phosphorylation which takes place in mitochondria. The enzymes involved in aerobic respiration, amino acid synthesis and fatty acid metabolism are located in the matrix. The matrix has 70S ribosomes. RNAs, circular DNA and inorganic salts.



Mitochondrial structure (redrawn from Vander, Sherman, and Luciano,[866] and from Becker and Deamer[939]).

FUNCTIONS:

1. The main function of mitochondria is the synthesis of an energy rich molecule ATP (Adenosine tri phosphate).

2. Operation of TCA cycle by matrix enzymes.
3. Electron transport from reduced co-enzymes to molecular oxygen coupled with oxidative phophorylation with the help of enzymes present on the inner membrane.
4. Oxidation of fatty acids.
5. Ion Transport.
6. Respiratory cycle that produces ATP also produce intermediates for the synthesis of cytochromes, chlorophyll, steroids, hemoglobin, amino acids and fatty acids.
7. It is also involved in heat production in animals.

CHLOROPLAST:

Plastids are double membraned cell organelles mainly present in plant cells. They are three types

1. **LEUCOPLASTS:** They are colourless plastids and help in storing the food materials.
2. **CHROMOPLASTS:** They are coloured plastids containing carotenoid pigments. They are non- Photosynthetic.
3. **CHLOROPLASTS:** These are photosynthetic plastids present in green plants and are capable of synthesizing organic food from inorganic raw materials.

CHLOROPLAST:

These are double membrane organelles present in plant cells. They are disc shaped or lens shaped structures with a length of 4-10µm.

STRUCTURE:

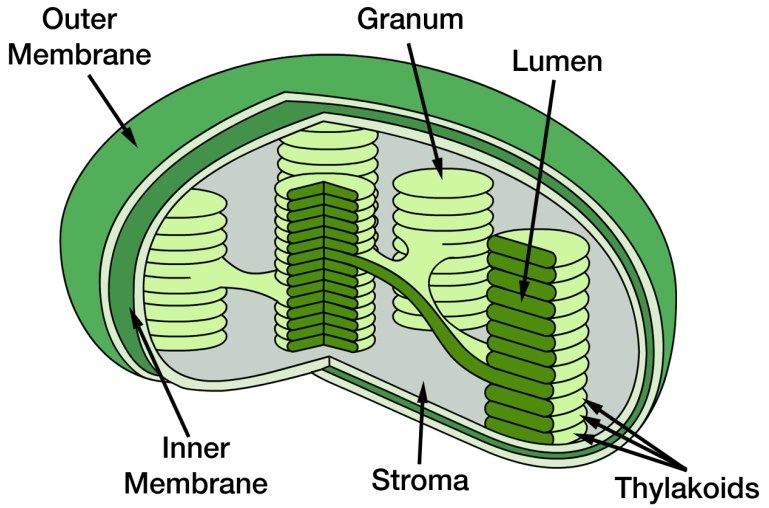
There are three major structural regions of the Chloroplast.

1. ENVELOPE: Consisting of an outer and inner membranes with an enclosed space called perichloroplastidial space filled with a fluid matrix or stroma.

2. STROMA OR MATRIX: The matrix contains the enzymes for protein synthesis, metabolism, DNA, RANs and ribosomes.

3. THYLAKOIDS:

The internal membranes form discs which are stacked together like a pile of coins to from a granum. Each disc is a sac or vesicle and is termed a thylakoid. Chlorophyll is found in the thylakoid membranes. Built into the thylakoid membranes are pigment systems and electron carriers which carry out the light phase of Photosynthesis.



FUNCTIONS:

1. Chloroplasts serve as the site of photosynthesis. They converts the energy of sunlight to chemical energy of organic compounds.
2. During Photosynthesis oxygen is produced which is important for the survival of aerobic organisms.

3. They keep the level of carbon dioxide in the atmosphere in appropriate limits by utilizing it for Photosynthesis.

CHECK POINTS

- Mitochondria are described as power houses of the cell.
- Mitochondria are bounded by double membrane – the outer and inner membranes.
- Inner membrane forms cristae into the matrix.
- Elementary particles or F_1 Particles or oxysomes are found on cristae.
- Enzymes of electron transport system and oxidative phosphorylation are found on the cristae.
- Enzymes of amino acid synthesis and fatty acid metabolism are found in the matrix.
- Main function of Mitochondria is the synthesis of ATP.
- Chloroplasts are the photosynthetic plastids found in green plants.
- Chlorophyll is found in the thylakoid membranes.
- Chloroplasts serve as the site of Photosynthesis.

MULTIPLE CHOICE QUESTIONS

1. Mitochondria Possesses
   a) Dictyo some b) Qunatasome
   c) Oxysome d) Polysome
2. ATP is
   a) An Enzyme a) A hormone c) An energy rich protein
   d) A molecule with high energy phosphate bond.
3. In Chloroplasts, chlorophyll is found in
   a) Outer membrane b) Inter membrane space
   c) Stroma **d) Thylakoid membranes**
4. Mitochondria are absent in
   a) Prokaryotes b) Eukaryotes
   c) In mature RBC **d) A & C**
5. Power houses of the cell
   a) Golgi **b) Mitochondria**
   c) Ribosomes d) Lysosomes.
6. One of the following is not the function of mitochondria
   a) Synthesis of ATP b) Electron transport
   c) Oxidation of fatty acids **d) Photosynthesis**
7. Matrix of the Chloroplasts contain
   a) Enzymes b) DNA & RNA
   c) Ribosomes **d) All**
8. In chloroplasts Pigment systems and electron carriers are present in
   a) Thylakoid membranes b) Peri chloroplastidial space
   c) Stroma d) Inner membrane
9. Plastids capable of synthesizing organic food from inorganic raw materials.
   a) Leucoplasts b) Chromoplasts
   c) Chloroplasts d) All
10. One of the following keeps the level of CO_2 in the atmosphere in appropriate limits by utilising it for synthetic purpose.
    a) Leucoplasts **b) Chloroplasts**
    c) Chromoplasts d)None

SHORT ANSWER QUESTIONS

1. Write short notes on plastids?
2. Describe different types of plastids?
3. Describe briefly the structure of chloroplasts?
4. What are the parts of mitochondria?
5. Write short notes on oxysomes?
6. List out the functions of mitochondria?
7. Describe Thylakoids?

LONG ANSWER QUESTIONS

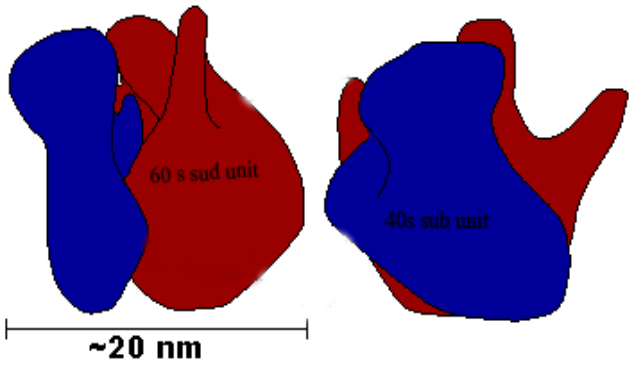
1. Describe the structure and function of mitochondria?
2. What are chloroplasts? Describe the structure and function of chloroplasts?

BIOLOGY COURSE: PUC-I, SEMESTER-I
UNIT-I: CELL BIOLOGY
MODULE-5: CELL ORGANELLES: RIBOSOMES, GOLGI, MICRO BODIES, LYSOSOMES, CENTRIOLES, VACUOLES AND MICROTUBULES

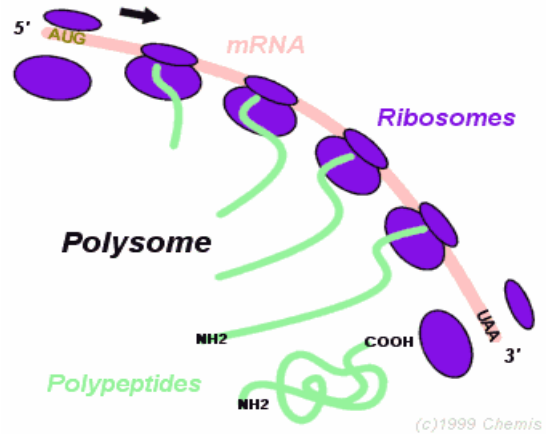
All eukaryotic cells are typically made of outer cell membrane or plasma membrane, cytoplasm and nucleus. The cytoplasm contains certain non-living and living structures. The non-living structures are called inclusions or paraplasm or deutoplasm. The living structures are called as organelles. Organelles are membrane bound structures. They carry out several important metabolic activities such as transport, secretion, storage, respiration, reproduction etc. They are endoplasmic reticulum, Ribosomes, mitochondria, Golgi complex, lysosomes, centrioles, microtubules, basal granules, plastids, cytoplasmic vacuoles, micro bodies, cilia and flagella. Of these Golgi complex and mitochondria are double unit membranes while endoplasmic reticulum and lysosomes are single unit membranes. Ribosomes do not follow the membrane concept. Centrosomes are devoid of any limiting membrane.

RIBOSOMES:

Ribosomes are present in all organisms but absent in mature RBC. The ribosomes composed of RNA and proteins. Eukaryotic ribosomes belongs to '80 S' type (sedimentation coefficient). In eukaryotes the ribosomes are present either attached to the endoplasmic reticulum or freely scattered in the cytoplasm. Each ribosome is composed of a larger and a smaller subunit. The two subunits come together only during protein synthesis. Association and dissociation of the two subunits depend on magnesium concentration.

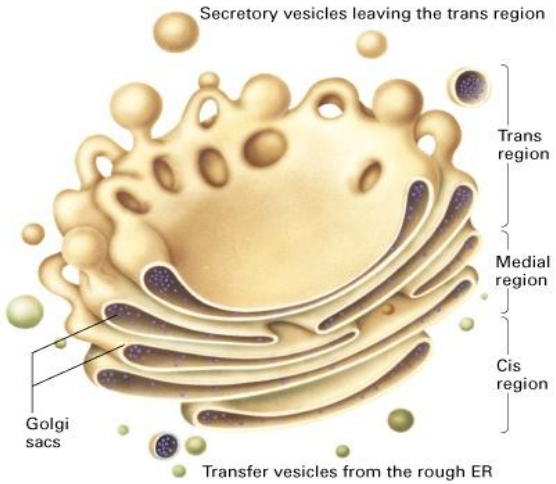


The main function of Ribosomes is protein synthesis. So they are most abundant in cells that are active in protein synthesis, such as pancreas and brain cells. During protein synthesis several ribosomes form into long chains called 'Polysomes or Poly Ribosomes'. They translate the genetic message present in messenger RNA to form proteins.



GOLGI COMPLEX (DICTYOSOMES)

It is found in all eukaryotic cells except in mature RBC. It occurs between the nucleus and the plasma membrane. Golgi complexes are double unit membranes made of lipoproteins. Golgi complex consists of flattened cisternae, tubules, vesicles and large vacuoles. They are abundant in secretory cells.



FUNCTIONS:

1. Golgi synthesizes carbohydrates, lipids, hormones and enzymes with the help of several enzymes present in the membrane.
2. Break down of the golgi cisternae which contain the lytic enzymes results in the formation of lysosomes.
3. Acrosome of the sperm head is formed by golgi membrane.

MICRO BODIES:

Various small spherical, single membraned organelles found in the cytoplasm associated with the mitochondria, Endoplasmic reticulum and chloroplast. They are two types.

A). PEROXISOMES:

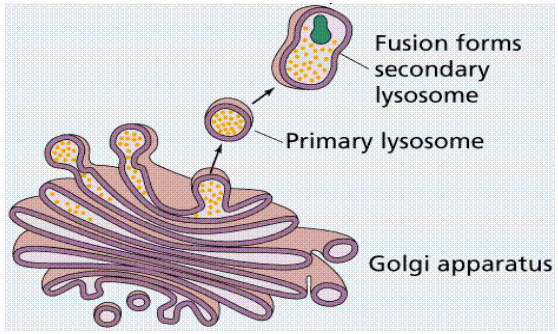
They are found in animal cells and also in the leaves of higher plants. They cause break down of hydrogen peroxide (H_2O_2) and protect the cells from toxic effects. They cause oxidation of fatty acids and play important role in the synthesis of phospholipids. In plant leaves they are involved in a process called photo respiration.

B). GLYOXYSOMES:

They are found only in plant cells. Particularly in seeds. They have enzymes for the oxidation of fatty acids. They are involved in gluconeogenesis (convert fats to carbohydrates).

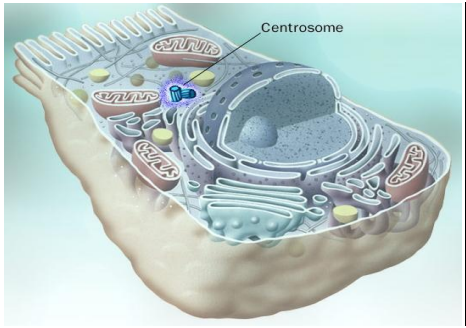
LYSOSOMES:

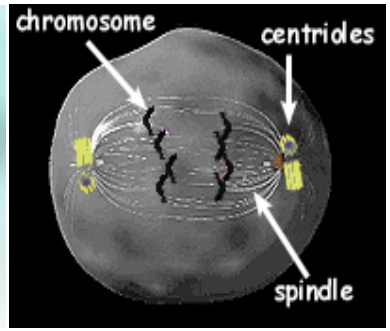
Lysosomes are surrounded by a single unit membrane. They are irregular or oval shaped structures present in the cytoplasm. Lysosomes contain acid hydrolases. They carry out intra cellular digestion (digest proteins, Lipids and glycogen during starvation), extra cellular digestion (digest foreign proteins, bacteria, viruses and help in defence), auto phagy (digest worn out organelles and other intracellular substances) and autolysis (some time due to rupture of the membrane the lysosomal enzymes cause destruction of the cell). Hence lysosomes are described as the suicidal baskets of the cell



CENTRIOLES:

Centrioles are found in all animal cells except in mature RBC. Centrioles are cylindrical, rod shaped micro tubular structures found near the nucleus. They lie in a clear area of cytoplasm called the centrospheres. Centrioles and centrosphere put together called centrosome. They are not bound by any membrane. The main function of centrioles is to initiate cell division in animal cells.



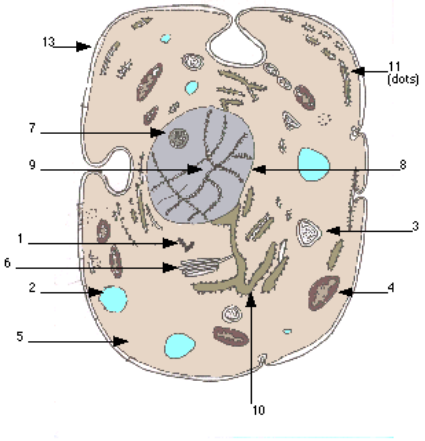


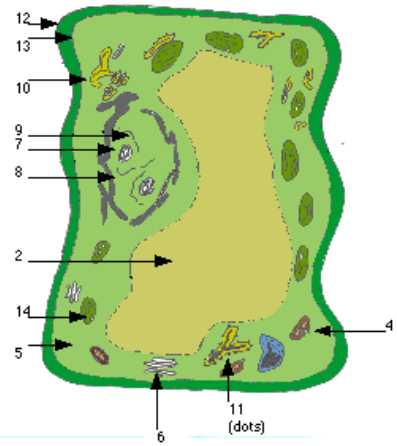
CYTOPLASMIC VACUOLES:

Vacuoles are membrane bound structure found in the cytoplasm of plants and animals. The membrane surrounding the vacuole in plant cell is called tonoplast. They are various types

a) SAP VACUOLES:

They are storage vacuoles. They contain cell sap rich in water, phenol, pigments (antho cyanins and antho xanthins), alkaloids and storage products such as proteins and sugars.



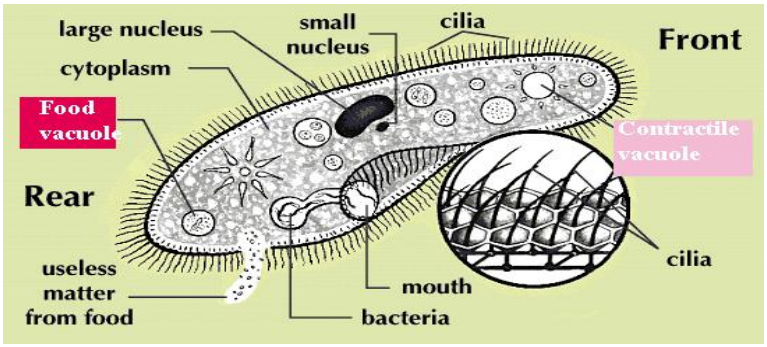


a) FOOD VACUOLES:

Food vacuoles are vacuoles that function as the sites for storage and digestion of food substances.

b) CONTRACTILE VACUOLES:

They are found in fresh water protozoan, algae etc. They are responsible for osmoregulation and excretion.



MICROTUBULES:

They are found in almost all eukaryotic cells. They are hollow, cylindrical tubules made of a protein called Tubulin. The Transverse section of microtubules shows the presence of 13 subunits called protofilaments which are spirally arranged around a central axi

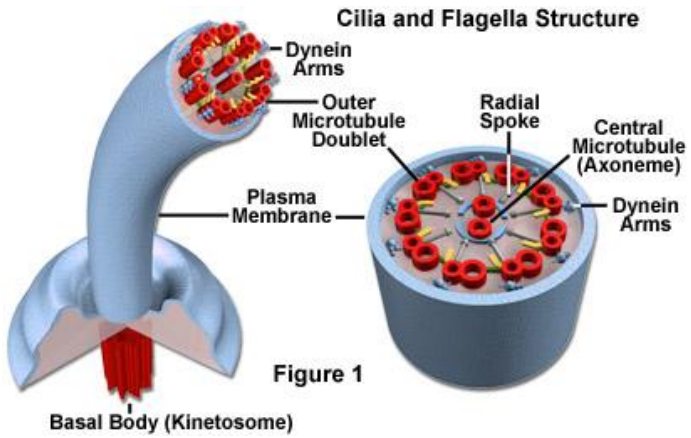


Figure 1

FUNCTIONS:

1. They act as cytoskeleton and maintain cell shape.
2. They also act as the basic units for the origin of centrioles, basal granules, cilia and flagella.
3. The micro tubules are also concerned with the formation of asters and spindle fibres during cell division.
4. They help in the intra cellular transport of water and ions.

PLASTIDS

Plastids are characteristic of plant cells but are also found in case of certain animal cells. They may be coloured green like chloroplasts or colour less like leucoplasts. The chloroplasts help in photo synthesis and protein storage. The leucoplasts store starch and lipids.

CILIA AND FLAGELLA

The cilia and flagella are filamentous processes that help in movement of the entire cell, create food currents, act as sense organs and perform many other mechanical functions in the cell. Cilia and flagella are connected with cytoplasm by basal bodies or blepharoplasts. The cilia and flagella consists of nine outer fibrils encircling the two large central fibrils, and each other fibril consists of two microtubules.

CELL INCLUSIONS (DEUTOPLASM):

Cell inclusions are usually stored secretary substances of the cell that are metabolically inactive. They are not bound by membranes and are non living materials. It includes

1) Reserved food materials (starch, glycogen, fat droplets)
2) Secretary substances (alkaloids, resins, oils, tannins in plant cells and mucus in animal cells)
3) Inorganic crystals (calcium oxalate, calcium carbonate and calcium sulphate etc)

4) Pigment granules (found in the skin of vertebrates such as melanophores and lipophores)

CHECK POINTS

- The cytoplasm of the cell contains non-living and living structures. The non-living structures are called as inclusions and living structures are called organelles.
- The main function of ribosomes is protein synthesis.
- Golgi complex is mainly associated with secretary activities such as secration of lipids, hormones and enzymes.
- Peroxisomes mainly cause breakdown of hydrogen peroxide and protect the cells from toxic effects.
- Glyoxysomes help in the oxidation of fatty acids and gluconeogenesis.
- Lysosomes contain acid hydrolases and are described as suicidal baskets of the cell.
- Centrioles initiate cell division in animal cells. They are absent in plant cells.
- Vacuoles perform different functions. They help in storage products, intra cellular digestion, osmoregulation and excretion.
- Cell inclusions includes reserve food materials, secretary substances, inorganic crystals and pigments.

OBJECT TYPE QUESTIONS:

1. The cell organelle responsible for digestive activities within the cell
   A. Ribosomes **B. Lysosomes**
   C. Peroxysomes D. Kinetosome
2. Suicidal baskets of the cell
   A. Ribosomes **B. Lysosomes**
   C. Peroxysomes D. Kinetosome
3. Ribosomes are most abundant in the
   A. Pancreas B. Muscle fibres
   C. Brain cell **D. A & C**
4. Cell organelles that contains double unit membranes
   A. Centrioles B. Golgi
   C. Mitochondria **D. B & C**
5. One of the following cell organelle contains single unit membrane
   A. **Lysosomes** B. Mitochondria
   C. Golgi D. Centriole
6. -------- cause break down of hydrogen peroxide and protect the cells from toxic effects
   A. **Peroxisomes** B. Glyoxysomes
   C. Dictyosomes D. Lysosomes
7. ------- initiate cell division in animal cells
   A. Golgi B. Glyoxysomes
   C. Centrioles D. Ribosomes
8. ------- act as cytoskeleton and help in maintaining cell shape
   A. Basal granules B. Centrioles
   C. Spindle fibres **D. Micro tubules**
9. The non-living, stored secretary substances present in the cell are called -----
   A. **Inclusions** B. Organelles
   C. Pigments D. Crystals
10. Association and dissociation of the two ribosome sub units is dependent on the concentration of --------- ions
    A. Calcium **B. Magnesium**
    C. Sulphur D. None

SHORT ANSWER QUESTIONS:

1. Describe Ribosomes?
2. List out the functions of Golgi complex?

3. Write short notes on micro bodies?
4. Why Lysosomes are describe as suicidal baskets of the cell?
5. Describe Centrioles?
6. What are micro tubules? List out their functions?
7. Write short notes on cell inclusions?

UNIT-II: CELL BIOLOGY
MODULE-6: NUCLEAR MEMBRANE, CHROMATIN, NUCLEOLUS

The nucleus is a highly specialized organelle that serves as the information and administrative centre of the cell. It is the most important part of the cell situated in the cytoplasm exerting a controlling influence an all cell activities. It is described as the dynamic centre of the cell, or control centre of the cell. The nucleus was discovered by Robert Brown in 1831. Generally there will be one nucleus in one cell. Some protozoans like Chaos, Pelomyxa etc, *Vaucheria* (Algae) have many nuclei. But the nucleus is absent in mammalian RBC. The size of the nucleus varies from 3-25 µm depending on cell type.

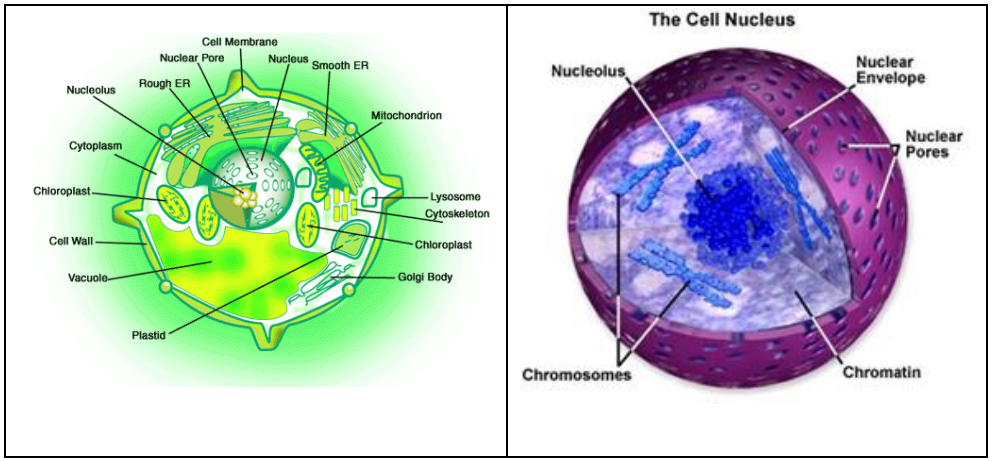
The nucleus is in the center of most cells. In plant cells, with the formation of large vacuole the position of nucleus is shifted from the center to the periphery of the cell. The nucleus is the largest membrane-bound organelle. Specifically, it is responsible for storing and transmitting genetic information. The nucleus is composed of the following structures – Nuclear membrane, nucleolus, nucleoplasm and chromatin fibres.

NUCLEAR MEMBRANE

The nucleus is separated from the cytoplasm by a limiting membrane called as nuclear membrane. It is a double layered membrane. The outer surface of the outer nuclear membrane is generally studded with ribosomes. The outer membrane has direct connections with endoplasmic reticulum. The inner membrane is smooth. The nuclear membrane is perforated by nuclear pores. Through nuclear pores building blocks for building DNA and RNA are allowed into the nucleus and mRNA, tRNA and ribosome sub units are exported to the cytoplasm.

NUCLEOPLASM

The transparent semi-solid substances filled inside the nucleus is called nuleoplasm. In this nucleoplasm chromatin threads, nucleo protein granules, nucleolus etc., are suspended. The nucleo plasm is rich in proteins, enzymes, minerals, and nucleotides.



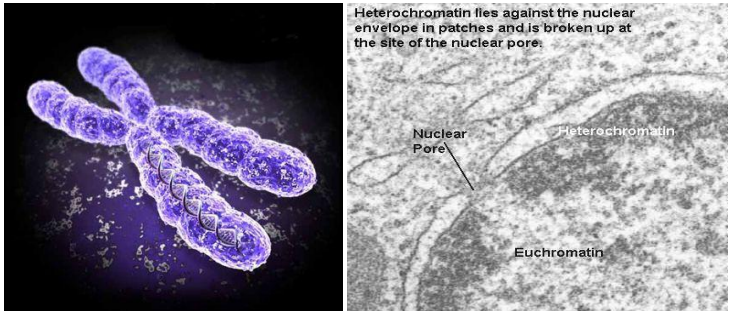
CHROMATIN FIBRES

The nucleoplasm contains many, deeply stained network like or thread like, coiled and much elongated structures called chromatin fibres. These are visible during interphase. During cell division chromatin fibres become thick, ribbon like structures which are known as chromosomes.

The chromatin material is of two types Heterochromatin and euchromatin. The chromosomes show differential staining. The darkly stained parts are called as heterochromatic regions or simply heterochromatin. Hetero chromatin contains inactive DNA. It is

metabolically and genetically inert because it contains small amount of DNA and large amount of RNA.

The light stained region of chromatin is called the euchromatic part or euchromatin. It is genetically active portion. Contains large amount of DNA and is involved in transcribing RNA to produce proteins.



NUCLEOLUS

Within the nucleus are present one or two dense spherical bodies called nucleoli. It is a membrane less organelle. It is very rich in RNA and proteins. It is concerned with the synthesis of ribosomal RNA and its assembly into ribosome sub units. Nucleolus is also called as endosome or karyosome.

FUNCTIONS OF THE NUCLEUS

1. Nucleus is the chief controlling centre of the cell. It controls and regulates the functions of all the cell organelles. It is therefore referred to as dynamic centre of cell or cell brain
2. It stores the cells hereditary material or DNA and plays an important role in heredity.
3. It has a role in the reproduction of unicellular organism.
4. Nucleolus help in protein synthesis by the formation of RNA's
5. Nucleus controls metabolic activities taking place in the cell.
6. Synthesis and regulation of activities of enzymes are controlled by the nucleus.
7. Nucleolus is the site where biogenesis of ribosomal subunits takes place
8. It is the site of DNA replication
9. It is the site of DNA transcription to m RNA.
10. It co-ordinates the cells activities, which include growth, intermediary metabolism, protein synthesis and reproduction (cell division) by regulating gene expression.

CHECK POINTS

- The cell has one or more nuclei. The nucleus is the dynamic center of the cell.
- It is bounded by two membranes, which together constitute the nuclear envelope interrupted by pores.
- Inside the nuclear membrane, the space is packed with fluid called Nucleoplasm.
- The Nucleoplasm contains the chromatin made up of DNA and one or two Nucleoli.
- RNA is primarily found in nucleolus.
- Nucleoplasm contains many thread like coiled structures called chromatin fibers.
- During cell division chromatin fibres become thick ribbon like structures called chromosomes.
- Heterochromatin is genetically inert where as euchromatin is genetically active.

OBJECT TYPE QUESTIONS:

1. Functions of nucleolus in a nucleus are
   A. Synthesis of RNA protein B.Secretary
   C. Synthesis of DNA
   D. Protein Synthesis and origin of Ribosomes
2. The nuclear membrane is a
   A. One membrane structure
   B. Double Membrane Structure
   C. Three membrane structure
   D. Four membrane structure
3. Nucleolus is rich in
   A. DNA and proteins **B. RNA and proteins**
   C. DNA and lipids D. RNA and lipids
4. The principal site of synthesis of ribosomal RNA is
   A. Golgi body B. Endoplasmic Reticulum
   C. Nucleolus D. Cytoplasm
5. The space between the nuclear membrane and nucleolus is filled with a substance called
   A. Nucleoplasm B. Cytoplasm
   C. Chromatin D. None
6. Nucleus was discovered by
   A. Robert Brown B. Robert hook
   C. Schwann D. Schleider

SHORT ANSWER QUESTIONS

1. Differentiate chromatin from chromosomes.
2. What is the function of a cell nucleus? How does it perform its function?
3. Give an account on nucleolus.
4. Briefly describe the structure and functions of nucleus.
5. What is a chromatin? Differentiate euchromatin and heterochromatin.

LONG ANSWER QUESTIONS

1. Give an account on the structure of nucleus?

UNIT-I: CELL BIOLOGY
MODULE-7: CELL DIVISION AND CELL CYCLE

CELL DIVISION

Organisms grow and repair themselves through the medium of cell division. Every living cell has the capacity to grow. When the growth reaches to the maximum size which is the characteristic feature of all the living beings, the cell divides. These cells again grow and continue the process of division. According to the cell theory, new cells originate from the division of pre – existing cells.

Cell division can be defined as a process by which the cell duplicates itself for growth and reproduction.

The characters of an organism are largely an account of the genes, which it has inherited from its parents. These genes in an organism are found in thousands and are arranged in a linear fashion in the chromosomes. These are transmitted from parents to the off springs through the process of cell division and reproduction.

Three types of cell divisions are seen among animals. They are

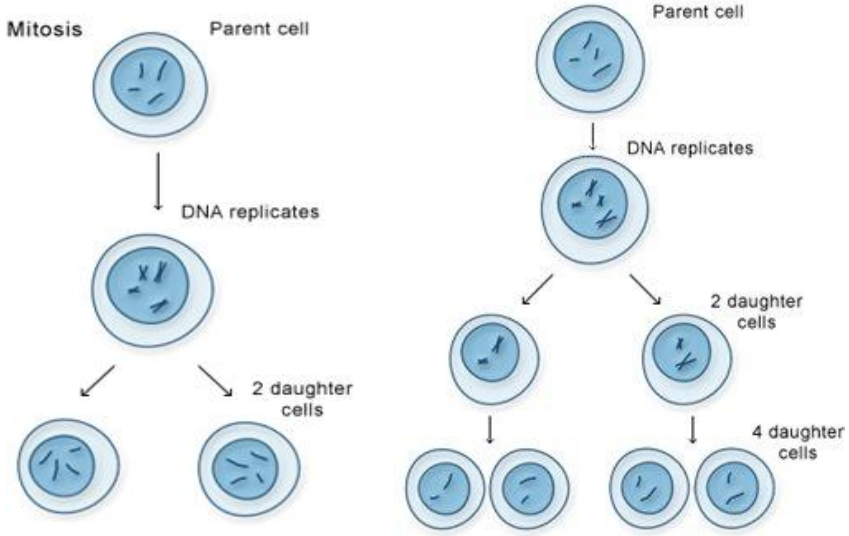
1. Amitosis
2. Mitosis and
3. Meiosis

Amitosis occurs in the acellular animals like protozoa, bacteria etc. It is a means of reproduction in unicellular organisms. It is the simplest division and in this division chromosomes do not undergo any kind of division. The nucleus first divides followed by the division of cytoplasm. As a result two daughter cells are formed.

Mitotic cell division occurs in all somatic cells. Hence mitosis is also called as somatic cell division. Due to mitotic cell division two daughter cells are formed from one parent cell, which are endowed with identical genes arranged in an identical fashion on the identical number of chromosomes. The two cells resulting from mitosis have equal amounts of DNA, chromosomes and other substances. Hence it is also called equational division and duplication division.

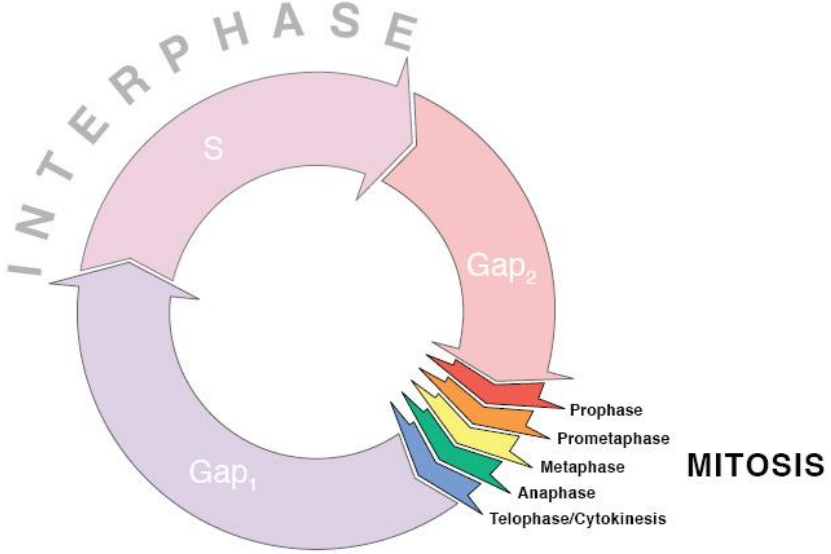
The unicellular organisms reproduce asexually by mitosis. The multicellular organisms develop from a single cell, the zygote or the fertilized egg by the process of mitosis. The zygote is formed by the union as of gametes, which are produced by meiosis or reduction division in the germ cells of sexually mature parents. As a result of meiosis, the number of chromosomes in the gametes is reduced to half (n). The number of chromosomes in the parent cell (2n). Therefore the regular distribution of genes from cell to cell can be explained by mitosis and from generation to generation through meiosis.

MITOSIS **MEIOSIS**



CELL CYCLE:

Cell cycle is an orderly series of changes that occurs in a cell by which it duplicates its contents and divides into two. Cell cycle consists of two phases – inter phase and M – phase. Both of them have a number of sub – stages.



INTER PHASE:

When a cell divides, it is necessary that its chromosomes and genes also duplicate themselves. The duplication of genes occur during interphase, which is a period of interval between two successive cell divisions, when the cell prepares itself for the division.

During this stage nucleus and cytoplasm are very active metabolically, synthesizing and storing all these substances which are essential for cell division.
During interphase the following processes takes place

1. Replication of DNA and histone proteins
2. Synthesis of energy rich compounds and proteins
3. Duplication of centriole in animal cells.

The interphase lasts more than 95% of the duration of cell cycle. The interphase is divided into three sub stages namely G_1 phase, S – phase and G_2 phase.

G_1-PHASE

It comes immediately after the cell division and is characterised by the general growth of cell. The various substances (proteins and nucleotides) necessary for the synthesis of DNA are formed in this phase.

S-PHASE

S-pphase is called synthesis phase. This phase is marked by the duplication of DNA and histone proteins. As a result of this the amount of DNA is doubled.

G_2-PHASE:

It is the second growth phase, also called post – synthetic phase or pre mitotic phase. Cell size increases. The nucleolus increases in size due to a accumulation of ribosomal RNA and proteins. Mitochondria and plastids undergo division. Microtubules and other substances directly involved in mitosis are produced. Multiplication of other cell organelles also occur. The chromosomes appear as diffused long coiled and indistinct chromatin fibres.

M-PHASE: (MITOTIC PHASE)

It is the actual phase of cell division. Division may occur by mitosis or meiosis. M-Phase is the process of final separation of already duplicated molecular units. M-Phase consists of two processes.

1. Karyokinesis or division of nucleus
2. Cytokinesis or division of cytoplasm

The duration of cell cycle and the different stages and substances varies in different types of cells. A typical animal cell cycle lasts roughly 24 hours, but depending on the type of cell, it can vary in length from less than 8 hours to more than a year. Most of the variability occurs in G1 phase.

CHECK POINTS

1. The cell duplicates itself for growth and representation is called cell division.
2. Three types of cell divisions are seen in animals. They are amitosis, mitosis and meiosis
3. In amitosis chromosomes do not undergo any kind of division.
4. Mitosis is also called as somatic cell division/equational division/duplication division.
5. Cell cycle consists of two phases – Inter phase and M– phase
6. Inter phase is divided into three sub phases – G_1 phase, S – phase ans G_2 phase
7. Growth of the cell takes place during G_1 and G_2 phases
8. M – Phase consists of two processes – karyokinesis and cytokinesis.

SHORT ANSWER QUESTIONS

1. What is cell cycle?
2. G1 and G2 - What does the "G" stand for? (not Gap)
3. What happens during 'S' phase.
4. Name the stages of cell cycle associated with Interphase.
5. What is the purpose of mitosis?

LONG ANSWER QUESTIONS

1. Describe the cell cycle of a typical cell. Describe what happens at each phase.

MULTIPLE CHOICE QUESTIONS

1. Which process provides new cells for growth and replacement of body cells?
   A. Metabolism B. Respiration
   C. Digestion **D. Cell division**
2. The Mitosis Is Also Called Equational Division Because
   A. It occurs in somatic cells
   B. The chromosome number is same in parent and progeny after division
   C. The chromosomes are equally distributed to the daughter cells after division
   D. The chromosome number is reduced to half after completion of mitosis
3. The stage of cell cycle where the cell is preparing to begin DNA replication is called
   A. G1 phase B. G2 phase
   B. S phase D.M phase
4. Which is of the following statement is correct for the S phase during cell division?
   A. The nucleus grows in size
   B. The chromosome number doubles
   C. The DNA replicates but the chromosome number remains same
   D. The centriole forms spindle fibers in plants

5. What occurs in the cell during the G_2 phase?
   A. Growth processes and synthesis of compounds other than DNA
   B. DNA composing the chromosomes is duplicated
   C. Molecules and structures necessary for mitosis are synthesized
   D. Division of the cell and cytoplasm
6. Interphase
   A. Is the same as prophase, metaphase anaphase and telophase
   B. Include stages G_1, S and G_2
   C. Requires the use of polar fibers and kinetochore fibers
   D. It is an optional phase during cell division
7. The Interphase lasts more than ___ of the duration of cell cycle.
   A. 80% B. 70%
   C. 20% D. **95%**
8. Karyokinesis
   A. Division of cytoplasm B. Division of chromosomes
   C. Division of nucleus D. Duplication of DNA

UNIT-II: CELL BIOLOGY
MODILE-8: MITOSIS AND ITS SIGNIFICANCE

Mitosis is a simple type of cell –division, in which new cells are formed in the growing regions of an organism. This type of division is found in all the animals and plants. This type of cell division occurs in all somatic cells, in which the same number and same type of chromosomes are maintained as in the parent cells.

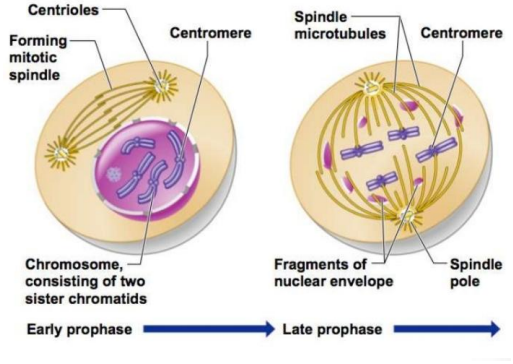
Mitosis has two steps, Karyokinesis and Cytokinesis.

KARYOKINESIS:

It is the term used for nuclear division. It has been divided into four phases – Prophase, Metaphase, Anaphase and Telophase.

PROPHASE

It is the first phase of karyokinesis and is of long duration, in which chromatin fibres condense to form chromosomes. Further condensation makes chromosomes shorter and thicker. Then each chromosome splits longitudinally consisting of two identical halves or chromatids. They are held together by centromere. The nucleolus disappears. Two centrioles continue their migration towards the poles. Finally nuclear membrane breaks down and disperses into cytoplasm as elements of endoplasmic reticulum.



METAPHASE

During this phase formation of spindle and orientation of chromosomes takes place. The cytoplasm around each centriole arranges as radiating fibres. This structure is called aster. Soon the cytoplasm between the asters differentiates into spindle fibres or microtubules. The middle part of the spindle is called equatorial plate or equator. The chromosomes arrange themselves in a regular manner at the equator in such a fashion that their centromeres lie on the equator and arms are oriented towards the poles. This is called as orientation. The chromosomes are attached to the spindle fibres at their contromeres. Each chromosome becomes more compact and short and its two chromatids separate except at the centromere which has not yet divided.

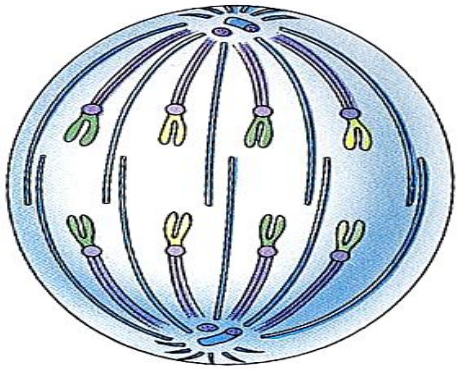
ANAPHASE

It is the shortest of all the stages in the mitotic cycle. During anaphase two things happens

1. Centromere divides and
2. Chromatids move to the opposite poles.

The centromere of each chromosome divides so that each chromatid contain a separate centromere and behaves as a chromosome. Chromatids begin to move towards the opposite poles and spindle fibres also move towards their respective poles. During their movement towards the poles the chromosomes look like U, V or J

shape. Since the centromere is also divided each pole gets the same number of chromatids as present in the parent.



TELOPHASE

This is the last phase in which two daughter cells are formed. Events occurred in prophase will be reversed in telophase. Chromosomes reach the opposite poles. Nuclear membrane develops around the chromosomes. Nucleolus reappears. Spindle fibres and asters begin to disappear. The chromosomes become long thread like structures which lose their identity. Each daughter nucleus gets the same number of chromosomes as present in the parent cell.

CYTOKINESIS

Division of cytoplasm is called cytokinesis. In this process a constriction or furrow appears in the middle of the cell on either side. It gradually deepens and divides the cell finally into two daughter cells. However in plant cells the cell wall formation starts in the center and grows outward to meet the existing lateral walls.

SIGNIFICANCE OF MITOSIS

1. Mitosis is essential for growth and development of a multi cellular organism.
2. The cells of some tissues are periodically worn out and these cells are replaced by new ones only by means of mitosis
3. Daughter cells formed by mitosis are identical to the mother cells. The hereditary characters are transmitted to the daughter cells.
4. Mitosis in unicellular organisms help in reproduction
5. Mitosis help in healing of wounds.
6. It is useful in regeneration of lost parts and grafting in vegetative reproduction.

CHECK POINTS

- Mitosis occurs in all somatic cells
- Nuclear division is called karyokinesis whereas division of cytoplasm is called cytokinesis.
- Mitosis is divided into 4 phases. 1. Prophase 2. Metaphase 3. Anaphase and 4. Telophase
- In prophase chromatin fibres condense to form chromosomes. Nuclear membrane and nucleolus disappears.
- During metaphase spindle formation and orientation of chromosomes takes place
- During anaphase stage centromere divides and chromatids move to the opposite poles.
- In telophase events occurred in prophase will be reversed.

OBJECT TYPE QUESTIONS:

1. What is mitosis?
   A. **The replication of nuclear material and division of the cell and cytoplasm into half.**
   B. Division of cytoplasm only
   C. The process of nuclear division that reduces the number of chromosomes in the resulting cells by half
   D. Replication of nuclear material only without cell division
2. In which phase of mitosis the chromosome move towards the poles?
   A. Prophase B. Metaphase C. Telophase **D. Anaphase**
3. In which of the following phases of mitosis does chromosome separation occur?
   A. Telophase B. Prophase **C. Anaphase** D. Metaphase
4. The first stage of mitosis when chromosomes start becoming visible in the microscope is called:
   A.Anaphase **B. Prophase** C. Telophase D. Metaphase
5. Cytokinesis in a plant cell is characterized by:
   A. The equal division of homologous chromosomes.
   B. Pinching off of the cell membrane to divide the cell.
   C. The formation of a cell plate in the cytoplasm.
   D. The movement of the chromosomes from the metaphase plate.
6. What is the structure in animal cells that divides the cytoplasm into two cells
   A. Mitotic spindle B. Centriole
   C. Cleavage furrow D. Cell plate
7. What occurs during anaphase?
   A. The mitotic spindle beings to form.
   B. The chromosomes align on a plane in the center of the cell.
   C. The sister chromatids separate.
   D. The mitotic apparatus disassembles.
8. ;Which of the following features of cell division are very different for animal and plant cells?
   A. Prophase B. Metaphase
   C. Anaphase **D. Cytokinesis**

SHORT ANSWER QUESTIONS:

1. What is the significance of Mitosis?
2. Mention the various phases of a mitotic cycle.
3. Give an account of the events that take place during metaphase of mitosis.
4. Give an account of spindle fibers and their role in cell division.
5. What is karyokinesis and cytokinesis?
6. What is the significance of anaphase?
7. What kind of change do chromatin fibers undergo during prophase and telophase?

LONG ANSWER QUESTIONS:

1 What are the changes found during the prophase and metaphase? Explain with neat labeled diagrams.
2 What are the changes found during the anaphase and telophase? Explain with neat labeled diagrams
3 Explain mitosis in detail?

UNIT-II: CELL BIOLOGY
MODULE-9: MEIOSIS AND ITS SIGNIFICANCE

INTRODUCTION OF MEIOSIS

Meiosis is a specialized type of cell division which occurs in the reproductive cells at the time of gamete formation. As a result of meiosis four daughter cells are formed from the parent cell and the number of chromosomes in the daughter cells is reduced to half.

Meiosis includes two successive divisions, the **meiosis I(**reduction division**)** and the **meiosis II (**similar to mitotic division**).** Each division is separated into the same five stages as in mitosis.

Meiosis I	**Meiosis II**
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II

MEIOSIS I

PROPHASE I

It is the most complicated stage of meiosis. It is of very long duration. The prophase I is divided on the basis of chromosomal behaviour into 5 substages namely Leptotene, zygotene, Pachytene, Diplotene and Diakinesis.

LEPTOTENE

In leptotene stage nucleus is enlarged. The chromosomes appear as long, fine, uncoiled threads by the condensation of chromatin material. The chromosomes are made of two sister chromatids. Chromatids are not distinguishable. Chromosomes present beaded appearance due to the presence of chromomeres at regular intervals. The centriole of the cell divides.

ZYGOTENE

During this stage the homologous chromosomes of each pair are attracted towards one another and undergo pairing. This is called **synapsis**. Each pair of homologous chromosomes is known as **bivalent**. The synapsis is equal, exact and occurs from chromomere to chromomere. Centrioles move apart initiating the spindle formation.

PACHYTENE

In each bivalent chromosome four chromatids appear more clearly than earlier. It is called tetrad. The two chromatids of same chromosome are called sister chromatids and those of different chromosomes called non-sister chromatids. An important event that occurs in the pachytene is crossing over, It occurs between the non sister chromotids of two homologous chromosomes. Crossing over is the exchange of genetic material between two homologous chromosomes. Crossing over leads to recombination of genetic material on the two chromosomes.

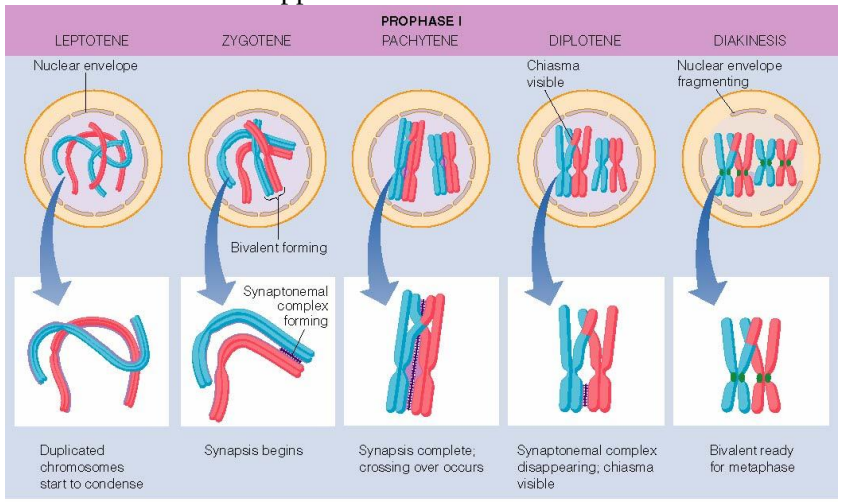
DIPLOTENE

This is the longest duration. The point of attachment at crossing over sites is known as **chiasmata**. Chiasmata appears X shaped. The **chiasmata appear at diplotene stage.** There may be one , two or more chiasmata in a tetrad. At diplotene, further thickening and shortening of chromosomes take place. Homologous chromosomes start separating from one another. This separation starts at centromeres and travels along towards the ends. This kind of separation of chromosomes from centromere towards the end is

known as "terminalization". Thus the displacement of chiasmata is known as terminalization.

DIAKINESIS

Terminalization of chiasmata completes at diakinesis. After terminalization is completed, chromosomes undergo complete separation. Each chromosome looks like a short, darkly stained body. By the end of diakinesis, the nucleolus disappears and the nuclear membrane disappears.



METAPHASE-I

During metaphase-I spindle is formed between the two centrioles and the chromosomes are arranged on the equator of the spindle. Their centromeres are attached to the chromosomal fibres of the spindle. The centromeres of the chromosomes will be facing towards the poles.

ANAPHASE-I

During this stage the chromosomal spindle fibres pull the chromosomes towards the opposite poles. The centromeres of homologous chromosomes donot divide. So half the number of chromosomes will migrate to the poles and actual reduction of chromosomes taking place at this stage.

TELOPHASE I

During this stage, nuclear membranes are formed around the groups of chromosomes at the two poles. The chromosomes become uncoiled and lose their identity. Nucleolus reappear. The karyokinesis may be followed by cytokinesis giving rise to two haploid cells.

MEIOSIS II

First meiotic division is followed by a second meiotic division with or without the intervening interphase. The second division is essentially a mitotic division. The various events occur in mitosis also occur here in meiosis-II with regards to chromosomes, nucleolus, cytoplasm etc. At prophase-II chromosomes are already double , each having two sister chromotids, with a single functional centromere. These chromosomes soon arrange at equator of the spindle during metaphase-II. The centromere then splits and two chromatids, which may now be called chromosomes, pass to two poles during anaphase-II . This is soon followed by telephase-II and cytokinesis. At the end of cytokinesis four daughter cells are formed each of which will be having haploid number of chromosomes. Since the process mitosis has already been discussed in Module 16, the same will not be repeated here.

SIGNIFICANCE OF MEIOSIS

- Meiosis is the mechanism by which conservation of specific chromosome number of each species is maintained across the generations. This is possible because during meiosis the chromosomal number is reduced to half in gamets. When these gametes fuse and form zygote, again the diploid number is attained.
- Purpose of meiosis is to form haploid cells from diploid cells.
- Meiosis provides opportunities for new combinations of genes to occur in the gametes. This leads to genetic variation in the offspring produced by random fusion of the gametes.
- Maternal and paternal chromosomes independently assort, producing a large number of possible combinations.
- New species are evolved due to crossing over and genetic recombination.

CHECK POINTS

1. Meiosis is a process where the number of chromosomes in the cell is reduced exactly to the half. It occurs in diploid cells to form haploid gametes during sexual reproduction.
2. Meiosis occurs in two successive stages. which are divided arbitrary for clear understanding but the events happens continuously in nature.
3. In meiosis I, the stages are referred to as prophase I, Metaphase I, anaphase I and Telophase I.
4. The prophase in again identified with four substages as Leptotene, Pachytene, Diplotene and Diakinesis. Homologous chromosomes one from each parent are aligned very closely to each other in leptotene.
5. In Pachytene, the homologous chromosomes are paired to form bivalents with four chromatids in each pair. Exchange of genetic materials takes place by crossing over of chromatids through chiasmata formation.
6. In diplotene, the separation of bivalent starts and the condensation, contraction and thickening of chromosomes occurs.
7. By the end of diakinesis, the nucleolus disappears and the nuclear envelope also breaks down and releases chromosomes into cytoplasm. The chaismata terminalizes.
8. In metaphase I, the chromosomes align in equatorial plane in pairs. The migration of chromosomes takes place in anaphase I.
9. In telophase I, the chromosomes with two groups enter the interphase stage or initiate the second division that is similar to the mitosis.
10. All the cells are haploid and have same number of chromosomes at the end of meiosis.
11. Each cell has different genetic makeup due to exchange of genetic material during this process.

QUESTIONS

SHORT ANSWER QUESTIONS

1) What is Meiosis? Explain the Significance.
2) What are the different stages in meiosis?
3) What are the events in leptotene?
4) What happens during zygotene?
5) Write about pachytene and mention its significance?
6) What is the significance of diplotene and diakinesis?
7) Define (a) Synapsis (b) Chiasmata.
8) What is the main difference between mitosis and meiosis?

LONG ANSWER QUESTIONS

1) Explain meiosis I in detail. What is its significance?
2) Compare mitosis and meiosis.

MULTIPLE CHOICE QUESTIONS

1. Which statement best describes the process of crossing-over?
   A. It takes place between homologous chromosomes and results in an increased gene mutation rate.
   B. It takes place between non homologous chromosomes and results in new gene combinations.
   C. **It takes place between homologous chromosomes and results in new gene combinations**.
   D. It takes place between non homologous chromosomes results in an increased gene mutation rate.
2. Crossing over occurs during which phase of meiosis.
   A. Prophase I
   B. Prophase II
   C. Metaphase I
   D. Metaphase II
   E. Cytokinesis
3. During what process do eukaryotic cells become haploid?
   A. S phase
   B. Anaphase of mitosis
   C. Meiosis I
   D. Meiosis II
4. Which of the following statements regarding meiosis is false?
   A. In meiosis I, whole chromosomes separate.
   B. Exchange of paternal and maternal DNA takes place in meiosis I.
   C. Anaphase II leads to chromosome separation into 4 haploid cells.
   D. The chromosomes replicate and number doubles.
5. Which event(s) create the most critical difference between mitosis and meiosis?
   A. Separation of sister chromatids
   B. Formation of bivalents and crossing over
   C. Replication of chromosomes and connection to the spindle
   D. Formation of the spindle
6. During which phase of meiosis the homologous chromosomes are separated
   A. Metaphase I
   B. Metaphase II
   C. Anaphase I
   D. Anaphase II
7. Which meiotic division more closely resembles mitosis
   A. Meiosis I
   B. Meiosis II
   C. Meiosis I and II, both resemble mitosis closely.
   D. Meiosis I and II, both are significantly different from mitosis.
8. Arrange the stages of meiotic prophase I below in order.
   A. **Leptotene, Zygotene, Pachytene, Diplotene, Diakinesis**
   B. Leptotene, Pachytene, Zygotene, Diplotene, Diakinesis
   C. Zygotene, Diplotene, Diakinesis, Pachytene, Leptotene
   D. Leptotene, Zygotene, Pachytene, Diakinesis, Diplotene
9. How many daughter cells are formed from single cell in meiosis?
   A. 4 B. 2 C. 23 D. 46
10. Which of the following is not a correct description of meiosis?
    A. It is a part of sexual reproduction.
    B. Cells at the start and end are identical.
    C. Four cells are formed.
    D. Cells at the start and end are different.

UNIT-III: DIVERSITY IN THE LIVING WORLD
MODULE-10: CLASSIFICATION OF LIVING ORGANISMS

Scientists have found and described millions of species on Earth and new species are being discovered every day. With so many flora and fauna on planet Earth, there must be a method to classify each organism to distinguish it from others, so it can be correctly identified.

The living organisms are to be named such that they are known by same name all over the world. This process is called "Nomenclature" which is providing a scientific name to an identified organism. This is possible only when the organism is correctly identified. "Identification" is to determine whether the collected organism is entirely new or already known. For plants, scientific names are based on agreed principles and criteria which are provided in "International Code For Botanical Nomenclature" (ICBN). The scientific names ensure that each organism has only one name.

WHAT IS CLASSIFICATION

Classification is the process of grouping things together on the basis of the features they have in common. Classification is defined as identification, naming and grouping of organisms into a formal system based on similarities such as internal and external anatomy, physiological functions, genetic makeup or evolutionary history. This means that organisms that share similar features are placed in one group. The science of classifying organisms is known as taxonomy.

Classification involves hierarchy of steps in which each step represents a rank or category. Since the category is a part of overall taxonomic arrangement, it is called taxonomic category and all categories together constitute the "taxonomic hierarchy". Each category referred to as a unit of classification, represents a rank and is commonly termed as "taxon". Thus each taxon represents a unit of classification.

THE HIERARCHICAL CLASSIFICATION SYSTEM:

There are various sizes of groups into which living organisms are put. These groups are arranged from the largest group of organisms to the smallest group of organisms. The groups from largest to smallest are arranged as follows: kingdom, phylum, class, order, family, genus and species. The species is the smallest group of organisms. As you go through the classification hierarchy, you will see that scientists have used broader features to put organisms into kingdoms, which are the largest groups of organisms. When you move down towards the species, which are the smallest groups of organisms, features are becoming specific.

SPECIES

Species is the basic unit of classification in the hierarchical taxonomic system. A species can be defined as a group of organisms with similar features and these organisms are capable of breeding and produce fertile off springs. Each genus may have more than one specific epithets representing different organisms, but having morphological similarities. For ex. Solanum includes species tuberosum, nigrum and melogena.

GENUS

A genus is an aggregate of closely related species. For example potato and brinjal are two different species but belong to the genus Solanum.

FAMILY

Family has a group of related genera with fewer similarities as compared to genus and species. For example three different genera Solanum, Nicotiana and Lycopersicon are placed in family Solanaceae.

ORDER

Order is the assemblage of families which exhibit a few similar characters which are less in number compared to genera included in a family. Families like convolvulaceae, Solanaceae are included in the order polemoniales mainly based on the floral characters.

CLASS

Class includes related orders. Example in plant kingdom orders like Malvales, Rosales, Polemoniales etc are included in the class Dicotyledonae.

DIVISION OR PHYLUM

Related classes are included here. Classes like Dicotyledonae and Monocotyledonae with few similar characters are assigned to the division Spermatophyta. In animals related classes are included in a phylum.

KINGDOM

All plants belonging to various divisions are placed in highest category called kingdom plantae. The kingdom animalia comprises all animals from various phyla.

TAXONOMIC AIDS

Taxonomical aids are defined as the collection of the prime sources of various species of plants, animals and other organisms, which help in their classification, identification and study of the bio-resources. Biologists worldwide have established certain procedures and techniques that help in collecting and storing the data of specimens of the organisms.

HERBARIUM

Plant specimens are preserved by drying leaves and pressing them on sheets. These sheets along with specimens and their description are arranged according to universally accepted system of classification and placed in a store house called herbarium. The herbarium sheets carry information like date and place the specimen was collected, English, local and botanical names, family, collector's name etc. These herbarium sheets provide a quick reference to taxonomical studies.

BOTANICAL GARDENS

Botanical gardens are places of live plant specimens. These gardens have living plants specimens and are great aid in studying the plants and their response to environment. In these gardens, the plants and trees are labeled with their scientific name and its family.

MUSEUMS

Biological museums are collections of plant and animal specimens preserved for study and reference. In museums, specimens are preserved in containers and jars containing preservatory chemical solutions. Insects are preserved in insect boxes, where as larger animals like birds and mammals are usually stuffed and preserved. Museums also contain skeletons and fossils of animals.

ZOOLOGICAL PARKS

Zoological parks are places where animals are kept in a protective environment and looked after from other stress like predators etc. In

zoological parks, all animals are provided with an environment similar to their natural habitat.

KEY

This is another taxonomic aid used in identification of plants and animals based on the similarities and dissimilarities. The keys are based on the contrasting characters generally in a pair called couplet. It represents the choice made between two opposite options. This results in acceptance of only one and rejection of the other. Each statement in the key is called a lead. Separate taxonomic keys are required for each taxonomic category such as family, genus and species for identification purposes. Keys are generally analytical in nature.

EARLY CLASSIFICATION SYSTEM

2000 years ago Aristotle (384-322 BC) was the first taxonomist. Aristotle divided organisms into plants and animals. He divided them by their habitat-land, see or air dwellers. From Aristotle's time to the late nineteenth century, the living things were classified as Plant kingdom and Animal kingdom. The modern taxonomic system was developed by the Swedish Botanist Carolus Linnaeus (1707-1788). He used simple physical characteristics of organisms to identity and differentiate between different species. Linnaeus is regarded as the father of Taxonomy.

BINOMIAL NOMENCLATURE

Linnaeus published a book called "Systema Naturae" in which he outlined the schema of classifying of living things. Linnaeus proposed the concept of "Binomial Nomenclature". According to this every animal or plant will be called by two names. The first name is generic name and the second name is the specific name. Both the names are to be Latinized and italicized. As a rule the generic name is to be placed before the species name. The first letter of generic name should be written a capital letter and specific name in small letters. For example, Linnaeus described humans in his system with the binomial name" "*Homo sapiens*", Homo is genus and sapiens is species.

BIOLOGICAL CLASSIFICATION

Biological classification is a method by which biologists group and categorize organisms by biological type, such as genus or species. Living things are divided into three groups based on their genetic similarity. The three groups are Archaea, Eubacteria and Eukaryota. These three groups are called Domains. The Eukaryota domain is divided into several groups called kingdoms. Within each kingdom, species are further classified into groups based on similarities. For example, the full classification of a human is

Domain Eukarya
Kingdom Animalia
Phylum Chordata
Subphylum Vertebrata
Class Mammalia
Order Primates
Family Hominidae
Genus Homo
Species sapiens

TWO KINGDOM SYSTEM OF CLASSIFICATION

The living organisms from the beginning have been grouped into plants and animals. Linnaeus proposed two kingdoms into which all living organisms could be placed- a). The plant kingdom and b). The animal kingdom.

WHITTAKER'S FIVE KINGDOM CLASSIFICATION

R.H. Whittaker (1969) proposed a five kingdom classification. The kingdoms defined by him were named Monera, Protista, Fungi, Plantae and Animalia. The main criteria for classification used by him include complexity of cell structure, evolutionary status, complexity of body organization, mode of nutrition, mutual evolutionary tendencies, reproduction and phylogenetic relationships.

1. KINGDOM MONERA

Individuals are single celled, may or may not move, have a cell wall. Nucleus, chloroplasts and other organelles are absent. It includes true bacteria (Eubacteria) and Archaebacteria

2. KINGDOM PROTISTA

Protista are unicellular, solitary and colonial, usually move by cilia, flagella or by amoeboid mechanisms. They have organelles including a nucleus and may have chloroplasts. It includes Protozoans and unicellular algae.

3. KINGDOM FUNGI

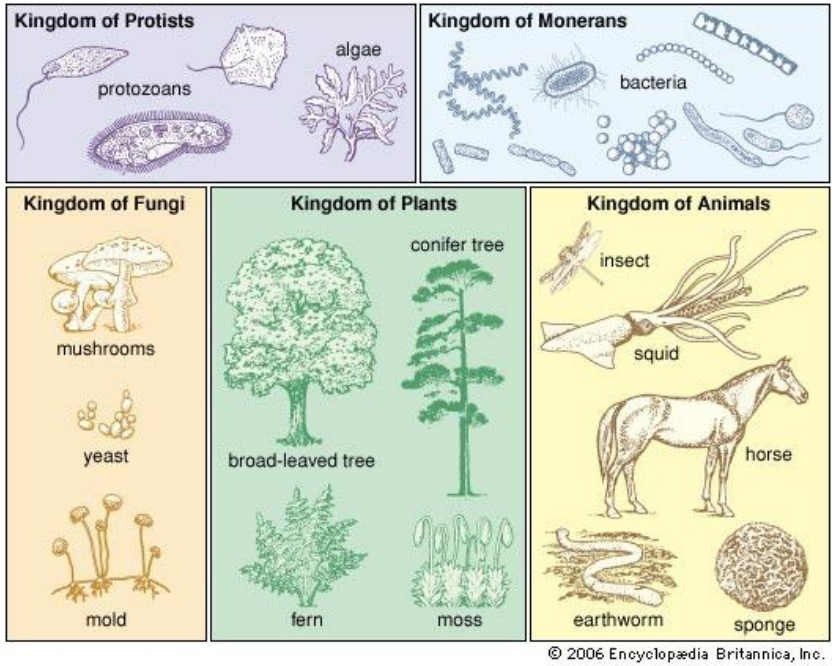
Fungi are multicellular, with a cell wall, organelles including a nucleus, but no chloroplasts. They have no mechanism for locomotion. Fungi may be microscopic to very large in size. Nutrients are acquired by absorption.

4. KINGDOM PLANTAE

Plants are multicellular and most do not move, although gametes of some plants move using cilia or flagella. Organelles including nucleus, chloroplasts are present and cell walls are present. Nutrients are acquired by photo synthesis.

5. KINGDOM ANIMALIA

Animals are multicellular and move with the aid of cilia, flagella or muscular organs based on contractile proteins. They have organelles including a nucleus but no chloroplasts or cell walls. Animals acquire nutrients by ingestion.



The five kingdoms can be distinguished from one another as given below:

Character	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Non cellular	Present in some	Non cellular	Cellulose	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organization	Cellular	Cellular	Multi cellular	Tissue/ organs	Tissue/ organ systems
Nutrition	Autotrophic/ heterotrophic	Autotrophic/ Heterotrophic	Heterotrophic	Autotrophic	Heterotrophic

CHECK POINTS

1. Nomenclature is providing a scientific name to an identified organism.
2. Classification is the process of grouping things together on the basis of the features they have in common.
3. The science of classifying organisms is known as taxonomy.
4. Classification involves hierarchy of steps in which each step represents a rank or category.
5. Species is the basic unit of classification in the hierarchical taxonomic system.
6. Aristotle was the first taxonomist and he divided the organisms into plants and Animals
7. Karl Von Linnaeus proposed the concept of Binomial Nomenclature
8. Linnaeus classified living organisms into two kingdoms as Animalia and plantae based on the cellular organization, nutritive and reproductive characters.
9. In 1969, Whittaker proposed five kingdom classification based on complexity of cell structure and body organization, modes of obtaining nutrition, life style and phylogenetic or evolutionary relation ships
10. The five kingdoms proposed by Whittaker are Monera, Protista, Fungi, Plantae and Animalia

MULTIPLE CHOICE QUESTIONS

1. Which one of the following has correct sequence
   a. Class, phylum, order family
   b. Phylum, class, order, family
   c. Order, family, class, phylum
   d. Family, order, class, phylum
2. Binomial nomenclature was introduced by
   a. John Ray
   b. A.P.de Candolle
   c. Whittaker
   d. Carolus Linnaeus

3. The level of hierarchy just below phylum is
   a. Class
   b. Family
   c. Genus
   d. Order
4. Whittaker divided living world into
   a. Two kingdoms
   b. Three kingdoms
   c. Four kingdoms
   d. Five kingdoms
5. Using the binomial system, an organism is named by its
   a. Kingdom
   b. Genus and species
   c. Phylum and class
   d. Mode of reproduction
6. A certain organism is multicellular, adapted for photosynthesis, and has reproductive organs. To which kingdom does it belong?
   a. Animal
   b. Monera
   c. Plant
   d. Fungi
7. Which of the following is a character of living organism
   a. Movement
   b. Growth
   c. Respiration
   d. All of the above
8. -------- is taken into consideration in phylogenetic system of classification
   a. Evolutionary and genetic relationships
   b. Superficial characters
   c. Similarities and dissimilarities
   d. Complexity of cell structure
9. The kingdom animalia differ from plantae in the absence of
   a. Nucleus
   b. Cell membrane
   c. Cell wall
   d. Tissues
10. ---------- is called father of taxonomy
   a. Linnaeus
   b. Whittaker
   c. Aristotle
   d. None of the above

SHORT ANSWER QUESTIONS

1. What is classification
2. Describe Binomial Nomenclature
3. Describe Trinomial nomenclature
4. What is Biological classification

LONG ANSWER QUESTIONS

1. Describe various systems of classification
2. Describe Whittaker's classification into five kingdoms
3. Describe briefly the classification of living organisms.

UNIT-III: DIVERSITY IN THE LIVING WORLD
MODULE-11: FIVE KINGDOM CLASSIFICATION

KINGDOM MONERA

This kingdom is represented by bacteria. All prokaryotes like Archaebacteria, Eubacteria, mycoplasma and actinomycetes are included in this kingdom.

ARCHAE

The Archae have cell membrane made up of branched chain lipids which helps them to survive in salty areas (Halophiles), hot springs (thermoacidophiles) or marshy areas (methanogens). The cell wall contains pseudomurein instead of Peptidoglycan. Methanogens are present in guts of ruminate animals. When present they produce methane or biogas, in the dung of the animals.

Archae

EUBACTERIA

It constitutes most abundant microorganisms which occur/survive in extreme habitats from snow covered regions to deserts, to hot springs.

They include cyanobacteria and true bacteria. The bacteria are with a rigid cell wall consisting of Peptidoglycan (murein or mucopeptide). The cells have a single length of genetic material that consists of nucleic acid. The cells have ribosomes smaller than that of plant and animal cells. On the basis of the shape, they are classified into spherical (coccus), rod shaped (bacillus), comma shaped (vibrium) and spiral shaped (spirillum). From the structural point of view the bacteria are simple, but they exhibit metabolic diversity. They may be autotrophic- synthesize their own food from simpler inorganic substances (photosynthetic or chemosynthetic). Or they may be heterotrophic- depend on other organisms (parasitic) or dead organic matter (saprophytic) for their food.

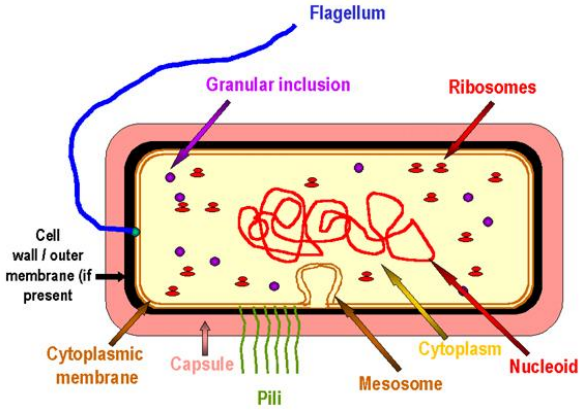
The bacteria are usually heterotrophs or chemoautotrophs. The latter oxidize various inorganic substances such as Nitrates. They play great role in recycling nutrients like nitrogen, phosphorus, iron and sulphur. The saprophytic heterotrophic bacteria are the important decomposers of organic matter. Some of them turn milk into curd, while others produce antibiotics, and fix atmospheric nitrogen. The other types of heterotrophic bacteria are pathogenic and may cause serious diseases in human beings, animals and plants (cholera, typhoid, tetanus, citrus canker). Both auto- and heterotrophic bacteria mainly reproduce by fission, or under unfavorable conditions produce spores. The sexual reproduction is by DNA transfer from one bacterium into other bacterium.

The Cyanobacteria (also known as blue- green algae), are the photoautotrophs and contain chlorophyll-A, a universal pigment. They may be unicellular, colonial or filamentous. Flagella are absent. They often form blooms in polluted waters. Some of them (*Nostoc* and *Anabaena*) fix atmospheric nitrogen in special cells called heterocysts. The red colour of red sea is due to the presence of cyanobacteria *Trichodesmium erythrium.*

While the bacteria are characterized by a cell wall the Mycoplasma included in Monera, completely lack the cell wall. They are the smallest living cells known and were previously called

pleuropneumonia like organisms. These membrane bound organisms are either saprophytes or parasites. Some of them can survive without oxygen. Many of them are pathogenic on human beings, plants and animals.

The actinomycetes are branched filamentous bacteria. Most of them are saprophytic and decomposers. Some of them like Mycobacterium and Corynebacterium are parasites. Many antibiotics are produced form actinomycetes members specially the genus *Streptomyces*.



KINGDOM PROTISTA

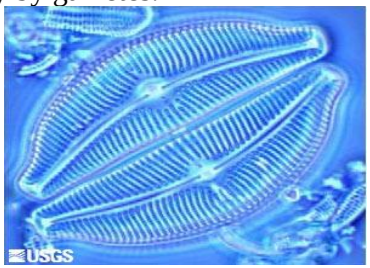
The kingdom Protista has organisms with just one eukaryotic cell. It includes:

1. Chrysophytes (diatoms),
2. Dinoflagellates,
3. Euglenoids,
4. Slime-moulds and
5. Protozoans

All these organisms are with or without flagella. They reproduce sexually or asexually. Earlier, these are treated as members of Algae, Fungi and Animals according to traditional system of classification.

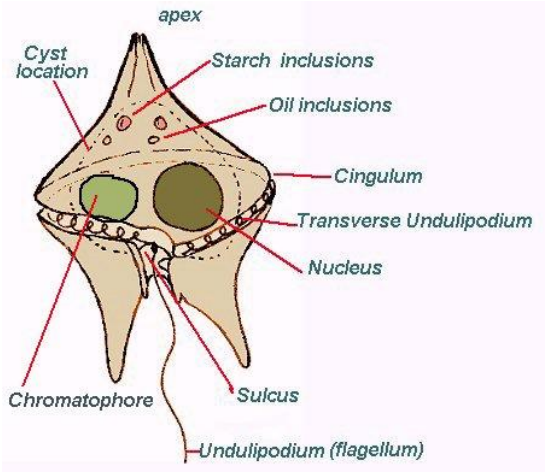
DIATOMS

are commonly referred to as golden algae. They are found in fresh water or marine environment as fruiting forms. They are the chief producers in oceans. They have a soap box like silica body which is indestructible. The siliceous body deposits of over several thousands of years form as diatomaceous earth, which is used as abrasive for polishing, filtration of oil etc. They reproduce asexually by binary fission and sexually by gametes.



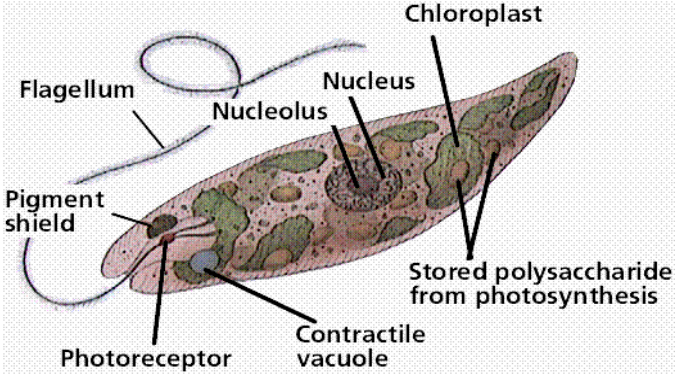
DINOFLAGELLATES

are the marine photosynthetic algae, which appear in various colors. The most characteristic feature of this group is the presence of stiff cellulose beads on the outer surface of the body. They have two flagella, one longitudinal and other transverse. The flagella produce spinning movements and hence these organisms are called whirling whips. The marine dinoflagellate *Noctiluca* shows Red coloured *Gonyaulax* with its rapid multiplication makes the sea appear red (red tides in Mediterranean Sea). They release toxins into the surrounding environment.



EUGLENOIDS

are mainly fresh water organisms. Instead of a cell wall they have a protein rich layer called pellicle. They have two unequal flagella. They lead an autotrophic life during sunlight and heterotrophic life in dark. Their pigments are similar to higher plants. They are sometimes referred to as animals.

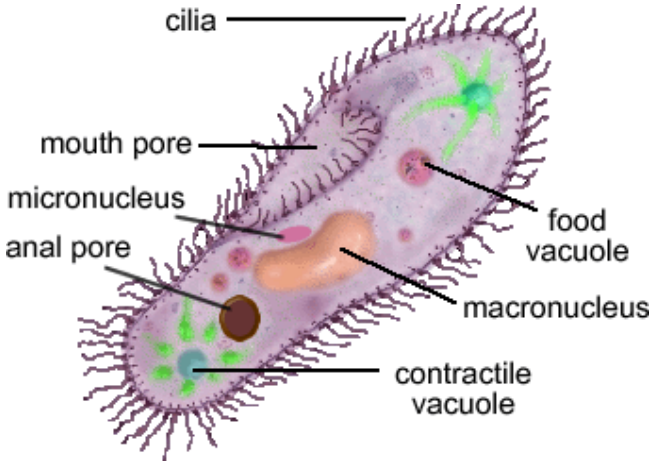


The **Slime-moulds** are basically saprophytic. The body moves along decaying twigs. The nutrition is phagocytic i.e., by engulfing organic material, resembling the character of animals. They form an aggregation called plasmodium (These contain many nuclei without cell membranes between them) during favourable conditions, while during unfavourable conditions the plasmodium differentiates into spore producing fruiting bodies (sporangium), the character of fungi.

***Arcyria* species**

***Diachea leucopodia* - Fruiting Bodies**

1. The members of **protozoa** lead a heterotrophic life. They are regarded as primitive animals. They do not contain cell wall. There are four types of protozoans.
2. The amoeboid ones are non-flagellated and move to capture the prey by pseudopodia or false feet. Some of them like *Entamoeba* are parasites.
3. The flagellated ones are basically parasitic causing diseases, ex: *Trypanosome (*sleeping sickness*).*
4. The ciliated ones as the name denotes have several cilia all over the body which show coordinated movement (*Paramecium*).
5. Lastly the protozoans called sporozoans have infectious spore like stage in their life cycle, ex: *Plasmodium (malaria parasite).*



CHECK POINTS

- Kingdom Monera is represented by bacteria.
- Archaebacteria, Eubacteria, mycoplasma and actinomycetes are included in this kingdom.
- Archae survive in extreme environments
- The Eubacteria includes cyanobacteria and true bacteria
- Mycoplasmas are the smallest living cells known and they lack a cell wall.
- Actinomycetes are branched filamentous bacteria.
- Protista includes organisms with a single eukaryotic cell. It includes Chrysophytes (diatoms), Dinoflagellates, Euglenoids, Slime-moulds and Protozoans.
- Diatoms are found in fresh and marine waters. They have soap box like silica body and are the chief producers in oceans.
- Dinoflagellates are marine photosynthetic algae with various colours. They have cellulose beads on the outer surface of the body.
- Euglenoids are mainly fresh water organisms. They have a protein rich layer called pellicle instead of cell wall.
- Slime moulds are basically parasitic. They form an aggregation called plasmodium.
- The protozoans are regarded as primitive animals. They may be amoeboid, flagellated, ciliated or sporozoans.

SHORT ANSWER QUESTIONS:

1. Give four different characters that differentiate bacteria from Archae.
2. Write briefly on the characters of Monera.
3. What are the different organisms classified under Protista?
4. Differentiate diatoms and dinoflagellates?
5. Give an account of slime moulds and euglenoids?
6. What are the distinguishing characters of protozoa?

LONG ANSWER QUESTIONS

1. Describe the characters of kingdom Monera?
2. Write in detail the characters of different groups of kingdom Protista?

MULTIPLE CHOICE QUESTIONS

1. A scientist recently discovered a pond organism that is unicellular, contains chloroplasts and other membrane-bound organelles, and possesses a flagellum. In which kingdom is this organism classified?
   a. Monera
   b. Fungi
   c. **Protista**
   d. Plant
2. Which of the following groups of bacteria completely lack a cell wall?

a. Archae
b. Photoautotrophic bacteria
c. Chemoautotrophic bacteria
d. **Mycoplasma**

3. Silica deposits are found in the body of
a. Diatoms
b. Dinoflagellates
c. Slime moulds
d. Euglenoids

4. Instead of a cell wall pellicle is present in
a. Diatoms
b. Euglenoids
c. Protozoa
d. Archae

5. Border line organisms between Protista and fungi are _____.
a. Euglenoids
b. Diatoms
c. Slime moulds
d. Dinoflagellates

6. Diatomaceous earth is used as
a. Abrasive
b. Filtering agent
c. For polishing
d. All of the above

7. At the end of migration, resulting from lack of food or moisture, plasmodial slime mold form a
a. Sorocarp
b. Macrocyst
c. Sporangium
d. Slug

8. Which of the following is a locomotor mechanism not found in Protista
a. Pseudopodia
b. Cilia
c. Flagella
d. Tube feet

9. Which statement is true about dinoflagellates?
a. They release toxins into the surrounding environment
b. They can be both photosynthetic and heterotrophic
c. They have a single flagellum
d. They possess cell walls made of silica

10. _____ are regarded as primitive animals
a. Diatoms
b. Euglenoids
c. Protozoans
d. Slime moulds

UNIT-IV: PLANT KINGDOM
CLASSIFICATION OF PLANT KINGDOM

BROAD CLASSIFICATION OF PLANT KINGDOM

The classification is the orderly arrangement of plants. The biologists group and organize the species of known organisms to show some relationship. It involves process of classification and product of the process. The former resulted in grouping of different taxa and the latter in the taxonomic hierarchy. The scientific classification follows a system of rules that standardizes the results, and groups successive categories into a hierarchy.

Since Linnaeus's time (1707-1778) a number of categories have been added between levels of kingdom and genus. The plant kingdom in traditional classifications comprises of organisms which have cell or cells with definite cell wall.

The classification of plant kingdom facilitates the study of different groups of plants in a scientific manner. The plant kingdom in traditional classifications comprise of organisms which have cell or cells with cell wall and absorptive mode of nutrition.

Based on the system of classification proposed by Eichler (1875-78), the plant kingdom is divided into two subkingdoms. They are:

I. Cryptogamae II. Phanerogamae

I. CRYPTOGAMAE (CRYPTOGAMS):

The cryptogams are flowerless (Non-flowering) and seedless, spore bearing plants.

This is subdivided into three divisions:

A) Thallophyta B) Bryophyta C) Pteridophyta

THALLOPHYTA

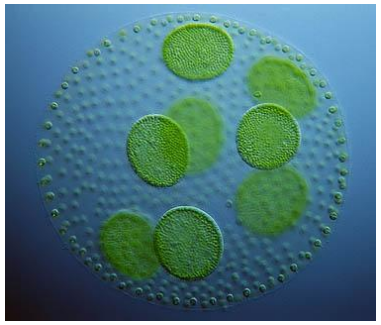
It is the largest division of cryptogams. The thallophytes are simplest and the most primitive plants. All of them have thallus body which is not differentiated into root, stem and leaves. The division Thallophyta is classified into two sub-divisions: i) Algae and ii) Fungi.

ALGAE

Algae are chlorophyll bearing thalloid, autotrophic and largely aquatic (both fresh water and marine) organisms. They also occur in a variety of other habitats like moist stones, soils and wood. Some of them also occur in association with fungi to form lichens.

e.g. ***Volvox***, ***Spirogyra***

Volvox



Spirogyra

FUNGI

Fungi are achlorophyllous (non-green) heterotrophic thallophytes. They live as saprophytes or parasites or in symbiotic association with algae to form lichens. Some fungi grow in close association with roots of vascular plants forming mycorrhizae. They reproduce by spores. e.g.: mushrooms, yeasts, moulds and morels.

Mushroom

Rhizopus

BRYOPHYTA

Bryophytes are chlorophyllous, autotrophic, embryophytic and atracheophytic cryptogams. They are mostly found on damp and shady places. They are called ***amphibians of plant kingdom.***

E.g. *Funaria, Marchantia, Anthoceros*

PTERIDOPHYTA

Pteridophytes are chlorophyllous, autotrophic, embryophytic and tracheophytic cryptogams. They are the non-flowering plants to possess vascular tissues – xylem and phloem. Hence they are called ***vascular cryptogams.***

Ex: *Selaginella, Equisetum*, Fern

Fern

Selaginella

II. PHANEROGAMAE (PHANEROGAMS):

Phanerogams are flower bearing (flowering plants), seed producing tracheophytes. This subkingdom has only one division – Spermatophyta

SPERMATOPHYTA (SPERMATOPHYTES):

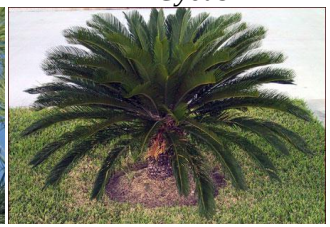
Spermatophytes are seed plants which are with or without fruits. The spermatophyta is classified into 2 sub-divisions.

GYMNOSPERMAE (GYMNOSPERMS):

This term is formed from two Greek words: *gymno*– means naked and *sperma*– means seed. Gymnosperms are phanerogams or spermatophytes without ovary and fruit. The seeds are naked and are usually perennial, evergreen and woody. Examples are deodar, *Cycas, Pinus and Gnetum.*

Pinus

Cycas



ANGIOSPERMAE (ANGIOSPERMS):

The Angiospermae is the largest and most important plant phylum, with at least 300,000 species. This word is formed from two Greek words: *angio* means covered and *sperma*– means seed. Angiosperms are the flowering plants in which the seeds are enclosed by fruits. The seeds develop inside an organ which is modified to become a fruit. Plant embryos in seeds have structures called cotyledons. Cotyledons are called 'seed leaves' because in many instances they emerge and become green when the seed germinates. The angiosperms are divided into two groups on the basis of the number of cotyledons present in the seed. Plants with seeds having a single cotyledon are called monocotyledons or monocots. Plants with seeds having two cotyledons are called dicotyledons or dicots.

Dicotyledons: eg: Bean, Pea

Monocotyledons: eg: Maize, rice.

CHECK POINTS

- The classification is the orderly arrangement of plants.
- Based on the system of classification proposed by Eichler (1875-78), the plant kingdom is divided into two subkingdoms. Cryptogamae and Phanerogamae.
- The cryptogams are flowerless (Non-flowering) and seedless, spore bearing plants. These are again divided into Thallophyta, Bryophyta and Pteridophyta.
- The plant body is undifferentiated into roots, stem etc and like thallus in thallophytes. The members of algae, fungi are included here are considered as most primitive pants.
- Bryophytes are called amphibians of plant kingdom. These are chlorophyllous, autotrophic, embryophytic and atracheophytic cryptogams. They are mostly found on damp and shady places.
- Pteridophytes are vascular cryptogams. These are chlorophyllous, autotrophic, embryophytic, tracheophytic and non-flowering.
- Phanerogams are flower bearing (flowering plants), seed producing tracheophytes. It is divided into gymnospermae and angiospermae.
- Gymnospermae are naked seed bearing trachaeophytes.
- Angiospermae are seed bearing plants where seeds are enclosed in a fruit and are largest division.
- The angiosperms are divided into dicots and monocots which have one or two cotyledons respectively.

SHORT ANSWER QUESTIONS

1. What is the importance of plant classification?
2. Which groups are included under Thallophyta?
3. Give distinguishing features of algae.
4. What are the characters of Fungi?
5. What are the features of gymnosperms?
6. What are the important characters of angiosperms?

7. How gymnosperms are different from angiosperms?
8. How do you distinguish monocots from dicots?

LONG ANSWER QUESTIONS:

1. What are cryptogams? Describe their characters?
2. Compare the characters between groups of spermatophyte.

.MULTIPLE CHOICE QUESTIONS

1. The non vascular land plants are included in the group
   a. Thallophyta
   b. Bryophyta
   c. Gymnosperms
   d. Pteridophyta
2. Which among the following produces seeds
   a. Thallophyta
   b. Bryophyta
   c. Pteridophyta
   d. Gymnosperms
3. Naked seeds are seen in _____.
   a. Angiospermae
   b. Gymnospermae
   c. Bryophyte
   d. Pteridophyta
4. Flowering plants are placed under which of the following divisions
   a. Thallophyta
   b. Pteridophyta
   c. Spermatophyta
   d. None of the above
5. _____ are regarded as amphibians of plant kingdom
   a. Algae
   b. Fungi
   c. Pteridophytes
   d. Bryophytes
6. Which of the following is a heterotrophic thallophyte
   a. Spirogyra
   b. Volvox
   c. Mushroom
   d. Gnetum
7. Which of the following statement regarding Pteridophytes is true?
   a. Non-flowering plants to possess vascular tissues
   b. Flowering plants to possess vascular tissues
   c. Non flowering plants without vascular tissues
   d. Seed bearing flowering plants
8. Angiosperms are divided into two groups based on _____
   a. Flowering and non flowering
   b. Number of cotyledons
   c. Spore bearing
   d. Plant organization
9. Ovary and fruit is absent but seeds are present in
   a. Algae
   b. Fungi
   c. Pteridophytes
   d. Gymnosperms
10. Which one of the following does not have thallus organization
    a. Volvox
    b. Spirogyra
    c. Rhizopus
    d. **Fern**

UNIT-IV: PLANT KINGDOM
MODULE-13: ALGAE

INTRODUCTION

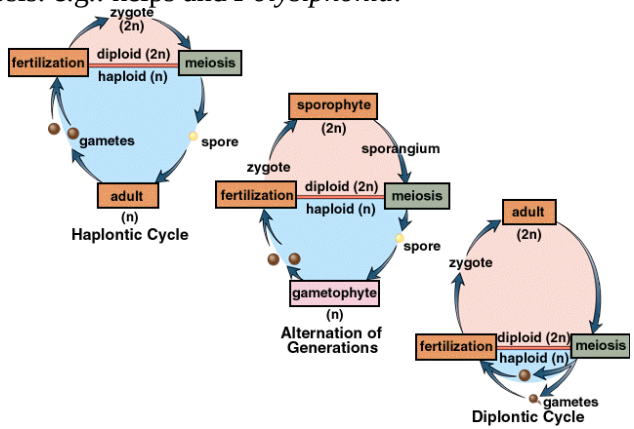
Algae include the most primitive plants with chlorophyll and a simple thalloid body that is not differentiated into roots, stem and leaves. They mostly live in fresh and marine waters. They are also found on moist stones, soil and wood, in association with fungi, plants and animals.

The algae vary greatly in size and form. The simplest algae are single cell e.g: *Chlamydomonas*. The more complex forms consist of many cells grouped in a spherical colony e.g: *Volvox*, in a ribbon like filament e.g: *Spirogyra*, or in a branching thallus form e.g: *Fucus* or into huge plant bodies like in marine kelps. The algae are autotrophic and light energy is harvested by chlorophyll pigments and other accessory pigments like carotenoids and xanthophylls.

The reproduction may be by vegetative, asexual or sexual processes. The vegetative reproduction is by fragmentation. Each fragment of plant body develops into new thallus. The asexual reproduction takes place by the formation of motile/non motile spores. The most common asexual motile spores found in algae are flagellated zoospores. Each spore on germination gives rise to new thallus. The sexual reproduction takes place by the fusion of gametes. It may be isogamous, anisogamous or oogamous. Fusion of two gametes of similar size is called isogamous reproduction. The gametes may be motile (*Chlamydomonas*) or non motile (*Spirogyra*). Fusion of two dissimilar motile or non motile gametes is called anisogamous reproduction (*Chlamydomonas*). The oogamous reproduction is a type of anisogamy where the nonmotile female gamete is non-motile and significantly larger, while the male gamete is smaller and motile. This kind of oogamous reproduction takes place in *Volvox*.

The life cycle of sexually reproducing algae shows alternation of generation between gamete producing haploid gametophyte and spore producing diploid sporophyte. The life cycle may be haplontic, diplontic or haplodiplontic. In haplontic life cycle, the sporophyte is represented by a single celled zygote. There is no free living sporophyte. Zygote undergoes meiosis to form haploid spores which gives rise to gametophyte. The dominant phase is represented by free living gametophyte. E.g: *Volvox*, *Chlamydomonas*, *Spirogyra*.

In diplontic life cycle, the diploid sporophytic phase is dominant. The gametophytic phase is represented by single or few celled haploid plants. e.g. some brown algae. In haplodiplontic life cycle sporophyte and gametophyte are present. But fertilization gives rise to a multicellular diploid sporophyte, which produces haploid spores via meiosis. e.g.: kelps and *Polysiphonia*.

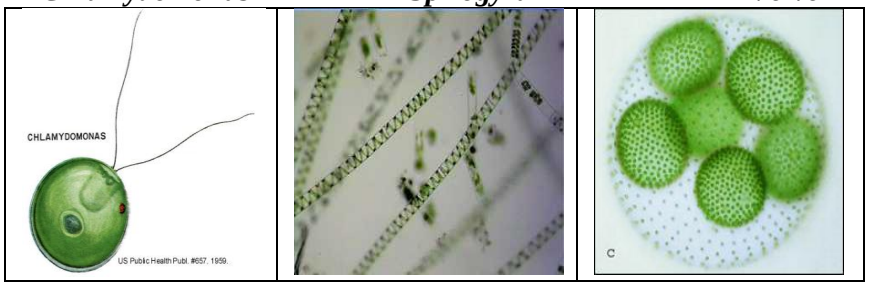


The algae are divided into many classes based on the combination of characters like pigments, reproduction and reserve food materials. Three main classes Chlorophyceae, Phaeophyceae and Rhodophyceae are discussed below.

CHLOROPHYCEAE

They are called green algae due to the presence of chlorophyll a and b in their thallus. Some of the common species of Chlorophyceae are C*hlamydomonas, Volvox* and *Spirogyra*. They are found commonly in fresh water and marine habitats. Some are terrestrial growing on soil, trees or rocks. Some are symbiotic with fungus as lichens. *Chlorella* is symbiotic with animals, e.g. the fresh water coelenterate *Hydra*. They may be unicellular, colonial or filamentous. The cell walls are rigid with an outer layer of pectin and an inner layer of cellulose. They have membrane bound chloroplasts and nuclei. The chloroplasts may be cup shaped, discoid, spiral or ribbon shaped. The food material is stored in the structures called pyrenoids in the chloroplasts. The pyrenoids contain protein and starch. Some of them store food material in the form of oil droplets.

Chlamydomonas ***Spirogyra*** ***Volvox***



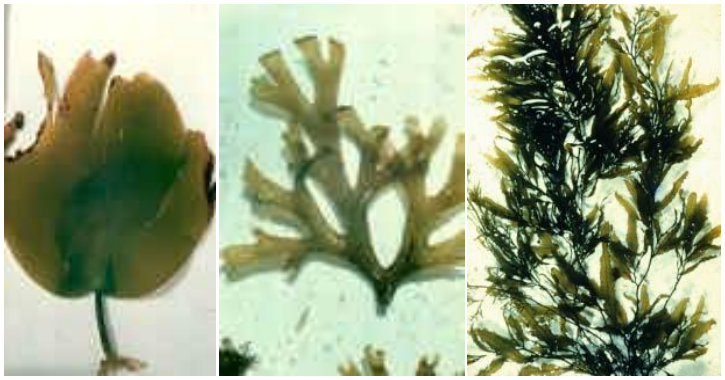
Vegetative reproduction is by fragmentation or by different types of spores. Asexual reproduction is by motile zoospores formed in the zoosporangium. Sexual reproduction may be isogamous, anisogamous or oogamous.

PHAEOPHYCEAE

They are commonly called brown algae. They are relatively large and none is unicellular or colonial. Some of the common species are *Ectocarpus*, *Dictyota*, *Laminaria* and *Fucus*. They are mainly found in marine habitat, few in fresh water. They mainly consist of chlorophyll a, c, carotenoids and xanthophylls. They may be green or brown depending on the amount of brown coloured pigment fucoxanthin. They vary greatly in their size and form. They are filamentous and may be simple (*Ectocarpus*) or profusely branched (kelps which reach a height of more than 100 meters).

The plant body consists of leaf like photosynthetic organ called frond and a stalk called stipe. The stipe is attached to the substratum with the help of holdfast. The cells have cell wall made up of cellulose covered with gelatinous material algin. The algin constitutes 40% of the dry weight of kelps. The protoplast consists of a central vacuole and nucleus. The reserve food materials are complex carbohydrates mannitol and laminarin.

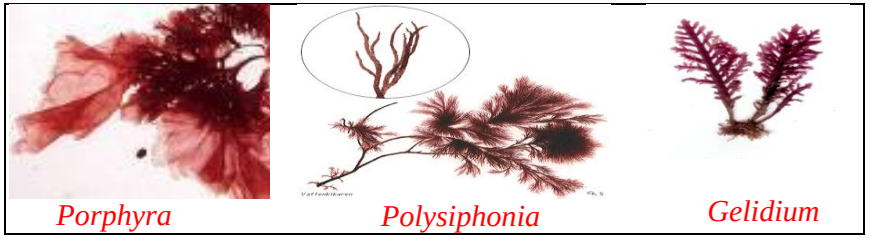
The vegetative reproduction is by fragmentation and asexual reproduction is by pear shaped, two unequal biflagellate zoospores. Sexual reproduction is isogamous, anisogamous or oogamous.



Laminaria *Dictyota* *Sargassum*

RHODOPHYCEAE

They are commonly called red algae due to the presence of more of red pigment r -phycoerythrin. The other major pigments include chlorophyll a, d and the red pigment. Most of the red algae are found in warmer and deeper seas and are known as seaweeds. Some of the common species are *Polysiphonia*, *Gracilaria*, *Gelidium* and *Porphyra*. Mostly the plant body is multicellular with complex body organization reaching up to one meter. They are not large as kelps of phaeophyceae. The filaments are closely arranged hence appear as flattened blades or segments. Some appear as beautiful feathery structures like delicate art works. Food is stored in the form of floridean starch.



Porphyra *Polysiphonia* *Gelidium*

Vegetative reproduction is by fragmentation. Asexual reproduction is by non motile spores. Sexual reproduction is oogamous. It is by non motile gametes. The life cycle is complex. The female sex organ is a flask shaped **carpogonium** and non flagellated male gamete is called **spermatium**. Sexual reproduction is accompanied by complex post fertilization developments.

HUMAN RELEVANCE OF ALGAE

Algae are of great importance to human beings. They are the primary producers. Almost one third of the carbon fixed on this planet is achieved by algae. Being photosynthetic they increase the level of dissolved oxygen in their immediate environment. They are of importance as primary producers of energy rich compounds which form the basis of food cycles of all aquatic animals.

Sea weeds are used as fertilizers and even as food (*Spirullina*, *Chlorella*). These algae are used as food supplements even by space travellers. Marine algae such as *Porphyra*, *Laminaria* and *Sargassum* are used in soups, confections, with meat, vegetable food.

Extracts of cell walls of brown and red algae provide polysaccharides and agar. These are used in food, surgical dressings, textile industry, paper industry, pharmaceuticals, and cosmetics and in microbial growth as thickening smoothing or suspension agent. Algin (brown algae) and carrageen (red algae) are used commercially. Agar one of the commercial products obtained from *Gracilaria* and *Gelidium* is used as culture media for growing microbes. Agar is used in tissue culture, gel electrophoresis and experiments in molecular biology. Iodine is extracted from kelps like *Laminaria*.

Funori from another red alga is used as dried food in soups, laundry starch, as an adhesive in hair dressings and in some paints. The skeletons of a group of algae the diatoms are glass like and used for a variety of purposes like reflective road signs, swimming pool filters etc.

CHECK POINTS

- Algae are the most primitive plants with chlorophyll and a simple thalloid body.
- They are found in fresh and marine waters.
- They may be unicellular, colonial or filamentous.
- Reproduction may be vegetative, asexual or sexual.
- Sexual reproduction may be isogamous, anisogamous or oogamous.
- The life cycle may be haplontic or diplontic or haplodiplontic.
- The algae are divided into many classes based on the pigments, reproduction and reserve food materials. Chlorophyceae, Phaeophyceae and Rhodophyceae are the important classes of algae.
- The class Chlorophyceae includes green algae which have chlorophyll a and b.
- The class Phaeophyceae includes brown algae where fucoxanthin is the main pigment.
- In the class Rhodophyceae the red algae the main pigment is r-phycoerythrin.
- Algae are economically useful to human beings in many ways.

SHORT ANSWER QUESTIONS

1. What are the different types of pigments found in the classes of algae studied by you?
2. Give a brief account of asexual reproduction in algae.
3. Write about sexual reproduction in algae.
4. Differentiate haplontic, diplontic and haplodiplontic life cycles.
5. Give an account of the characters of the class Chlorophyceae.
6. Mention the type of food materials stored in different classes of algae.
7. Give an account of human relevance of algae.

LONG ANSWER QUESTIONS.

1. Describe the general characters of the different classes of algae with their relevance to humans.

MULTIPLE CHOICE QUESTIONS

1. Oogamous reproduction is the fusion between
   a. Morphologically similar motile gametes
   b. Small motile male and large non motile female gamete
   c. Two motile gametes of unequal size
   d. Similar non motile gametes
2. Food is stored in the form of laminarin in the class
   a. Chlorophyceae
   b. Phaeophyceae
   c. Rhodophyceae
   d. Bacillariophyceae
3. In the class Chlorophyceae the dominant pigments are
   a. Fucoxanthin and floridean starch
   b. Chlorophyll a and b
   c. Laminarin and xanthophyll
   d. Phycoerythrin and chlorophyll

4. The plant body is attached to the substratum in the members of Phaeophyceae with the help of _____.
   a. Frond
   b. Stipe
   c. Roots
   d. **Holdfast**
5. The symbiotic relationship between algae and fungi is called
   a. Mycorrhiza
   b. Lichen
   c. Mutualism
   d. Commensalism
6. The red, brown and green algae are distinguished from each other on the basis of
   a. Habit and habitat
   b. Modes of sexual reproduction
   c. Nature of photosynthetic pigments
   d. Modes of asexual reproduction
7. A protein rich organism used as food is
   a. Chlamydomonas
   b. Spirogyra
   c. Spirulina
   d. Laminaria
8. The algae that secrete glass like boxes around themselves are
   a. Protists
   b. Diatoms
   c. *Laminaria*
   d. *Spirogyra*
9. The phase which is dominant in diplontic life cycle is
   a. Haploid sporophytic
   b. Diploid sporophytic
   c. Diploid gametophytic
   d. Haploid gametophytic
10. Which pigment is responsible for the brown colour in phaeophyceae?
   a. phycoerythrin
   b. Chloroplasts
   c. Algin
   d. Fucoxanthin
11. Agar is extracted from
   a. Brown algae
   b. Red algae
   c. Green algae
   d. Both A and B

UNIT-IV: PLANT KINGDOM
MODULE-14: FUNGI, LICHENS, VIRUS AND VIROIDS

FUNGI

They are non-chlorophyllous organisms that exhibit remarkable diversity in habitat and structure. They have following characters

PLANT BODY:

Thread like known as hyphae which form a net work called mycelium. It is unicellular to multicellular filamentous. May be septate or aseptate. Primitive forms have coenocytic mycelium. Some have pseudo-parenchymatous body. Yeasts are unicellular. The cell walls are composed of chitin and polysaccharides. The reserve food material is glycogen and oil.

NUTRITION

Due to absence of chlorophyll they are heterotrophic and lead a parasitic or saprophytic life. Some may have symbiotic associations with algae to form lichens or with roots of higher plants to form mycorrhizae.

REPRODUCTION

They reproduce asexually by conidia, sporangiospores, zoospores etc. The sexual reproduction involves plasmogamy (fusion of protoplasm), karyogamy (fusion of nuclei) and meiosis after zygote formation.

- In sexual reproduction two haploid hyphae of compatible mating types come together and fuse. In a few fungi there is an intervening dikaryotic phase.
- In primitive fungal groups ex: *Rhizopus* the sexual reproduction is by fusion of morphologically similar or dissimilar gametes. In sac fungi (ascomycetes) sexual reproduction is by ascospores produced in a sac like structure called ascus ex: *Claviceps*.
- In structurally evolved group the fungi (basidiomycetes) commonly referred to as mushrooms, the sexual reproduction is brought by the fusion of two vegetative or somatic cells of different strains.
- The fungi where asexual reproduction alone is discovered are placed in deuteromycetes. They are also known as fungi imperfecti. As and when sexual reproduction is discovered they are transferred to the appropriate groups of fungi mentioned above.

BROAD CLASSIFICATION OF FUNGI

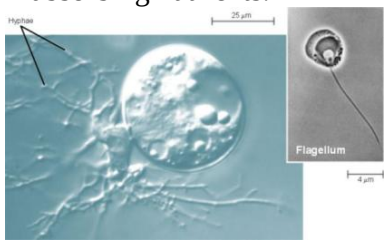
Around 80,000 fungal species are identified and they are historically divided into various phyla based on the nutrition, morphology of mycelium, mode of spore formation and fruiting bodies. Following broad groups of fungi are recognized.

PHYLUM CHYTRIDIOMYCOTA-THE CHYTRIDS

Chytrids are classified under fungi but a controversy exists due to some reasons. Like most protists, their reproductive cells have flagella. However, like other fungi Chytrids have chitin in cell walls. Chytrids are probably more closely related to fungi than to protists. Hence are placed under kingdom fungi.

They are aquatic and not terrestrial. The plant body is simple and mostly one celled. They live as parasites of protists, aquatic fungi, aquatic flowering plants and algae. The most common chytrids consist of a spherical cell which anchors at one end to the

substratum with colourless branching threads called rhizoids. The rhizoids also help in absorbing nutrients.

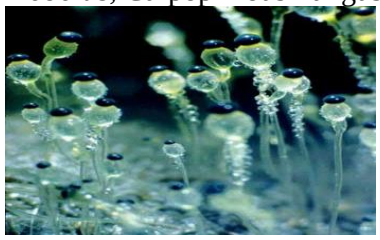


PHYLUM ZYGOMYCOTA-THE COENOCYTIC TRUE FUNGI

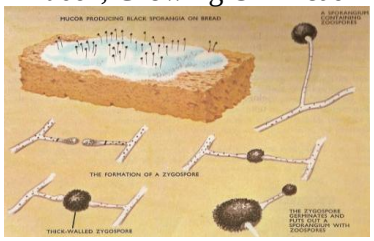
These are familiar as bread moulds. The species are *Mucor*, *Rhizopus* (bread mould), and *Pilobolus* (dung inhabiting genus). They mostly live in aquatic habitat, decaying wood or as parasites on plants and animals or symbiotic organisms as mycorrhizae.

The mycelium is aseptate and coenocytic. Asexual reproduction takes place by spores which may be motile or non motile. Motile spores are called zoospores and non motile spores as aplanospores. They are produced in sacs called sporangia. The sexual reproduction is by gametes. The gametes may be similar (isogamous), or dissimilar (anisogamous). Two gametes fuse to produce a zygospore. After meiosis haploid nuclei are formed which give rise to the zygosporangium with a sporangium at the tip.

Pilobolus, Carpophilous Fungus



Mucor, Growing On Bread



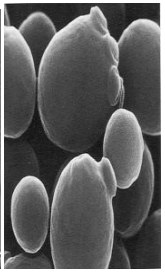
PHYLUM ASCOMYCOTA-THE ASCOMYCETES (SAC FUNGI)

They may be multicellular (*Penicillium*) or unicellular fungi (Yeast). These are large class of fungi. They produce microscopic spores through sexual reproduction inside specialized elongated sacs called asci hence commonly known as sac fungi.

These fungi are saprophytic, parasitic or decomposers. The mycelium is branched septate and have specialized bodies called Woronian bodies (highly refractive particles occurring on either side of the septum). Some of the common examples of this class are Yeasts, powdery mildews, brown fruit rot, ergot, morels. Some of them are edible like morels. Asexual reproduction is by conidia which are produced on special mycelia strands called conidiophores. Sexual reproduction is by ascospores produced inside asci. Karyogamy and meiosis occur in these asci. The asci are arranged in different types of fruiting bodies called ascocarps. A globose ascocarp without opening is called cleistothecium. The flask shaped ascocarp with apical opening is called perithecium and cup or saucer shaped ascocarp is called apothecium. Some examples are *Aspergillus, Claviceps*, and *Neurospora. Neurospora* is used extensively in biochemical work. Morels and truffles are edible and are considered delicacies.

Morchella esculenta, the tasty morel

Tuber melanosporum, a truffle



Penicillium *Yeast*

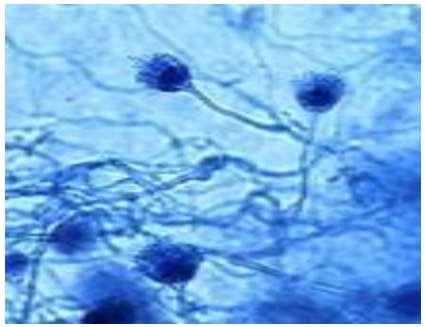
PHYLUM BASIDIOMYCOTA-THE BASIDIOMYCETES (CLUB FUNGI)

The most beautiful and common known fungi belong to Basidiomycetes which include mushrooms (*Agaricus*), puffballs, rusts (*Puccinia*), and smuts (*Ustilago*). They grow in soil, logs, tree stumps and as saprophytes or live as parasites on plants and animals. The edible mushrooms and mycorrhizae fungi are some important members.

The hyphae are septate with dolipore septum and branched. Vegetative reproduction is by fragmentation. Asexual reproduction is less frequent and by means of conidia. In sexual reproduction mycelium of different strains fuses forming dikaryotic mycelium or dikaryon. This ultimately gives rise to basidia. Karyogamy and meiosis take place in the basidium giving rise to four basidiospores. The spores are produced exogenously. The basidia are arranged in a fruiting body called the basidiocarp.

THE IMPERFECT FUNGI-THE DEUTEROMYCETES:

They are commonly called imperfect fungi since the sexual reproduction is not identified. Only asexual and vegetative phases are known. They have well developed septate mycelium. They reproduce asexually by conidia. Conidia are produced in asexual fruiting bodies called pycnidia or acervuli. They are saprophytes or parasites. Most of them are decomposers and help in mineral



cycling. Some of the common species are *Aspergillus*, *Alternaria* (early blight), *Colletotrichum* (red rot).

Aspergillus *Ear rot disease*

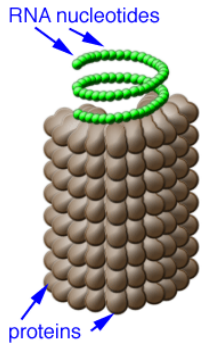
LICHENS

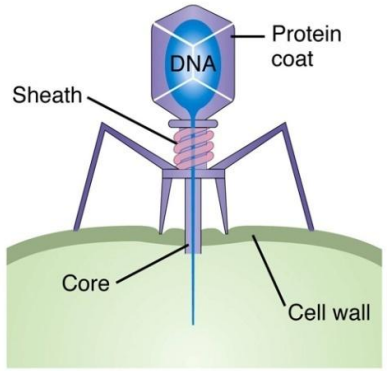
Lichens are symbiotic associations between a fungus (mycobiont) and photosynthetic partner algae (phycobiont) which are heterotrophic and autotrophic respectively. The body (thallus) of most lichens is different from those of either fungus or alga growing separately. The fungus surrounds the algal cells, often enclosing them within complex fungal tissues unique to lichen associations. The algae prepare food for fungi and the fungi provide shelter and absorb mineral nutrients and water. Lichens do not grow in polluted areas and are good pollution indicators. They are also used in making dyes and perfumes and in traditional medicines.

VIRUSES

Virus means venom or poison the name that was given by Pasteur. A group of pathogens which do not fit into any of above kingdoms are viruses. They do not show many characteristics of living beings but have a collection of very complex chemicals assembled into nucleic acids or proteins. Once they infect a living cell, they take over the host machinery and replicate killing the host. Viruses are obligate parasites.

A virus particle, also known as a virion, is essentially a nucleic acid enclosed in a protein coat called capsid. The nucleic acid is infectious. It can be either DNA or RNA but never both. TMV (Tobacco Mosaic Virus) and HIV (Human Immuno Virus) are RNA containing viruses and the viruses which infect bacteria (bacteriophage) contain DNA as genetic material.





VIROIDS

Viroids were discovered and named by Theodor Otto Diener, a plant pathologist in 1971. Potato spindle tuber and at least 15 other crop diseases are caused by viroids. Diener, who discovered the pathogen, named it the "viroid," because it is "like a virus". Viroids consist of circular single stranded RNA which is of low molecular weight. The difference between viroids and RNA viruses is that viroids have no protective protein coat.

CHECK POINTS

- Fungi are eukaryotic non vascular organisms which are cosmopolitan in distribution.
- They are mostly filamentous. The filaments are represented as hyphae which form a net work called mycelium.
- The hyphae may be septate or aseptate.
- Cell wall is made up of chitin and polysaccharides.
- They are heterotrophic in nutrition. They may be saprophytic or parasitic. They are also found as symbionts.
- They store food as glycogen.
- Reproduction is by vegetative, asexual or sexual means.
- Chytrids are a distinct group of fungi which have characters of both protists and fungi.
- Zygomycotina includes the bread molds. They are coenocytic. Asexual reproduction is by sporangiospores and sexual reproduction by zygospores.
- Ascomycotina includes Sac fungi in which sexual reproduction is by ascospores produced in fruiting bodies.
- Basidiomycotina includes Club fungi. The sexual reproduction is by basidiospores produced in basidiocarp.
- Deuteromycotina includes the species which do not have a sexual phase in their life cycle.
- Lichens are symbiotic associations between a fungus (mycobiont) and photosynthetic partner algae (phycobiont).
- A virus particle, also known as a virion, is a nucleic acid enclosed in a protein coat called capsid.
- Viroids consist of circular single stranded RNA which is of low molecular weight.

SHORT ANSWER QUESTIONS

1. Give an account of the different modes of reproduction in fungi?
2. Write in brief the characters of chytrids?
3. Write briefly about the sac fungi and club fungi?
4. Differentiate between virion and a viroid?

LONG ANSWER QUESTIONS

1. Describe the characters of fungi?
2. Into how many groups are fungi classified? Describe in detail the characters of different groups of fungi?
3. Write about

a. Lichens
b. Viruses
c. Viroids

MULTIPLE CHOICE QUESTIONS

1. Cell walls of fungi are composed primarily of
   a. Lignin
   b. Cellulose
   c. Chitin
   d. Pectin
2. Which of these fungal structures are involved in asexual reproduction?
   a. Zygospores
   b. Basidium
   c. Conidium
   d. Ascus
3. The mode of nutrition in fungi is
   a. Autotrophic
   b. Heterotrophic
   c. Both a and b
   d. None of the above

4. Food materials are stored in fungi in the form of
   a. Glycogen
   b. Starch
   c. Carbohydrates
   d. Both b and c
5. The symbiotic association of algae and fungi is known as
   a. Mycorrhiza
   b. Lichen
   c. Root nodules
   d. None of the above
6. Fungi imperfecti reproduce only
   a. Sexually
   b. Asexually
   c. Conjugation
   d. None of these
7. A dikaryon is a cell with
   a. Two nuclei of different mating types
   b. Two nuclei of same mating type
   c. Only one nucleus of same mating type fuse
   d. None of these
8. Coenocytic mycelium occurs in
   a. Deuteromycetes
   b. Ascomycetes
   c. Zygomycetes
   d. Basidiomycetes
9. Mycorrhizae are mutualistic and have symbiotic associations between
   a. Fungi and stems of non vascular plants
   b. Fungi and stems of vascular plants
   c. Fungi and roots of non vascular plants
   d. Fungi and roots of vascular plants

10. Fungi which can grow on dung are termed as
   a. Carpophilous
   b. Heterotrophic
   c. Sacxicolous
   d. Saxiphilous
11. The infectious part in a virus is
   a. Capsid
   b. Nucleic acid
   c. Tail fibers
   d. Envelope
12. Which of the following best explains viroids
   a. They do not have RNA
   b. They do not have DNA
   c. They have RNA with protein coat
   d. They have RNA without a protein coat

UNIT-IV: PLANT KINGDOM
MODULE-15: BRYOPHYTA AND PTERIDOPHYTA

INTRODUCTION

Bryophytes means (Greek: Bryon = moss; Phyton = plants). The division bryophyta includes the simplest green, seedless, moist land plants. They are considered as the most primitive non-vascular land plants. Bryophytes are small, herbaceous plants that grow closely packed together in mats or cushions on rocks, soil, or on the trunks and leaves of forest trees. They add considerable beauty to the wild landscapes of the world.

TAXONOMIC POSITION

The division Bryophyta belongs to sub-kingdom Cryptogamae. They occupy a position intermediate to aquatic algae and terrestrial pteridophyta. The division bryophyta consists of about 960 genera and 25,000 species occurring worldwide in distribution. They consist of Liverworts, Hornworts and Mosses.

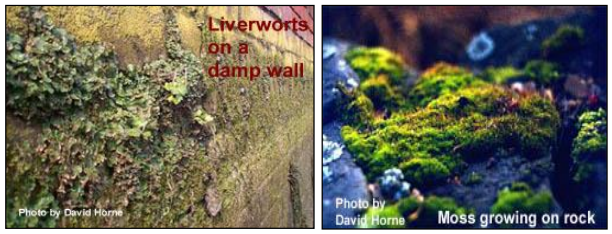
GENERAL CHARACTERS OF BRYOPHYTES

HABITAT

Bryophytes are primitive land plants and usually occur in damp, humid and shaded areas. They are archegoniate, embryophytic and atracheophytic cryptogams. The bryophytes are fundamentally terrestrial plants but they require water to complete their life cycle, therefore they are regarded as "Amphibians of the Plant Kingdom".

PLANT BODY

The plant body of bryophytes varies in two distinct phases during their life cycle - The Gametophytic Phase and The Sporophytic Phase



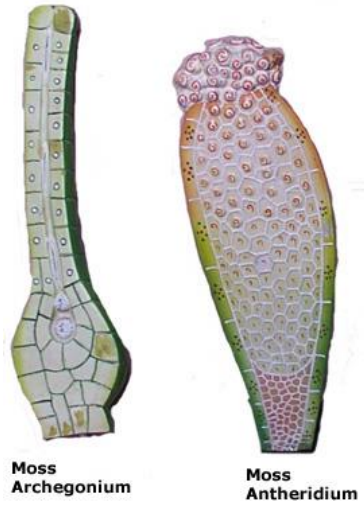
THE GAMETOPHYTIC PLANT BODY

1. The plants are small in size ranging from few millimeters to 30-40 centimeters.
2. They are chlorophyllous and Autotrophic.
3. The gametophytic plant body in primitive forms like "Liverworts" is Thalloid (i.e., not differentiated into true root, stem and leaves).

4. The gametophytic plant body in advanced forms like "Mosses" is Leafy shoot differentiated into stem like central axis and leaf like appendages.
5. True roots are absent and are replaced by unicellular or multicellular thread like Rhizoids.
6. The plant body is made up of simple parenchymatous cells.
7. Vascular tissues such as xylem and phloem are completely absent hence they are Atracheophytic.
8. The main plant body of bryophytes is haploid. It produces gametes and hence is called a gametophyte.

SEX ORGANS

Sex organs are multicellular, stalked and are enclosed in a sterile jacket layer. The female and male gametangia are called Archegonium and Antheridium respectively. Archegonium appears for the first time in the Bryophytes in evolution of plant kingdom. The Archegonium is flask shaped with a defined neck and Venter. It produces large non-motile egg. The Antheridia are differentiated into stalk and body .They produce flagellated male gametes called sperms or antherozoids or spermatozoids.



REPRODUCTION

Bryophytes reproduce by Asexual and Sexual methods.

Asexual Reproduction:

It takes place by Fragmentation of body parts and production of specialized vegetative units called Gemmae.

Sexual Reproduction:

It is oogamous type i.e., the male gametes are small and flagellated while the female gametes are large and non- motile. The male gamete swims in water and reaches the archegonia and fertilizes the egg. Presence of water is mandatory for fertilization.

THE SPOROPHYTIC PLANT BODY:

1. The diploid fertilized egg called the zygote is the first cell of sporophytic generation.
2. The zygote divides mitotically to form an embryo called the sporogonium which is the sporophytic plant body.
3. The sporogonium develops into the sporophyte and is completely or partially parasitic on the gametophyte throughout the life cycle.
4. The sporophyte is usually differentiated into Foot, Seta and Capsule.
5. The sporophyte involves in the production of Meiospores or Haploid spores.
6. Bryophytes are homosporous because they produce only one kind of spores.
7. Spores are first cells of gametophytic generation.
8. Spores germinate to give gametophytic plant body directly or through filamentous stage, called Protonema.

9. Bryophytes show heteromorphic alternation of generations (because gametophytic and sporophytic bodies are conspicuously different) and the life cycle is **haplo- diplontic.**

ECONOMIC IMPORTANCE OF BRYOPHYTES

1. Bryophytes grow as dense mats over soil and prevent soil erosion.
2. In nature bryophytes initiate soil formation and maintain soil moisture.
3. Peat moss is economically important to humans in horticulture and as an energy source.
4. Some bryophytes are used ornamentally, as in moss gardens.
5. They recycle nutrients in forest ecosystems.

CLASSIFICATION OF BRYOPHYTES

The bryophytes are divided into three classes - Hepaticopsida (Liverworts), Anthocerotopsida (Hornworts) and Bryopsida (Mosses).

LIVERWORTS

They usually grow in moist and shady places. The plant body is thalloid. Ex: *Marchantia*. The thallus is prostrate, dorsiventral and closely appressed to the substrate. Vegetative reproduction is by fragmentation of thalli or formation of specialized structures called Gemmae. They develop in Gemmae cups located on the thallus. The Gemmae detach from the parent body and germinate to form new individuals. In sexual reproduction the male and female sex organs are produced on the same or different thalli. The sporophyte is differentiated into foot, seta and capsule. Spores are produced within the capsule. The spores germinate to form free living gametophytes. Elaters are present in the capsule of *Marchantia* to help in spore dispersal.

HORNWORTS

The plant body is also thalloid consisting of rhizoids. Ex: Anthoceros. They possess elongated horn like sporophyte. The sporophyte consists of foot, intercalary meristematic zone and capsule. The capsule produces spores and pseudo-elaters.

MOSSES

The predominant stage in the life cycle of a moss is gametophyte which has two stages- Protonema and gametophore. Protonema is the juvenile stage and develops directly from the spore. The second stage called the gametophore is the adult leafy stage and develops directly from the Protonema as lateral adventitious bud. It consists of upright slender axes bearing spirally arranged leaves. They are attached to the soil by multicellular and branched rhizoids. This stage bears the sex organs.

Vegetative reproduction is by fragmentation, Gemmae formation and budding in the secondary Protonema. In sexual reproduction the antheridia and archegonia are produced at the apex of leafy shoots. They are intermixed with multicellular, uniseriate filamentous, sterile hairs called paraphyses. After fertilization zygote develops into a sporophyte consisting of a foot, seta and capsule. The sporophyte is more elaborate than that of liverworts. The capsule consists of spores formed from spore mother cells after meiosis. The mosses have an elaborate mechanism of spore dispersal. They contain peristomial teeth which help in spore dispersal. Example: *Funaria* (cord moss), *Polytrichum* (haircap moss) and *Sphagnum* (peat moss).

PTERIDOPHYTES

Pteridophytes means (Greek: pteron = feather; Phyton = plants). The division pteridophyta includes first true land plants having complex internal organization. They are considered as the most primitive vascular land plants. They are known as vascular cryptogams Pteridophytes are frequently grown ornamental plants .They include horsetails and ferns. They are found in cool, damp, shady places.

TAXONOMIC POSITION

The division Pteridophyta belongs to sub-kingdom Cryptogamae. They occupy a position intermediate to Bryophytes and Spermatophytes. The division pteridophyta has a long fossil history. The division consists of about 10,000 species occurring worldwide in distribution.

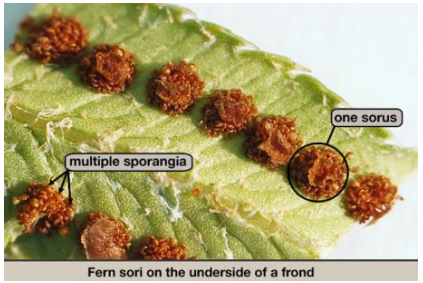
GENERAL CHARACTERS OF PTERIDOPHYTA

HABITAT

1. Pteridophytes occur in both hills as well as in plains in cold, moist and shady places.
2. They also occur in humid and tropical climates and usually grow on soil, rocks, in ponds and as epiphytes on other plants.

PLANT BODY

The plant body of Pteridophytes varies in two distinct phases during their life cycle. The two phases are The Gametophytic Phase and the Sporophytic Phase. The diploid sporophyte is the dominant phase in the life cycle and the sporophyte is independent of gametophyte.



Fern sori on the underside of a frond

THE SPOROPHYTIC PLANT BODY

1. The sporophyte is generally herbaceous and is differentiated into true roots (adventitious), stem and leaves. The leaves may be small microphyllous or large macrophyllous (fronds)
2. They are chlorophyllous and Autotrophic.
3. All vegetative parts possess vascular tissues organized into steles or vascular bundles. So, pteridophytes are first tracheophytes in evolution of plant kingdom.
4. The sporophyte performs vegetative reproduction and asexual reproduction.
5. Vegetative reproduction takes place by vegetative buds that develop on the rhizome or by fragmentation of rhizome.
6. Asexual reproduction takes place by means of spores produced inside the sporangia.
7. The sporangia are borne on lower surface or in axils of fertile leaves called sporophylls.
8. The sporangia are borne singly or in groups called Sori.
9. Plants may be Homosporous i.e., they produce only one type of spores or may be Heterosporous i.e., produce two different types of spores-Smaller Microspores and Larger Megaspores.
10. These spores germinate to produce haploid Gametophyte

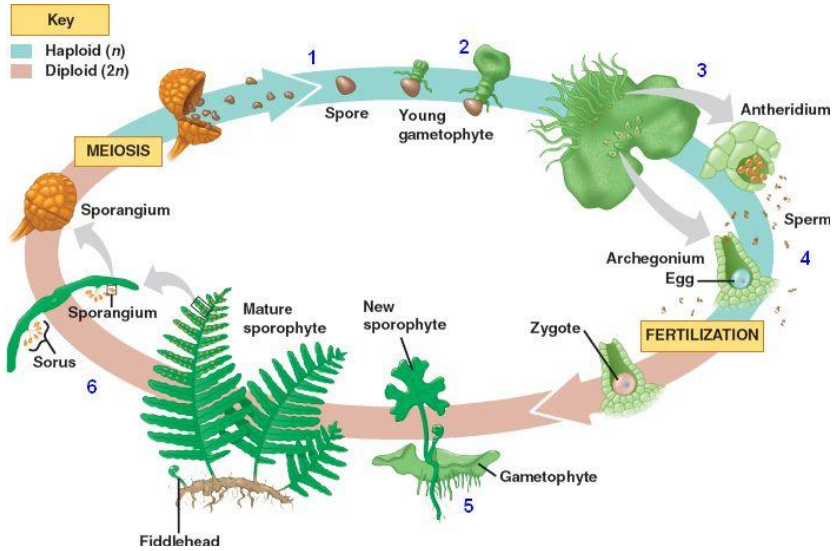
THE GAMETOPHYTIC PLANT BODY:

1. The gametophyte is called Prothallus.
2. Homosporous species produce bisexual gametophytes whereas heterosporous species produce unisexual gametophytes. Microspore germinates to produce male gametophyte and megaspore female gametophyte.
3. The gametophyte performs sexual reproduction and is oogamous.
4. The male sex organs are Antheridia and female sex organs are Archegonia. They are multicellular with sterile jacket, but without stalks.
5. Fertilization occurs in presence of water and takes place in the venter of archegonium.
6. The diploid zygote develops into embryo in archegonial venter. The embryo grows into sporophyte.
7. The development of young embryos takes place within female gametophytes. This event is a precursor to **seed habit**, considered an important step in evolution.
8. The life cycle is diplohaplontic that shows heteromorphic alternation of sporophyte and gametophyte which are independent of each other.

In ferns like Dryopteris the stem is an underground rhizome. The large aerial leaves are called the fronds. Young leaves show circinate vernation (coiling from the tip to the base). The petioles are covered with brown multicellular hairs called ramenta. The sporangia are formed on the lower surface of the leaf (sporophyll) in groups called sori. Each sorus is covered by membranous sheath of its own called true indusium. The antherozoids in ferns are spirally coiled and multiciliate.

The pteridophytes are classified into four classes-

- **PSILOPSIDA** (Psilotum),
- **LYCOPSIDA** (Selaginella, Lycopodium),
- **SPHENOPSIDA** (Equisetum) and
- **PTEROPSIDA** (Dryopteris, Pteris, Adiantum etc., commonly called ferns).



CHECK POINTS

- Bryophytes are primitive non-vascular land plants.
- They are amphibians of plant kingdom.
- Plant body shows gametophytic phase and sporophytic phase.
- Life cycle shows regular alternation of generations.
- Sporophyte is differentiated into foot, setae and capsule.
- Spores germinate and produce protonema.
- There is alternation of haploid gametophyte and diploid sporophyte.
- The bryophytes are divided into three classes - Hepaticopsida (Liverworts), Anthocerotopsida (Hornworts) and Bryopsida (Mosses).
- Pteridophytes are first vascular land plants.
- Plant body shows gametophytic phase and sporophytic phase.
- The diploid sporophytic phase is the dominant phase.
- Life cycle shows regular alternation of generations.

SHORT ANSWER QUESTIONS

1. Where do you find the bryophytes?
2. What are the vegetative characters of Bryophytes?
3. What is alternation of generation?
4. Give economic importance of bryophytes.
5. What are the distinctive phases of pteridophytes?
6. Describe the salient features of sporophytic plant body of pteridophytes.
7. Describe the salient features of Gametophytic plant body of pteridophytes.

LONG ANSWER QUESTIONS

1. Write the salient features of bryophytes and give a brief description of their importance.
2. Write the salient features of Pteridophytes.

MULTIPLE CHOICE QUESTIONS

1. The sexual reproduction in bryophytes is
   a) Oogamous
   b) Isogamous
   c) Anisogamous
   d) Absent
2. The gemmae are involved in
   a) Dispersal of spores
   b) Sexual reproduction
   c) Asexual reproduction
   d) Capsule formation
3. The shape of archegonia is
   a) Circular shape
   b) Irregular
   c) Flask shaped
   d) Pear shaped
4. The pteridophytes differ from bryophytes in having
   a) Motile sperms
   b) Archegonia
   c) Presence of vascular tissue
   d) Heterosporous
5. The sporophytic plant body of bryophytes is known as
   a) Sporogonium
   b) Sporocarp
   c) Sporoderm
   d) Calyptra
6. The bryophytes comprises of
   a) True Roots
   b) Well developed vascular tissues
   c) Seeds and flowers

d) Rhizoids and gametophores

6. What is the name given to the flask like, egg-producing female gametangia of bryophytes?
   a) Archegonium
   b) Antheridium
   c) Gemmae
   d) Capsule
7. In the bryophytes, spores produced in capsule are
   a) Diploid
   b) Haploid
   c) Dikaryotic
   d) Prokaryotic
8. Sexual reproduction in Pteridophytes is
   a. Oogamous
   b. Isogamous
   c. Anisogamous
   d. Absent
9. Sporangia –bearing leaf is called a
   a. Sporophyll
   b. Spermogonia
   c. Spore-sac
   d. Cone
10. Production of two kinds of spores by a plant is called
    a. Heterospory
    b. Homospory
    c. Heterosis
    d. None of the above
11. In Pteridophytes meiosis occurs when
    a. Spores are formed
    b. Gametes are formed
    c. Sex organs are formed
    d. Prothallus is formed
12. Which one of the following does not belong to Pteridophytes
    a. Strobilus
    b. Sori
    c. Gemmae
    d. Seed
13. Fertilization takes place only in presence of water in
    a. Pteridophytes & gymnosperms
    b. Angiosperms & gymnosperms
    c. Bryophytes & Pteridophytes
    d. Bryophytes and Angiosperms
14. First vascular land plants are
    a. Angiosperms
    b. Pteridophytes
    c. Gymnosperms
    d. Bryophytes

UNIT-IV: PLANT KINGDOM
MODULE-16: GYMNOSPERMS

The word gymnosperm is coined by Theophrastus in 300 B.C. and called them "plants with naked seeds".Gymnosperms means (Greek: gymnos = naked; sperma = seed) i.e., the plants with naked seeds. Gymnosperms are phanerogams or spermatophytes without ovary and fruit. Their seeds or ovules are naked or exposed, without a fruit wall. They are therefore considered as fruitless flowering plants and are referred to as "Phanerogams without ovary". The seeds are different from spores of lower plants in having protecting covering called seed coat and also have a supply of food for the embryo. As the seeds (both angiosperms and gymnosperms) are protected by the seed coat, they are capable of surviving the long periods of freezing, dry weather even sometimes fire. This survival value has undoubtedly played a role in becoming the vegetation on earth today. Seeds provided a significant adaptation for plants that had invaded the land. Gymnosperms are mostly distributed in cooler northern region of Europe, Asia and North America.

Gymnosperms are considered a group of seedless plants coordinating with the Angiosperms, within spermatophyta or phanerogams (flowering plants). The gymnosperms flourished during Jurassic period, 250 million years ago. Most of the gymnosperms have now become extinct and are represented by only 900 living species belonging to different classes.

GENERAL CHARACTERS OF GYMNOSPERMS:

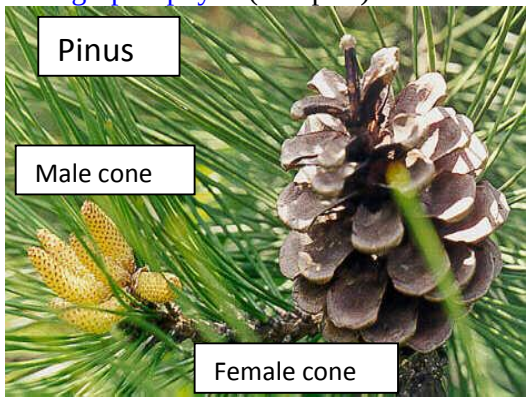
Habitat:

1. Gymnosperms are predominantly evergreen, perennial, woody plants, either trees or shrubs and a very few are climbers.
2. One of the gymnosperms the giant red wood tree *Sequoia* is one of the tallest tree species. *Ginkgo* is considered to be a living fossil.
3. They are widely distributed in the cold climates where there is snow, rather than rain. The only gymnosperms which thrive in warmer areas are the cycads.

THE SPOROPHYTIC PLANT BODY:

1. The sporophytic plant body is woody and is differentiated into root, stem and leaves.
2. The plants posses well developed tap root system. Roots in some genera have fungal association in the form of mycorrhiza (Pinus), while in some others(Cycas) small specialized roots called coralloid roots are associated with nitrogen-fixing cyanobacteria
3. The stem is erect, aerial, solid, woody and branched or unbranched.
4. Anatomically the stem shows eustele.
5. Well developed vascular systems are present. Secondary growth occurs and annual rings are distinct in most of the gymnosperms.
6. Leaves of gymnospermous plants are extremely variable. Most gymnosperms are evergreen, with leaves lasting more than one growing season, while others are deciduous and drop their leaves at the end of every growing season. Leaves are always simple; they may be small and scale like or needlelike or have a broad blade.
7. The plants have vascular tissues. Vessels are absent in xylem except in class Gnetopsida. Companion cells are absent in phloem.
8. Gymnosperms are heterosporous, i.e., produce two different kinds of spores. The microspores are formed in microsporangia of male cones and megaspores in megasporangia of female cones.

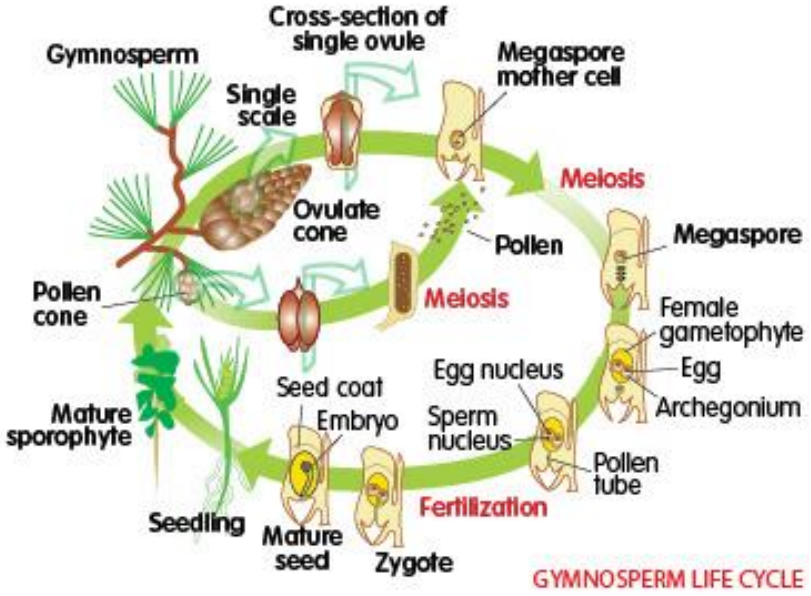
9. These two types of sporangia are borne on special leaf-like structures called sporophylls.
10. The sporophylls are usually aggregate in the form of compact structures called cones or strobili. The sporophylls are arranged spirally in the cone.
11. The microsporangia (pollen sacs) are borne on microsporophylls (= stamens) and the megasporangia (ovules) are borne on megasporophylls (=carpels).



THE GAMETOPHYTIC PLANT BODY:

1. The microsporangium produces numerous pollen grains.
2. The pollen grains are the male gametophyte and each pollen grain produces two male gametes.
3. Ovules are orthotropous and covered by integuments. The female gametophyte formed from the haploid megaspore is called "endosperm". It produces archegonia and also provides nutrition to embryo. So endosperm is haploid and is a prefertilization product.
4. The sexual reproduction is zooidogamous or siphonogamous type of oogamy. Pollination is anemophilous and direct.
5. The diploid zygote develops into an embryo while still enclosed within the ovule. Later the female gametophyte grows into endosperm and ovule becomes the seed.
6. The wall of the ovule forms the seed coat.
7. Polyembryony is common.
8. As there is no ovary, fruit is not formed hence the seeds are naked.
9. The seeds under favourable conditions germinate to form a seedling which develops into a sporophyte.
10. The microsporophylls (male) and megasporophylls (female) may be borne on the same tree (*Pinus*) or on different trees (*Cycas*)

ALTERNATION OF GENERATIONS



1. Heteromorphic alternation of generations is present.
2. The life cycle shows alternate phases of independent, diploid, dominant sporophytic phase and dependant, haploid, reduced gametophytic phase, the character similar to angiosperms.
3. So life cycle is diplohaplontic.

CHECK POINTS

- They are plants, shrubs or trees with naked seeds.
- The plant body is differentiated into roots, leaves and stem.
- They are fruitless flowering plants.
- Plants have well developed vascular tissue.
- The diploid sporophyte is dominant phase in the life cycle.
- Nutritive tissue called endosperm is formed in the seed.
- Heteromorphic alternation of generation is prominent.
- Life cycle is diplohaplontic.

SHORT ANSWER QUESTIONS

1. Describe the salient features of sporophytic plant body of gymnosperms.
2. Describe the salient features of gametophytic plant body of gymnosperms.
3. Describe female gametophyte in gymnosperms.
4. Write short notes on economic importance of gymnosperms.
5. Write short notes on diploid dominant phase of gymnosperms.
6. What is Sporophyll?
7.

LONG ANSWER QUESTIONS

1. Write the salient features of gymnosperms.
2. Describe fertilization in gymnosperms and explain alternation of generation.

MULTIPLE CHOICE QUESTIONS

1. Some vascular plants produce seeds but no fruits. They belong to:
   a. Bryophytes
   b. Pteridophytes
   c. Gymnosperms
   d. Angiosperms
2. In gymnosperms, the xylem generally lacks
   a. Fibers
   b. Vessels
   c. Tracheids
   d. Parenchyma
3. In gymnosperms, endosperm is formed by the
   a. Germination of a megaspore
   b. Germination of a microspore
   c. Fusion of male gamete with egg
   d. Fusion of one male gamete with two polar nuclei
4. Which of the following plants produce seeds but not fruits?
   a. Maize
   b. *Spirogyra*
   c. *Funaria*
   d. *Pinus*
5. In gymnosperms, the phloem lacks
   a. Phloem fibers
   b. Sieve tubes
   c. Companion cells
   d. Phloem parenchyma
6. Pollination in gymnosperms is
   a. Entomophilous
   b. Ornithophilous
   c. Anemophilous
   d. Hydrophilous

7. The coralloid roots are associated with
   a. Sulphur bacteria
   b. Algae
   c. Fungi
   d. Nitrogen-fixing bacteria
8. Pinus is a gymnosperm because
   a. It is a large tree
   b. Has exposed ovules
   c. Produces seeds and has narrow leaves
   d. Is wind pollinated
9. The megasporophyll represents
   a. Carpel
   b. Stamen
   c. Male flower
   d. Female flower
10. Which of the following represents the female gametophyte
   a. Embryo
   b. Endosperm
   c. Testa
   d. Cotyledons

UNIT-IV: PLANT KINGDOM
MODULE-17: ANGIOSPERMS

Angiosperms are flowering plants. Angiosperms are the biggest group in the plant kingdom and occur in various habitats. Today they are the most abundant and diverse plants on earth. There are about 260,000 living species classified in 453 families. The term angiosperm in Greek literally means vessel seed i.e. the plants bearing seeds which are borne within the ovary. They are defined as a group of flowering plants where seeds are enclosed within the carpel. The name angiosperm (enclosed seed) is drawn from a distinctive character of these plants: the ovules and seeds are enclosed in a modified leaf called a carpel. Besides protecting the ovules and seeds, the carpel often interacts with incoming pollen to prevent self pollination, thus favoring cross pollination and increasing genetic diversity.

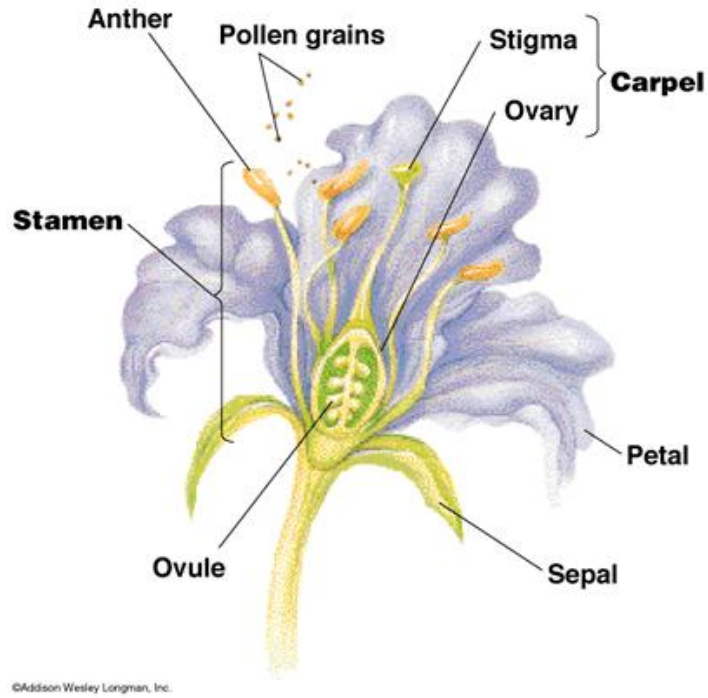
Angiosperms are more highly evolved than the algae, mosses, fungi and ferns. Their advanced structures allow angiosperms to thrive on land. They have roots that hold the plant in place and take in needed minerals and water. They have leaves that are the major food producing parts for the plant. They have stems that hold the plants up and move the nutrients and water about the plant.
In the gymnosperms the ovules are naked. Whereas in angiosperms or the flowering plants, the ovules and pollen grains develop in specialized structures called flowers.

Angiosperms the primary food source for animals and provides oxygen for us to breathe. They provide lumber for buildings and other objects, fibers for clothes, are the basis for many drugs, etc.

HABITAT

They occupy every habitat on Earth except extreme environments such as the highest mountaintops, the regions immediately surrounding the poles, and the deepest oceans. They live as epiphytes (i.e., living on other plants), as floating and rooted aquatics in both freshwater and marine habitats, and as terrestrial plants that vary tremendously in size, longevity, and overall form.

PLANT BODY

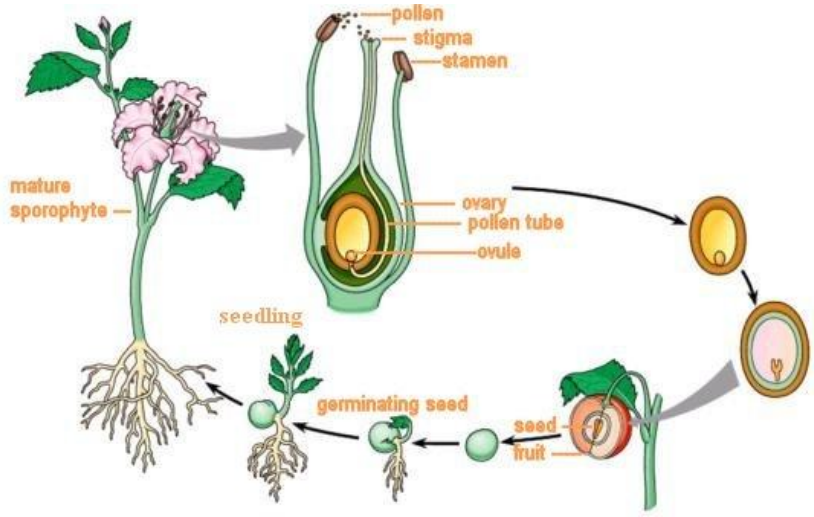


They can be small herbs, parasitic plants, shrubs or giant trees. They range in size from tiny (ex. Wolfia which is almost microscopic) to

tall trees (Ex. Eucalyptus which is 100 m tall). They have true roots, stems, leaves and flowers. They also have seeds. The seeds are formed when an egg or ovule is fertilized by pollen in the ovary. The ovary is within a flower. The flower contains the male and/or female parts of the plant. Fruits are frequently produced from these ripened ovaries.

The male sex organs in a flower are the stamens. They consist of a stalk the filament and a tip the anther where the microspores are produced and turn into pollen. The anther produces pollen grains by meiosis. The female sex organ is the pistil or the carpel. Pistil consists of an ovary enclosing one to many ovules. Style or the stalk portion and stigma which is the outer sticky tip where the pollen lands. Within the ovules are present female gametophytes which are highly reduced. They are called the embryo sacs. The embryo sac is formed after meiosis. So, each of the cells of the embryo sac is haploid. Each embryo sac has a three celled egg apparatus- one egg cell and two synergids, three antipodal cells and two polar nuclei. The polar nuclei fuse to form the diploid secondary nucleus.

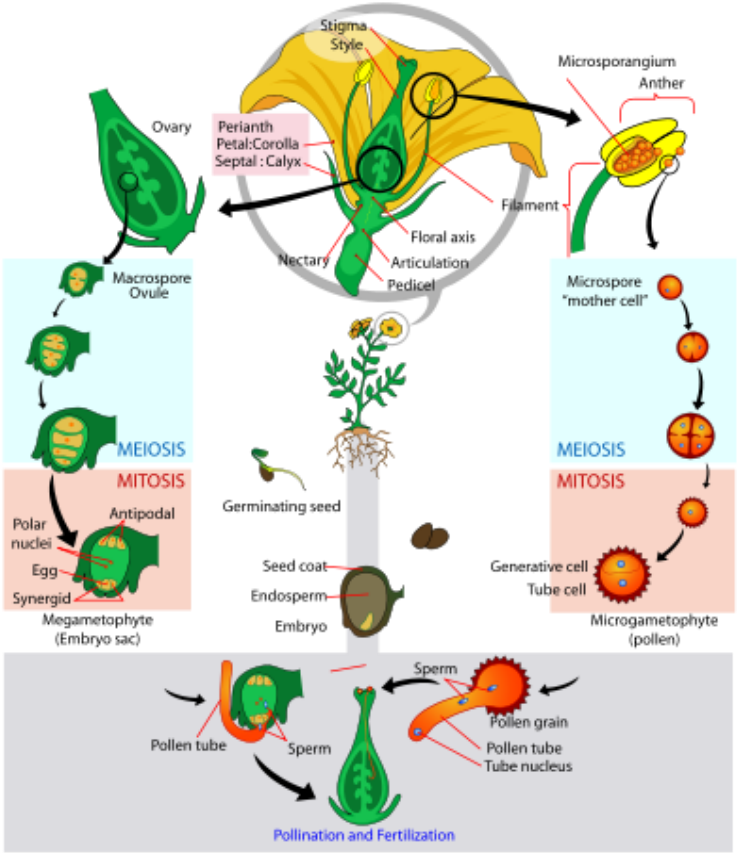
Pollen grains after dispersal from the anther are carried by various agents like wind; water etc. to the stigma of a pistil. This is called pollination. So, pollination is the transfer of pollen to the stigma. The pollen grain germinates on the stigma and forms a pollen tube which grows into the ovary. Two sperm nuclei (male gametes) travel down the pollen tube. The pollen tube enters the embryo sac where the two male gametes are discharged.



Angiosperms have double fertilization. When the two male gametes reach the female gametophyte, one male gamete fuses with the egg cell to form zygote which is diploid. This is called syngamy. The zygote grows into the embryo. The other male gamete fuses with the diploid secondary nucleus to form the endosperm which is triploid. This often serves as food for the embryo. Because of the involvement of two fusions this is termed as double fertilization. This is an event which is unique to angiosperms.

The synergids and antipodals of the embryosac degenerate after fertilization. The ovules develop into the seeds and the ovary into the fruit.

LIFE CYCLE OF AN ANGIOSPERM



The life cycle of angiosperms like all land plants, alternates between a diploid sporophyte generation and a haploid gametophyte generation. Angiosperms represent the extreme end of a trend in the evolution of vascular plants: the sporophyte generation becomes larger and more independent of the gametophyte while the gametophyte becomes smaller and more dependent on the sporophyte.

The angiosperm life cycle possesses the following advances over conifers:

- Reproductive structures are flowers rather than cones.
- Ovules embedded in female sporophyll rather than lying bare on the surface
- Gametophyte still further reduced
- Double fertilization to produce a triploid endosperm which is the nutritive material.
- Seeds enclosed in fruits that develop from the ovary or related structures

CLASSIFICATION

Angiosperms are divided into two classes-the dicotyledons and the monocotyledons.

Dicots	Monocots
Seeds with two cotyledons	Seeds with only one cotyledon
One main tap root	Many fibrous roots
Floral parts 4 or 5 and their multiples	Floral Parts 3
Net work or reticulate venation	Parallel venation
Vascular bundles in rings	Vascular bundles scattered
Cambium present	Cambium absent

CHECK POINTS

- Angiosperms are flowering plants.
- Angiosperms are the biggest group in the plant kingdom and occur in various habitats.
- Angiosperms are more highly evolved than the algae, mosses, fungi and ferns.
- They have roots that hold the plant in place and take in needed minerals and water.
- They have leaves that are the major food producing parts for the plant.
- They have stems that hold the plants up and move the nutrients and water about the plant.
- They occupy every habitat on Earth.
- They can be small herbs, parasitic plants, shrubs or giant trees. They range in size from tiny to tall trees.
- They have true roots, stems, leaves and flowers.
- They also have seeds which are formed when an egg or ovule is fertilized by pollen in the ovary.
- The ovary is within a flower. The flower contains the male and/or female parts of the plant.
- Fruits are produced from these ripened ovaries.
- The life cycle of angiosperms alternates between a diploid sporophyte generation and a haploid gametophyte generation.

SHORT ANSWER QUESTIONS

1. Distinguish between monocot and a dicot plant.
2. Name the following
   a. Angiosperms which have a tap root system
   b. Angiosperms having Trimerous(floral parts in 3) flowers
3. Give an account of the male sex organs of a flower
4. Give an account of the female sex organs of a flower.
5. What is double fertilization?
6. How are angiosperms advanced over conifers?

LONG ANSWER QUESTIONS

1. Describe in detail the general characters and life cycle of angiosperms.

MULTIPLE CHOICE QUESTIONS

1. Double fertilization which is a hallmark of angiosperm sexual reproduction results in _____ diploid cells
   a. Two
   b. Three
   c. Four
   d. None of the above
2. Which of the following is not a part of the sporophyte generation
   a. Flower
   b. Pollen grain
   c. Anther
   d. Leaf
3. In angiosperms which generation is the dominant one
   a. Sporophyte
   b. Gametophyte
   c. Both are equally dominant
4. Pollen grains are produced as a result of _____ division
   a. Mitotic
   b. Meiotic
   c. Both a and b
   d. None of the above
5. The flowering plant group which is the biggest in plant kingdom is
   a. Ferns

b. Bryophytes
c. Gymnosperms
d. Angiosperms

6. Angiosperms differ from mosses, ferns and fungi in that they have
a. **True leaves, stems and roots**
b. Fronds
c. Thallus
d. Mycelium

7. Angiosperms do not provide for man and animals which of the following
a. Food
b. **Carbondioxide**
c. Oxygen
d. All of the above

8. Angiosperm seeds are made in
a. Leaves
b. Stem
c. **Flower**
d. Root

9. In the life cycle of an angiosperm which phase is dominant
a. Gametophyte
b. Diploid Sporophyte
c. Both are equally dominant
d. Haploid sporophyte

10. Endosperm is formed as a result of fusion of
a. Diploid egg with male gamete
b. Diploid secondary nucleus with male gamete
c. Haploid egg with male gamete
d. Haploid secondary nucleus with male gamete

UNIT-V: ANIMAL KINGDOM
MODULE-18: CLASSIFICATION OF ANIMALS

The living world comprises an amazing diversity of living organisms and there are millions of plants and animals in this world. There are innumerable number of animals in this world. Sofar, over a million animal species have been identified and described. They show a lot of diversity in structure, habits, habitats and life styles.

It is difficult to study and know about all these varied animals unless they are arranged in a systemic plan. This systemic arrangement of animals is called classification or taxonomy. Species is the basic unit for this classification. A species can be defined as assemblage of animals having the same characters and can freely breed among themselves. To understand the diversity of organisms , classification is compulsory. A systematic classification of organisms according to their characters will help for the better understanding of the diversity in those organisms.

Karl von Linnaeus was the first person to classify the plants and animals. Linnaeus published his book "Systema Naturae" in which he proposed the concept of "Binomial Nomenclature". According to binomial nomenclature every animal or plant will be called by two names. The first name is generic name and the second name is the specific name. 'Species' is the fundamental unit of classification. Closely related species are grouped under a 'genus'. Closely related genera are placed in a 'family'. When the name of a family is coined, the suffix 'idae' is added to the name of the genus. Some closely related families are grouped under an 'order'. In the same way, some closely related orders form a 'class'. Different classes are grouped to form a phylum. All animals belonging to various phyla are assigned to the highest category called kingdom animalia or Animal kingdom in the classification system of animals. If we write all these levels of classification in a descending order, it will be as follows.

Kingdom
Phylum
Class
Order
Family
Genus
Species

The animal kingdom is divided into three subkingdoms namely protozoa, parazoa and metazoa. Protozoa includes all unicellular, microscopic organisms. The sub-kingdom parazoa includes multicellular organisms like sponges. Sub-kingdom Metazoa includes all more evolved organisms

In spite of differences in structure and form of different animals, there are fundamental features common to various individuals in relation to the arrangement of cells, body symmetry, nature of coelom, patterns of digestive, circulatory or reproductive systems. These features are used as the basis of animal classification.

Kingdom Animalia or Animal kingdom comprises of all diversified animals of the Biosphere. It is divided into two subkingdoms.

SUBKINGDOM PROTOZOA

It consists of all acellular animals where the body is made of only one cell. They are generally minute, microscopic, either free living or parasitic. It includes phylum Protozoa
Ex: *Amoeba, Euglena, Paramecium, Plasmodium etc*

SUB-KINGDOM METAZOA

All the multi cellular animals are included in it. It is divided into two branches

PARAZOA

These are multicellular animals without the formation of well defined tissues. These are simply aggregation of cells. It consists of sponges which are sedentary, aquatic animals with spongocoel lined by choanocytes and provided with numerous pores called ostia. Only phylum porifera is included in it.

EUMETAZOA

It consists of both radially and bilaterally symmetrical animals. These are multicellular animals with well defined tissues and higher level of organization such as organs and organ-systems in the body. It is sub divided into two grades namely Radiata or Diploblastica and Bilateria or Triploblastica.

RADIATA

It is the first formed metazoan group with tissue grade, radial symmetry (when the animal can be divided into two identical halves in more than one plane or axis) and diploblastic body wall (having two primary germinal layers, the ectoderm and endoderm). Phylum Cnidaria (ex. *Hydra, Aurelia* etc) and Ctenophora (ex. Combjellies) are included in this grade.

BILATERIA

It comprises of metazoans with three germ layers in the body wall and bilateral symmetry. (when the animal can be cut through only one axis or plane to get two identical halves).

This includes two divisions

DIVISION I: PROTOSTOMIA

In these metazoans, the blastopore of gastrula develops into mouth. This division includes three subdivisions

SUB-DIVISION I: ACOELOMATA

These animals donot show any true body cavity. The space between body wall and alimentary canal is filled with parenchyma. Phylum – platyhelminthes is included in it.
Ex: Tapeworm, Liver fluke, Blood fluke etc

SUB-DIVISION II: PSEUDOCOELOMATA

It includes animals with a false body cavity. In these animals body cavity is present between ectoderm and endoderm and not lined by mesoderm. Phylum-Nematoda is included in it.
Ex: *Ascaris*, Hook worm, *wuchereria* etc

SUB-DIVISION III: SCHIZOCOELOMATA

They have a true coelom, which is a 'schizocoel'. It is formed by splitting of the mesoderm into outer somatic and inner splanchnic layers.

Examples:

Phylum-Annelida—Earthworm, Leech
Phylum-Arthropoda—Cockroach, Prawn, Scorpion
Phylum- Mollusca—Pila, Unio, Sepia

DIVISION II: DEUTEROSTOMIA

In these metazoans, the blastopore of gastrula develops into anus. It includes only one sub division, Enterocoelomata

SUB-DIVISION: ENTEROCOELOMATA

They have a true coelom. If the coelom is formed from archenteron of gastrula, it is called enterocoel. Such animals are entero-coelomates.

Examples:

1. Phylum-Echinodermata- Starfish, Brittle star, Sea lily
2. Phylum-chordata- Amphioxus, Fishes, Amphibians, Reptiles, Birds and Mammals

PHYLUM-CHORDATA

All the animals with a notochord, at least at some stage in their life cycle, are included under the Phylum Chordata. Phylum Chordata is divided into three Sub Phyla. They are:

1. Uro chordata
2. Cephalochordata
3. Vertebrata or Craniata

Vertebrates are highly evolved, complex chordates with distinct heads. Sub-Phylum Vertebrata is divided into 2 Super Classes.

1. Agnatha and
2. Gnathostomata

Agnatha is characterized by the earliest vertebrates without jaws and paired appendages, where as Gnathostomatans are the advanced vertebrates with a pair of true jaws, paired appendages and paired nostrils. The Super Class Gnathostomata is divided into 7 classes.

They are:

1. Placodermi- Extinct fishes
2. Chondrichthyes- Cartilaginous fishes
3. Osteichthyes – Bony fishes
4. Amphibia – Frogs, Toads, salamanders
5. Reptilia – Lizards, snakes, crocodiles, Tortoises
6. Aves- Birds
7. Mammalia –Mammals

- Amphibians, Reptiles, Birds and Mammals are collectively termed Tetrapods (Four footed)
- Reptiles, Birds and Mammals are called Amniotes as they possess amnion
- Fishes and Amphibians are called anamniotes (without amnion)
- Fishes and Amphibian are grouped together as Ichthyopsida
- Reptiles and Aves are grouped together as Sauropsida

UNIT-V: ANIMAL KINGDOM
MODULE-19: STRUCTURAL ORGANIZATION IN ANIMALS

LEVELS OF ORGANIZATION IN ANIMALS

Though all members of Animalia are multicellular, all of them donot exhibit the same pattern of organization of cells. The study of different levels of organization of animate or living things helps us gain insights into complexities of their structure and functioning. Living beings have evolved from their single-called or unicellular forms into complex and giant multicellular bodies.

In the process of development, their body systems and mechanisms have become specialized in nature. Thus, in the course of evolution, different levels were formed. There are five levels of organization from protozoans to the higher metazoans. These levels in sequence are the cells, tissues, organs, organ systems and organisms.

LEVELS OF ORGANIZATION IN ANIMALS

PROTOPLASMIC LEVEL

The cell is considered as basic unit of life. A cell is bound by cell membraneand possesses a nucleus which acts as the brain of cell. Cytoplasm which surrounds the nucleus, contain cell organelles like mitochondria, ribosomes, vacuoles, endoplasmic reticulum, chloroplasts etc, which carry out different functions.

The unicellular protozoan groups are the simplest animal like organisms. All the basic functions of life like locomotion, digestion, respiration, excretion, reproduction etc. are performed by a single cell. Thus the single cell acts as a complete organism. It is called protoplasmic level of organization.

Metazoans exhibit division of labour at various levels of organization. A metazoan's body is composed of many kinds of cells specialized for performing different functions. The tissues are a collection of cells which perform specialized functions. Cells which form a tissue need not be identical however, should have the same origin. Tissues are combined into functional units called organs and groups of organs that work together form organ systems

CELLULAR LEVEL OF ORGANIZATION

This is the lowest level of organization in metazoans and is exhibited by the sponges. In sponges the cells donot form tissues but arranged as loose cell aggregates. Different types of cells perform different functions, i.e., division of labour is seen among the cells. The different types of cells are functionally isolated.

TISSUE LEVEL OF ORGANIZATION

Tissues make up the second level of organization. They are formed by the joining of cells that have similar function or structure. Diploblostic animals such as cnidarians exhibit tissue level of organization. The cells of a tissue together perform their common functions as a highly coordinated unit and this coordination is due to the presence of nerve cells and sensory cells

ORGAN LEVEL OF ORGANIZATION

An organ is a group of tissues that perform a specific function or group of functions. This is the third level of organization. It performs certain functions with the help of different tissues. Organ level of organization appeared for the first time in the members of the phylum-Platyhelminthes.

ORGAN-SYSTEM LEVEL OF ORGANIZATION

An organ system is a collection of organs that perform a specific function. An organ system cannot live by itself and is dependent on other organ systems to form an organism. Organ systems of an organism are interdependent, i.e., they take each other's help to carry out various functions of the body. It is the highest level of organization among the animals and is exhibited by the triploblastic animals such as, nematodes, annelids, arthropods, molluscs, echinoderms and chordates.

All the tissues are derived from three primary germ layers. In triploblastic animals evolution of mesoderm resulted in structural complexity. The tissues are assembled into larger functional units called organs. Organs are usually composed of more than one kind of issue and have a more specialized function than tissues. Triploblastic animals have highly specialized sensory cells and nerve cells, which bing about a higher level of coordination and integration of the constituent tissues, organs and systems.

ORGANISM

Amongst the different levels, this one is the highest. This is the fifth and last level of organization. Organisms that are closely related can be grouped together under a single species.

These are the basic, 5 levels of organization of living beings. However, you can go ahead and add more levels like population, community, ecosystem, biome
and biosphere.

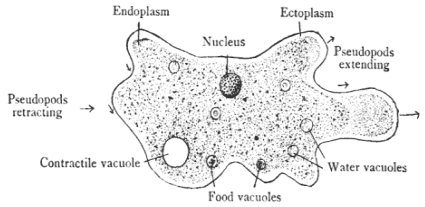
UNIT-V: ANIMAL KINGDOM
MODULE-20: PROTOZOA AND PORIFERA

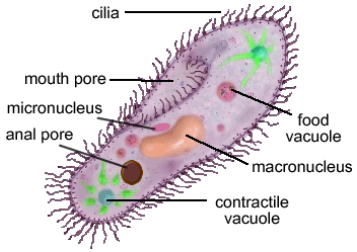
PHYLUM PROTOZOA

Study of Protozoans is called as Protozoology. Protozoa means "first animals". Hyman called these protozoans as acellular animals or noncellular organisms as cellular differentiation is not found in their bodies. So a protozoan can be defined as a mass of protoplasm which is not divided into cells but can carry on all the vital activities of life like all other metazoans. Anton Van Leeuwenhoek first discovered in 1671 the protozoans and called them as animalcules. Gold fuss (1817) coined the word "Protozoa" from the Greek words Protos = first and Zoon = animal.

GENERAL CHARACTERS

- Protozoans are small microscopic animalcules.
- They are cosmopolitan in distribution and live in sea water, fresh water and moist places. Some protozoans live as parasites on other organisms.
- The body is unicellular or a cellular.
- The body is naked or covered by a pellicle or a shell made of silica or calcium carbonate.
- They live solitarily or in colonies.
- Definite symmetry is not seen among protozoan's.
- Usually one nucleus is present. But in some protozons like ciliophorans two nuclei are present. Macronucleus carry the physiological activities while the micronucleus perform reproduction.
- Digestion is intracellular in food vacuoles. Nutrition is Holozoic or holophytic or saprozoic.
- The locomotion is by pseudopodia, flagella or cilia. They are absent in some parasites.
- Respiration is by diffusion through general body surface.
- The contractile vacuole may be present or absent, it helps in osmoregulation and excretion.
- The excretion is also by diffusion through general body surface or by contractile vacuoles
- The asexual Reproduction is by binary fission or multiple fission or budding.
- The sexual reproduction is by syngamy or conjugation.
- The nuclear reorganization takes place by conjugation, autogamy, endomixis.
- The life history may be complicated with alternations of generations.
- Encystment commonly occurs during unfavorable conditions and also helps in dispersal of organism.
- Protozoan's exhibit protoplasmic grade of organization.
- In protozoa, the somatoplasm and germplasm are not differentiated, hence they are called immortal.





CLASSIFICATION OF PHYLUM: PROTOZOA

The classification of protozoa is based on the nature of locomotory organelles. Protozoa is divided into two sub-phyla and six classes.

SUB-PHYLUM1: PLASMODROMA (OR SARCOMASTIGOPHORA)

1. Simple and primitive animals
2. Locomotory organelles are pseudopodia or flagella or may be absent
3. A single nucleus is present

CLASS-1: RHIZOPODA (OR SARCODINA)

1. Locomotion and ingestion of the food is by pseudopodia
2. Nutrition is holozoic
3. Encystment is common
   Ex: Amoeba, Entamoeba, Elphidium

CLASS-2: MASTIGOPHORA

1. Locomotion and food capture take place by one or more whip like flagella. Body is covered by pellicle
   Ex: *Euglena, Trypanosoma*

CLASS-3: SPOROZOA

1. All are parasitic
2. They are without locomotory organelles
   Ex: *Plasmodium*, Monocystis

CLASS-4: MYCETOZOA

1. They live in soil
2. They resemble fungi and commonly known as slime moulds
   Ex: *Dydyminum*

SUB-PHYLUM-II: CILIOPHORA

1. Locomotion is by cilia
2. Usually two types of nuclei are present
3. Sexual reproduction is by conjugation

CLASS-1: CILIATA

1. Body is covered by pellicle
2. Locomotion is by Cilia
   Ex: *Paramoecium, Vorticella*

CLASS-2: SUCTORIA

1. Cilia are present only in young stages and tentacles in adults
2. Food capture and ingestion of the food is by suctorial tentacles
   Ex: *Acinata*

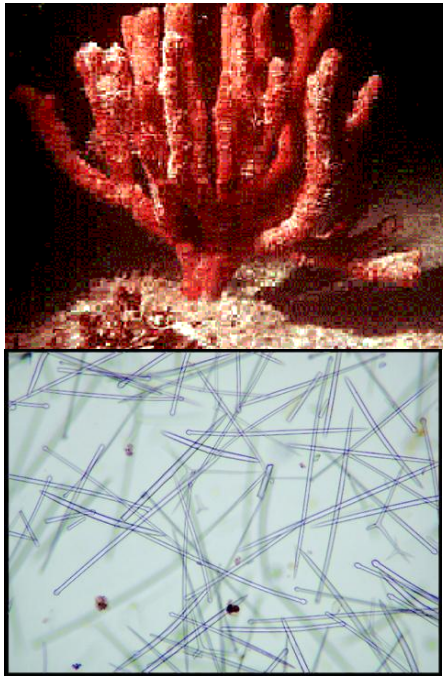
PHYLUM PORIFERA-(ANIMALS WITHOUT TISSUES)

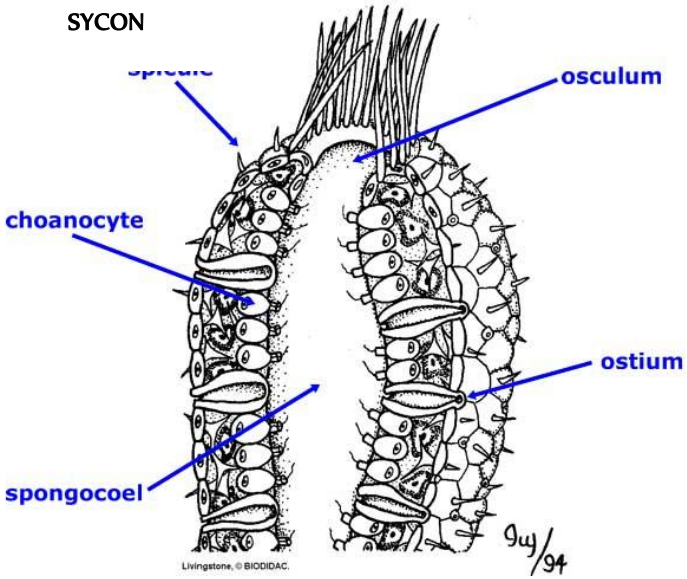
INTRODUCTION

Porifera (which means Pore-bearers) includes Sponges which are plant like primitive multicellular animals and have cellular level of organization. Cells of the body are not organized into definite tissues and organs. The study of sponges is called Parazoology.

GENERAL CHARACTERS

- Sponges are aquatic animals
- All are marine forms, except for the animals belonging to the family spongillidae which live in fresh water.
- Shape variable, vase-like, Cylindrical, tubular, globular, cushion shaped etc.
- They are sedentary organisms found attached to submerged rocks.
- Body is supported by skeleton made up of calcarious or siliceous spicules or proteinous spongin fibers or both.
- They are diploblastic. The outer dermal layer is made up of pinacocytes and inner Choanoderm layer is made up of choanocytes. In between these two layers is present non cellular, gelatinous mesenchyme having skeletal elements.
- They are without definite symmetry or show redial symmetry.
- The body surface is perforated by several pores (hence they are referred as pore bearers) called Ostia through which
- water enters the body and finally leaves through one or more openings, the Osculum.
- The Body cavity is called spongocoel. It opens to the outside through an osculum.
- Sponges are characterized by the presence of water canal system. It helps in nutrition, respiration, excretion and circulation.
- Digestive system is absent. Digestion is intracellular. Nutrition is Holozoic
- Respiration and excretion is by diffusion through body surface.
- Nervous system and sensory cells are absent.
- Some are hermaphrodite and some are unisexual.
- Reproduction is both by asexual or sexual methods.
- Asexual reproduction is by budding and by formation of gemmules.
- Sexual reproduction is by union of gametes.
- Fertilization is internal. Development of embryo is indirect type it includes Amphiblastula and paranchymula Larva.
- Sponges have high power of regeneration.





CLASSIFICATION OF PHYLUM PORIFERA

The phylum porifera is divided into 3 classes based on Skeleton

CLASS-1: CALCAREA

1. They are small sized calcareous sponges
2. Skeleton is composed of calcareous spicules
3. Larva is amphiblastula (sycon) or parenchymula (Leucosolena)
   Ex: *Sycon, Leucosolena*

CLASS-2: HEXACTINELLIDA

1. Glass sponges
2. Skeleton consists of six rayed silicious spicules or amphidiscs
   Ex: *Hyalonema, Euplectella*

CLASS -3: DEMOSPONGIAE

1. People sponges
2. Skeleton consists of silicious spicules other than six rayed spicules or sponging fibres or both
   Ex: *Cliona (*Boring sponge*)*
   *HIppospongia (*Horse sponge*)*
   *Spongilla (*Fresh water sponges*)*

CHECK POINTS

PROTOZOA

- First animals commonly called as animalcules
- Protoplasmic grade of organization
- Unicellular organisms
- Holozoic, Holophytic or Saprozoic nutrition
- Intracellular digestion
- Respiration and excretion is by diffusion
- Contractile vacuole helps in osmoregulation and excretion
- Pseudopodia, flagella and cilia are locomotor organelles.

PORIFERA

- Commonly called as sponges
- Cellular level of body organization
- Skeleton is represented by spicules
- Water canal system help in nutrition, respiration, excretion and circulation.
- Intracellular digestion
- Respiration and excretion is by diffusion
- Gemmules are asexual reproductive bodies.
- Amphiblastula and parenchymula are the larval forms found in sponges.

MULTIPLE CHOICE QUESTIONS

1. One of the following is not a locomotory organ in protozoa
   a. Flagella b. Pseudopodia c. Cilia **d. Setae**
2. Contractile vacuole is primarily ment for
   a. **Osmoregulation** b. Digestion c. Locomotion d. Excretion
3. Locomotion in Protozoa is performed by
   a. Pseudopodia b. Flagella c. Cilia d. **All the above**
4. Grade of organization in Protozoa
   a. Cellular grade b. Tissue grade c. Organ grade **d. Protoplasmic grade**
5. Nutrition in protozoa
   a. Holozoic b. Holophytic c. Saprozoic **d. All the above**
6. Protozoans are also called
   a. Unicellular b. Multicellular **c. A cellular** d. Prokaryote
7. The main criterion used in the classification of protozoa is
   a. Skeleton b. Nuclear organization c. **Locomotory organelles** d. Contractile vacuole
8. Water canal system is characteristic of
   a. Echinoderms **b. Sponges** c. Cnidarians d. Molluscs
9. Water canal system helps in
   a. Nutrition b. Respiration c. Excretion **d. All**
10. Asexual reproductive bodies found in sponges
    a. **Gemmules** b. Gametes c. Choanocytes d. Spicules
11. Digestion in sponges is
    a. **Intracellular** **b.** Extracellular c. Both d. None
12. Larva of the sponges

a. Grochidium **b. Amphiblastula** c. Paranchymula d. Both A & B

13. Respiration and excretion in Porifera takes place by

a. **Diffusion through body surface** b. Spicules c. Choanocytes d. Trichocytes

SHORT ANSWER QUESTIONS:

1. Describe the types of nutrition found in protozoa
2. What are the locomotary organelles found in protozoa
3. Explain the functions of water canal system of Sponges
4. Name the larval forms found in sponges
5. Describe spicules

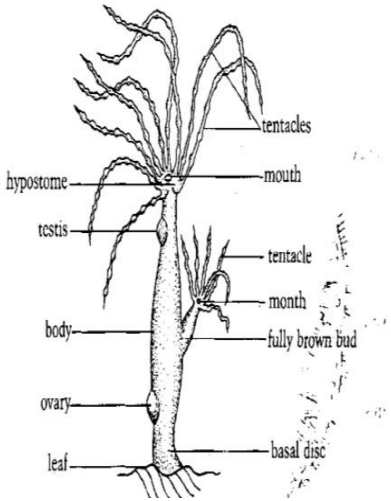
LONG ANSWER QUESTIONS:

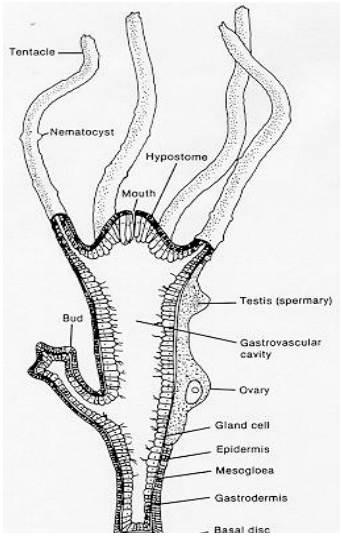
1. Write the general characters of the phylum protozoa
2. Write the general characters of phylum Porifera

UNIT-V
ANIMAL KINGDOM
MODULE-21: CNIDARIA AND CTENOPHORA

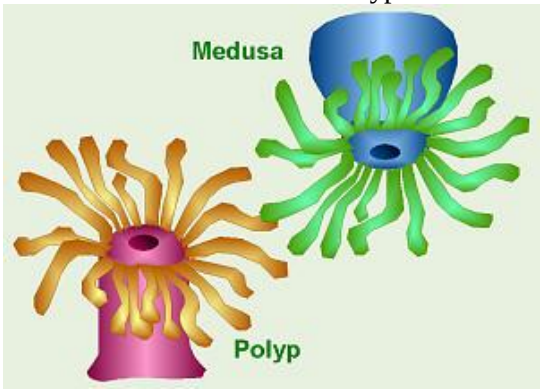
GENERAL CHARACTERS:

1. They are aquatic, mostly marine, few freshwater. They are sedentary or free-swimming, and solitary or colonial.
2. They are diploblastic with an outer ectoderm and inner endoderm and in between these two layers there is a gelatinous mesoglea.
3. Cnidarians exhibit tissue grade of organization.
4. The basic body shape of the cnidarians is a sac-like.
5. They are radically symmetrical or biradially symmetrical.
6. They have a central gastro-vascular cavity with a single opening known as hypostome. This serves as both mouth and anus. They are acoelomates





7. Digestion is both extracellular and intracellular.
8. Respiration and excretion are by diffusion through body wall.
9. Circulatory system is absent.
10. Mouth is surrounded by tentacles they have abundant Cnidoblasts cells, they are generally distributed throughout the epidermis and gastrodermis. They help in defence, adhesion and capture of prey.
11. They exist in two different forms – Polyp and Medusa



12. The polyp is asexual phase in the life cycle of coelenterates. It is cylindrical in shape and attached to the substratum with aboral end.
13. The medusa is a sexual stage in the life cycle of coelenterates and is flattened in appearance or umbrella shaped with the mouth oriented downward.
14. The life cycle alternates between an often sessile polyp stage and a free-swimming medusa stage. The existence of two distinct forms such as this is known as polymorphism.
15. Reproduction is by asexual (budding or fission) and sexual (gamets) methods.
16. Development exhibits planula larva.

17. Nervous system is in a Primitive stage. Nerve cells present in between the two body layers forms a nerve net.
18. Sense organs like statocysts are present, in medusoid form; it helps the animals in balance.
19. They form corals.

CLASSIFICATION OF PHYLUM-CNIDARIA

Phylum Cnideria is classified into three classes, basing on the presence or absence of Polyp and medusa stage.

CLASS -1: HYDROZA

1. Consists of both marine and fresh water Cnidarians
2. Mesogloea is devoid of cells
3. Polyps are predominant in life cycle
4. Medusa is umbrella like
5. Coelenteron is undivided
6. Polymorphism is common
7. Reproductive cells are usually ectodermal in origin and directly discharged into the water.
   Ex: *Hydra,Obelia, Physalia*

CLASS -2: SCYPHOZOA

1. Completely marine
2. Commonly called as jelly fishes
3. Polyp stage is reduced or absent
4. They are medusoid in form. Mouth is surrounded by four oral arms
5. Coeleteran is divided into four chambers
6. Mesoglea contain amoebocytes
7. Germ cells are derived from the endoderm.
   Ex: *Aurelia, Rhizostoma*

CLASS-3: ANTHOZOA

1. They are commonly referred as sea anemones
2. All are marine
3. Only polyp stage is present and medusa is absent
4. Coelenterons is divided into several compartments by vertical septa called mesenteries
5. Mesogloea is well developed with fibrous connective tissue.
6. Gonads are formed from endoderm
7. Epidermis in majority of anthozoa secretes a horny or calcareous skeleton
8. Fertilization is external in water. Planula larva is seen in development
   Ex: Adamsia (Sea Anemone), Gorgonia (Sea Fan), Pennatula (Sea pen)

CHECK POINTS:

- Diploblastic
- Tissue grade of body organization
- Gastrovascular cavity is present
- Extracellular and intracellular digestion
- Cnidoblasts help in defence, adhesion and food capture
- Exhibit polymorphism
- Planula larva is present in the development
- Statocyst help in balance

ADDITIONAL INFORMATION:

Scientific name	Common name
Physalia	Portuguese Man Of War
Aurelia	Moon Jelly
Alcyonium	Dead Man's Finger
Corallium Rubrum	Precious Coral
Gorgonia	Sea Fan
Pennatula	Sea Fan
Tubipora	The Organ Pipe Coral
Meandrina	Brain Coral
Astrea	Stone Coral
Fungia	Mushroom Coral

1. Study of coelenterates is called cnidology.
2. Leuckart used the term coelenterate. Barnes used the tern cnidaria
3. Individual of a coelenterate colony is termed as zooid
4. Occurrence of a specie in different forms which are structurally and functionally different is called Polymorphism. It serves for division of labour
5. Coral is a deposition of lime or $Caco_3$ formed by coelenterates . coral colonies grow enormously is size by budding of the polyps and often form extensive masses known as coral reefs

PHYLUM: CTENOPHORA

GENERAL CHARACTERS

1. They are commonly known as 'Sea walnuts' or comb jellies or sea gooseberries
2. They are marine animals with transparent and flat body shape
3. They are acoelomate, radially symmetrical, diploblastic organisms with tissue level of organization. Mesoglea is present between the ectoderm and endoderm layers
4. The body bears eight external rows of ciliated comb plates, which help in locomotion, hence the name 'Ctenophora'
5. Polyp phase is absent
6. Cnidoblasts are also absent
7. Gastrovascular cavity is branched and open to the exterior through mouth. Lassocells or colloblasts are present help in food capture. Digestion is both extracellular and intracellular
8. Sexes are not separate. They reproduce only by sexual reproduction. Fertilization is external
9. Development is indirect includes cydippid larva.
10. They exhibit Bioluminescence

Ex: *pleurobrachia*, *Hormiphora*

CLASSIFICATION

Phylum Ctenophora is classified into two classes

CLASS-1: TENTACULATA

The adults possess two aboral tentacles

Ex: *Pleurobrachia*

CLASS-2: NUDA

Tentacles are absent even in the larval stage

Ex: Beroe

CHECK POINTS

1. Commonly called as sea walnuts or combjellies or sea goose berries
2. Acoelamate, diploblastic
3. Comb plates help in locomotion
4. Lassocells help in food capture
5. Only sexual reproduction
6. Cydippid larva is present during development
7. Exhibit Bioluminescence

MULTIPLE CHOICE QUESTIONS

1. Planula larva can be seen in the development of
   A. Sponges **B. Cnidarians** C. Flat worms D. Round worms
2. Statocysts present in the medusa help in
   A. Excretion B. Respiration C. Adhesion **D. Balance**
3. Cnidoblast cells help in
   A. Defence B. Adhesion C. Capture of pray **D. All**
4. One of the following group of animals exhibits polymorphism
   A. Sponges **B. Cnidarians** C. Round worms D. Flat worm
5. Type of body organization found in cnidaria
   A. Tissue grade of organization
   B. Organ grade of organization
   C. Organ-system grade
   D. Cellular grade

SHORT ANSWER QUESTIONS:

1. Explain the functions of cnidoblast cells
2. What is polymorphism
3. What is the difference between Polyp and Medusa
4. What is alternation of generations

LONG ANSWER QUESTIONS:

1. Explain the General characters of Phylum Cnidaria
2. Explain the general characters of phylum ctenophora

UNIT-V: ANIMAL KINGDOM
MODULE-22: PLATYHELMINTHES AND NEMATHELMINTHES

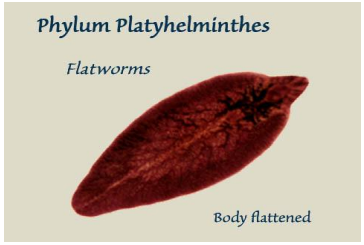
PHYLUM: PLATY HELMINTHES
(PLATYS=FLAT; HELMES=WORM)

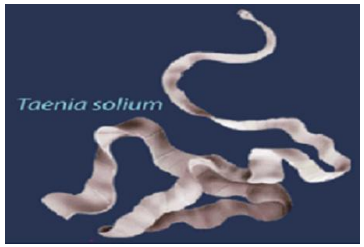
INTRODUCTION

The Platyhelminthes include free-living flatworms, like the planarians, and the parasitic tapeworms and blood flukes.

GENERAL CHARACTERS

- Commonly called as flat worms. Mostly parasitic but some are free living. Free living forms are mainly aquatic and mostly marine.





- The body is leaf like or ribbon like dorsoventrally flattened.
- Flatworms are the first organ grade animals to have well developed organs and organ systems.
- They are the first bilaterally symmetrical individuals.
- Definite coelom is absent. Space between the body wall and alimentary canal is filled with loose connective tissue called mesenchyme. Hence they are acoelomate animals.
- Segmentation is absent.
- Body is usually covered by tough resistant membrane called cuticle in parasitic form.
- They are the first triploblastic animals, to have three germ layers, outer ectoderm, inner endoderm and mesoderm in between.
- Definite alimentary canal is present (absent in cestoda).
- Circulatory system is absent.
- Excretory system is present. Protonephridia (Flame cells) are present help in osmoregulation and excretion.
- Respiratory system is absent. It is anaerobic type in parasitic forms.
- Nervous system is primitive and is ladder like
- Sense organs like ocelli and ciliary pits are present in turbellarians.
- Skeleton is completely absent. However hooks, spines and suckers are present which act as adhesive organs.
- Reproduction is both asexual (in turbellarians)and sexual.
- They are hermaphrodite. Definite copulatory organs are present.
- Cross fertilization is common in platyhelminthes. Fertilization is internal.
- Development of embryo is direct without larvae or indirect with larval stages like miracidium, sporo cyst, Redia, cercaria etc
- Polyembryony is common in the life history of liver flukes and blood flukes.

CLASSIFICATION OF PHYLUM PLATYHELMINTHES

It is classified into three classes

CLASS-1: TURBELLARIA

1. Most of them are free living flat worms
2. Cilia are present on epidermis. Rhabdites are rod like structure forming mucous
3. Body is flat and leaf like
4. Development is indirect involves Muller's larva
   Ex: Dugesia

CLASS 2: TREMATODA

1. All are parasitic
2. Body is flat and leaf like, commonly called flukes
3. Cuticle is present covering the body
4. Body bears two suckers, an oral and a ventral (acetabulum) for attachment.
5. Mouth is auterior and the intestine is bifurcated.
6. These are hermaphrodites.
   Ex: *Fasciola*
   Schistosoma

CLASS 3: CESTODA

1. All are endoparasites
2. Body is elongated and ribbon like, commonly called Tape worms
3. Body is covered by protective syncytial tegument
4. Anterior end is distinct, formed by scolex which bears rostellum and suckers. Restellum bears hooks
5. Mouth and digestive system are totally absent
6. These are hermaphrodites
   Ex: *Taenia solium*
   Echinococcus

CHECK POINTS

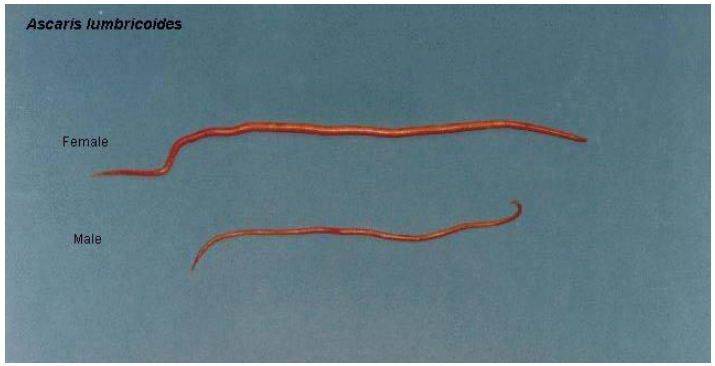
- Commonly called as flat worms
- Organ grade of body organization
- Triploblastic animals
- Flame cells help in osmoregulation and excretion
- Hooks, spines and suckers present help in adhesion
- Acoelomate animals
- Hermaphrodite animals

ADDITIONAL INFORMATION

1. Study of flat worms and round worms is known as Helminthology
2. Gegenbaur coined the terms platyhelmenthes and Nemat helminthes
3. First time, Bilateral symmetry, Triploblastic condition, organ system grade of organization, excretory organs, Reproductive organs and Brain appeared in this Phylum.
4. The formation of more than one embryo from a single animal zygote is called polyembryony.

PHYLUM: NEMATHELMINTHES (ASCHELMINTHES)

They are commonly called as round worms. They are also known as nematodes.



GENERAL CHARACTERS

1. They are triploblastic, unsegmented, bilaterally symmetrical cylindrical worms.
2. They have organ system grade of body organization.
3. These are mostly parasitic but few are free living (Rhabditis).
4. Body wall consists of resistant cuticle, epidermis and longitudinal muscles. Circular muscles are absent.
5. They are pseudocoelomate animals. Body cavity is not lined by mesoderm.
6. Alimentary canal is complete with mouth, muscular pharynx, intestine as well as anus. Digestion is both extracellular and intracellular.
7. Respiration is by diffusion through the body surface.
8. Circulatory system is absent.
9. Excretory system includes gland cells or H – shaped excretory canals or both.
10. Nervous system consists of circum pharyngeal nerve ring. (around the pharynx) and six longitudinal nerve cords.
11. Sense organs like papillae, amphids and phasmids are present.
12. They are unisexual. They exhibit sexual dimorphism. Males are smaller than females and have a curved posterior end, cloaca and copulatory spicules. Fertilization is internal. There is no Asexual reproduction. Development includes four moults.

CHECK POINTS

- Commonly called as round worms
- Organ system grade of body organization
- Triploblastic animals
- Pseudocoelomate animals
- Respiration is by diffusion
- No circulatory system
- H – shaped excretory canals are present
- Exhibits sexual dimorphism
- Development includes four moults.

CLASSIFICATION OF PHYLUM NEMATHELMINTHES

CLASS: APHASMIDIA

Mostly free living, phasmids are absent. There are no excretory canals.

Eg: Trichinella, Greeffiella

CLASS: PHASMIDIA:

Mostly parasitic. Phasmids are present. Excretory canals are present

Eg: Ascaris, Ancylostoma, wuchereria, Enterobius.

MULTIPLE CHOICE QUESTIONS

1. First triploblastic animals
   A. Sponges B. Cnidarians **C. Platy helminthes** D. Nemathelmenthes
2. In flat worm flame cells help in
   A. Digestion B. Excretion C. Osmoregulation **D. B & C**
3. Polyembryony is commonly seen in
   A. Liver flukes B. Blood flukes C. Taenia **D. A & B**
4. Pseudocoelomates animals
   A. Sponges B. Cniderians **C. Round worms** D. Flat Worms
5. H – Shaped excretory canals are found in
   A. **Round worm** B. Flat worm C. Blood flukes D. Coelenterates
6. One of the following characteristic feature is not correct for nemathelminthes
   A. Elongated cylindrical body
   B. Hermophroditism
   C. Pseudocoelomate
   D. Organ system grade of body organization

7. Organ and organ system developed for the first time in phylum
   A. Cnidarians **B. Platyhelminthes** C. Annelida D. Porifera

SHORT ANSWER QUESTIONS:

1. What is alternation of generations
2. Explain the functions of flame cells

LONG ANSWER QUESTIONS:

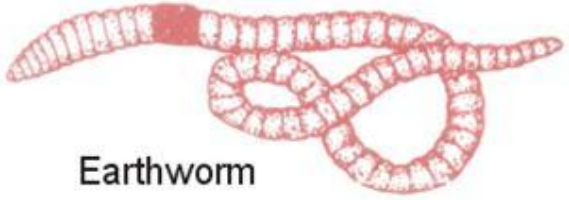
1. Write down the General characters of Phylum platy helminthes
2. Write the General characters of Phylum Nemat helminthes

UNIT-V: ANIMAL KINGDOM
MODULE-23: ANNELIDA

Lamarck (1758) coined the term Annelida from the Latin word annelus which means 'ring'.

GENERAL CHARACTERS:

- They are found in all habitats, fresh water, marine and on land.
- They are triploblastic with three germ layers namely ectoderm, endoderm and mesoderm. They exhibit bilateral symmetry.
- Body is usually segmented. This segmentation is seen both externally and internally. Each segement is called a metamere. Various organs are arranged metamerically in the body. This segmentation is called metameric segmentation.
- Body is covered with thin and nonchitinous cuticle which is protective in function.
- These are the first true ceolomate animals, ceolom is formed by splitting of mesodermal cells. Coelom is filled with coelomic fluid which acts as hydraulic skeleton.
- In leeches coelom is filled with botryoidal tissue.
- Chitinous bristles called setae present on all metameres helps in locomotion. Setae are absent in Leeches.
- Alimentary canal is a straight muscular tube with digestive glands.
- Excretion is carried as by segmentally arranged nephridia.
- Chloragogen tissue acts similarly to the vertebrate liver. It is a site of amino acid metabolism and converts excess carbohydrates into energy storage molecules of fat and glycogen.
- Respiratory is by skin (cutaneous respiration). In some polychaetes gills help in respiration.
- Circulatory system is closed type as blood flows in closed blood vessels. Blood is red in color. The blood contains pigments like hemoglobin or chlorocruorin or hemoerythrin. In leech open circulatory system is present. No RBC, free amoeboid blood corpuscles are present.
- Nervous system is well developed consists of a circum pharyngeal nerve ring and a double ventral nerve cord with segmental ganglia.
- Sexes may be separate (e.g: Nereis) or united (e.g: Earth worm, Leech).
- Fertilization is either external or internal.
- Development is either direct (e.g: Earthworm, Leeches) or indirect (e.g: polychaetes) with a larval form called Trochophore.



Annelida

Nereis

CHECK POINTS

- Triploblastic animals
- Body with metameric segmentation
- First true coelomate animals
- In leach coelom is filled with Botryoidal tissue
- Nephidia help in excretion
- Closed type of circulatory system
- Chloragogen tissue is similar to vertebrate liver
- Trochophore larva is present in the development

PHYLUM-ANNELIDA

Phylum Annelida is classified into three classes.

CLASS: POLYCHAETA
(POLY = MANY; CHACTAE = SETAE)

1. Commonly known as Bristle worms
2. All are marine
3. Clitellum is absent
4. Head is distinct with sense organs like eyes, tentacles and palps.
5. Parapodia helps in locomotion and respiration
6. Sexes are separates (Dioecious). Gonoducts are absent. Fertilization is external.
7. Development includes Trochophore larva
   Eg: Nereis, Aphrodite. (Sea mouse)

CLASS: OLIGOCHAETA
(OLIGOS = FEW; CHACTA = SETAE)

1. Setae are few in number, helps in locomotion.
2. Clitellum is present forms a cocoon during the breeding season.
3. District head is absent.
4. All are hermaphrodites (monoecious)
5. Development is direct

Eg: Pheretima, Tubifex

CLASS: HIRUDINEA

1. This class includes leeches. Body is dorsoventrally flattened with definite number of segments. Internal segmentation is absent
2. Blood sucking ecto parasites
3. Setae and parapodia are absent. Suckers help in locomotion.
4. Clitellum develops only during reproductive period.
5. Coelom is filled with botryoidal tissue
6. Development in direct.
   Eg: Hirudineria. (Fresh water leech)

MULTIPLE CHOICE QUESTIONS

1. Annelidan larva is called
   A. Glochidium B. Tornaria **C. Trochophore** D. Miracidium
2. In Annelida, the typical locomotory organs are
   A. Jointed feet B. Suckers **C. Setae** D. Tentacles
3. The term Annelida was coined by
   A. Lankester **B. Lamarck** C. Von siebold D. Aristotle
4. Which of the following is not Annelidan character
   A. Triploblastic B. Metameric segmentation
   C. Pseudocoelum D. Nephridia present
5. The true coelom of annelids is situated between
   A. Ectoderm and mesoderm
   B. Mesoderm and Endoderm
   C. Two endoderms
   D. Two mesoderms
6. Hydraulic skeleton is present in

A. Arthropods **B. Annelids** C. Mosquito D. Echinoderms

7. First true coelomate animals
   A. **Annelids** B. Arthropods C. Nematodes D. Platy helminthes

SHORT ANSWER QUESTIONS:

1. Describe chloragogen tissue?
2. Describe the circulatory system of annelids?
3. Describe the coelom of annelids?

LONG ANSWER QUESTIONS:

1. Write the general characters of the phylum Annelida?

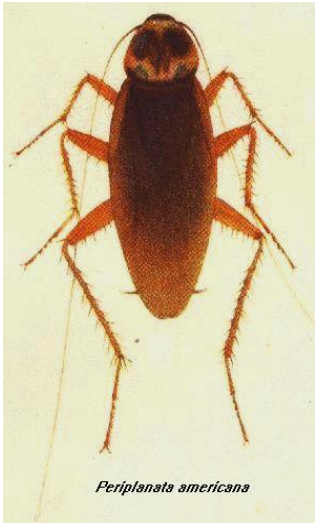
BIOLOGY COURSE: PUC-I, SEMESTER-I
UNIT-V: ANIMAL KINGDOM
ARTHROPODA

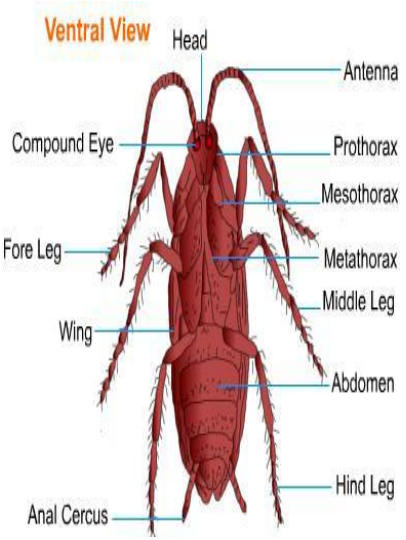
INTRODUCTION

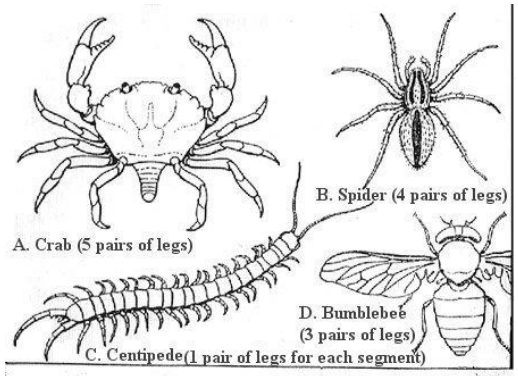
Arthropoda is the largest phylum in the Animal Kingdom. It accounts for 80% of the animal species in the world. Cosmopolitan in distribution. The term Arthropoda (arthros: Jointed; podos: feet) was Coined by Von Siebold. All the animals included under this phylum have jointed appendages. They have high economic importance.

GENERAL CHARACTERS

1. Arthropods occur in all types of habitats i.e., fresh, marine and brackish water besides the terrestrial environment.
2. Animals are triploblastic, bilaterally symmetrical and metamerically segmented.
3. Body is divided into head, thorax and abdomen. In majority of animals the head and thorax are fused to form cephalothorax.
4. Body is covered with thick chitinous cuticle forming an exoskeleton.
5. A unique phenomenon called moulting or ecdysis is present in arthropods, where in the exoskeleton is shed off at regular intervals.
6. Body is divided into segments each segment comprises of paired lateral and jointed appendages.
7. Animals are coelomates and the body cavity is called as haemocoel. True coelom is reduced.
8. The digestive system is well developed with digestive glands. Mouth is surrounded by mouth parts. Mouth parts are differently modified in different animals to suit feeding habits.
9. The circulatory system is of open type with dorsal heart and arteries. Blood is colour less due to the absence of hemoglobin. It is called as haemolymph. Blood flows in sinuses.
10. The nervous system consists of dorsal brain, oesophageal nerve ring and a double ventral nerve cord.
11. The respiratory organs are gills, tracheae or book lungs, or by general body surface.
12. Sensory organs are simple eyes or compound eyes and antennae
13. With hairs.
14. In arthropods excretory organs are malpighian tubules or green glands.
15. Sexes usually separate and sexual dimorphism is present.
16. Fertilization usually internal. Development may be direct or indirect with a larval and pupal stages. Metamorphosis occur during development.







Principal types of animals evolved in the phylum Arthropoda by different groupings of the segments

CHECK POINTS

- Largest phylum in the animal kingdom
- Triploblastic and bilaterally symmetrical animals
- Body with jointed appendages
- True coelom is reduced
- Moulting or ecdysis is common in arthropods
- Mouth parts are present and modified differently to suit feeding habits
- Open type circulatory system
- Malpighian tubules or green glands help in excretion.

CLASSIFICATION

Phylum: Arthropoda is classified into three subphylum.

SUB-PHYLUM I: TRILOBITA:

They are extinct marine arthropods. Body is divided into a median and two lateral lobes by longitudinal furrows, hence the name trilobite.
Eg: Triarthrus

SUB-PHYLUM II: CHELICERATA:

Body is divided into cephalothorax (with 6 segments)and abdomen (with 13 segments). Six pairs of appendages are present of which first pair is called chelicerae with claws ment for feeding. Antennas and Jaws are absent. This sub-phylum consists of two classes.

CLASS-I: XIPHOSURA

1. The cephalothorax is convex or dome shaped with 2 pairs of eyes on the dorsal side.
2. Mouth is on the ventral side surrounded by 6 pairs of appendases
3. Coxal glands are the excretory organs
   Eg: Limulus (King crab)

CLASS-II: ARACHNIDA

Terrestrial animals. Cepholothorax bears chelicerae and strong well built pedipalpi and 4pairs of Walking legs. Antennae are absent. Respiration is by book lungs or tracheal tubes. Malpighian tubules and coxal glands help in excretion.
Development is direct.
Eg: Palamnaeus (scorpion), Aranea (Spider)

SUB-PHYLUM III: MANDIBULATA:

1. All these animals have mandibles.
2. Body consists of head and trunk
3. 1 or 2 pairs of antennae and walking legs are present
4. Respiratory organs are gills or trachea

This sub – phylum consists of four classes

CLASS-I: CRUSTACEA

Includes prawns, crabs, lobsters, cray fishes.

1. Body is divisible into head, thorax and abdomen. In some head and thorax unite to form cepholathorax.

2. 5 pairs of cephalic appendages namely antennules, antennae, mandibles and 2 pairs of maxilla are present.
3. 8 pairs of thoracic and 6 pairs of abdominal appendages are present. The appendages are biramous. Excretory organs are green glands
4. Free swimming nauplius stage is present in the life cycle
   Eg: Palaemon (Fresh water prawn)
   Sacculina (root-headed barnacle)

CLASS-II: CHILOPODA

Includes centipedes

1. Commonly called as centipedes
2. Body dorsoventrally flattered. Head is formed by six segments and trunk by many segments
3. Head bears two pairs of maxillae
4. One pair of Walking legs in each segment except the last two segments of the trunk. First pair of legs of the trunk bear poisonous claws into which poisonous glands open
5. Respiration by tracheal tubes
   Eg: scolopendra

CLASS-III: DIPLOPODA

Inclues millipedes. Body consists of head and trunk. Head bears paired antennae, mandibles and maxillae. Each trunk segment bears two pairs of legs. Respiration is by tracheae. Poisonous glands and claws are absent.

Eg: Julus

CLASS-IV: HEXAPODA OR INSECTA

1. Body with head, thorax and abdomen.
2. Thorax with 3 pairs of jointed legs, two pairs of wings.
3. Body is divisible into head, thorax and abdomen
4. Head bears a pair of antennae, a pair of mandibles, two pairs of maxillae and a pair of compound eyes
5. Thorax consists of three segments and each segment bears a pair of jointed Walking legs. Thorax also bears one or two pairs of wings
6. Abdomen is without appendages
7. Excretion is done through malpighian tubules
8. Respiratory organs are tracheae
9. They are Uricotelic
   Eg: *Musca, Periplaneta.*

MULTIPLE CHOICE QUESTIONS

1. The blood of Arthropods is also known as
   A. Lymph B. Karyolymph **C. Haemolymph** D. Perilymph
2. Arthropods are characterized by the presence of
   A. Compound eyes **B. Jointed legs** C. Exo skeleton D. Antenae
3. Green glands are concerned with
   A. Respiration B. Reproduction **C. Excretion** D. Digestion
4. The largest phylum in the animal kingdom
   A. Mollusca B. Annelids **C. Arthropoda** D. Chordata
5. Who has used the term Arthropods for the first time
   A. Bur mister **B. Von siebold** C. Aristotle D. Lamarck
6. Respiratory organs found in Arthropods
   A. Gills B. Book lungs C. Trachea **D. All**

SHORT ANSWER QUESTIONS

1. What is ecdysis?
2. Name the respiratory organ found in arthropoda?

LONG ANSWER QUESTIONS

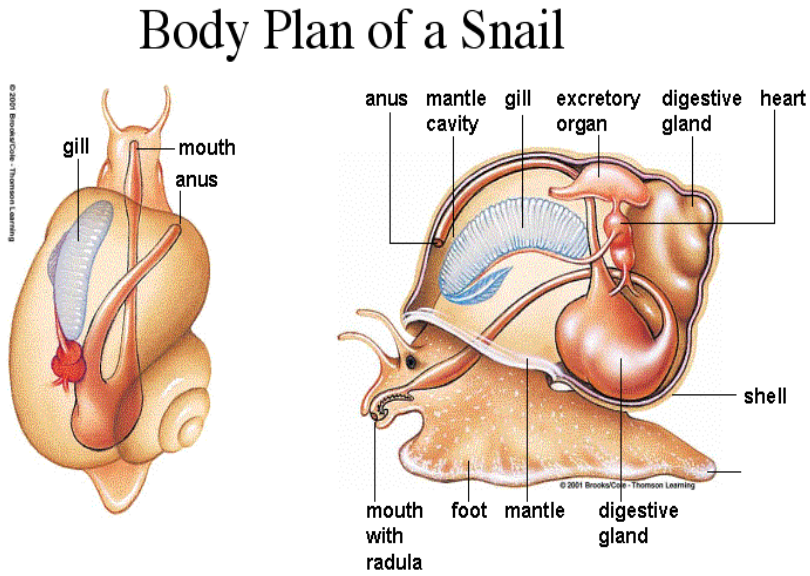
1. Write the general characters of the phylum Arthropoda?

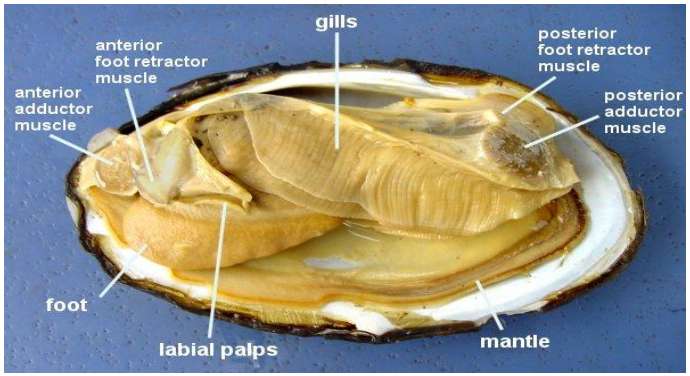
UNIT-V: ANIMAL KINGDOM
MODULE-25: MOLLUSCA AND ECHINODERMATA

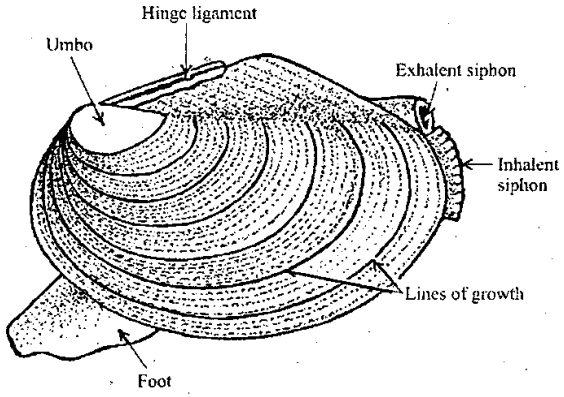
Mollusca is the second largest phylum in the Animal kingdom. They are commonly known as "Soft bodied animals" (Mollis = Soft). The main character of molluscs is the possession of shell.

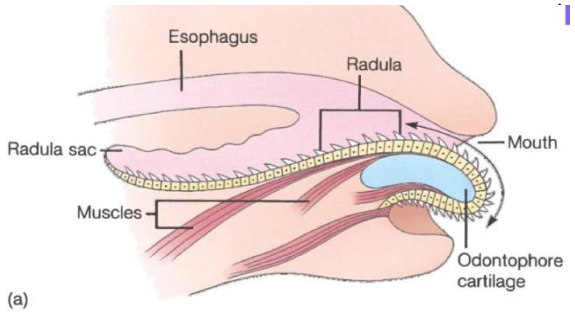
GENERAL CHARACTERS:

- They are mostly marine species, some are freshwater forms and some live on land.
- All are bilateral symmetrical, triploblastic, unsegmented and true coelomates.
- Generally body is divisible into head, visceral mass and foot. Foot helps in locomotion.
- Body is soft, covered by thin mantle, which encloses the various body parts. The space present between mantle and the body is called mantle cavity.
- Important character of mollusca is the presence of shell made up of calcium carbonate. Shell is secreted by the mantle. The shell may be either external or internal and in some shell is absent.
- Body cavity is haemocoel. True coelom is reduced and is limited to the space around the heart, gonads and kidneys.
- Digestive tract is complete. In the buccal cavity, except in bivalves, there is present a rasping organ called radula with transverse rows of chitinous teeth. Anus opens into the mantle cavity. A large digestive gland called hepato pancreas is present and helps in digestion and absorption.
- Circulatory system is an open type and blood flows in lacunae. A dorsal heart is present. Blood contain a respiratory pigment called haemocyanin.
- Usually excretory organs are Metanephridia but in some they are bojanus and Kerb's organ in fresh water mussel.
- The Nervous system is well developed with a circumesophageal ring and paired cerebral, pedal, pleural and visceral ganglion. These ganglia are interconnected by connectives and commisures.
- The special sense organ called osphradium is present, which tests the quality of water.(Which occurs in the bivalves and the gastropods). In addition to osphradium, eyes, tentacles, statocyst are present which perform different functions.
- Sexes are separate though some are hermophrodites.
- Fertilization is internal or external.
- Development is direct or indirect.
- There are three types of larva – trochophore, veliger (Pila) and glochidium (unio).









CHECK POINTS

- Soft bodied animals.
- Presence of shell is the characteristic feature
- True coelomates
- Foot help in locomotion
- Body cavity is Haemocoel
- Radula is present in the buccal cavity
- Hepato pancreas help in digestion and absorption
- Osphredium test the quality of water.

CLASSIFICATION OF PHYLUM-MOLLUSA

Phylum Mollusca is divided into the following classes

CLASS 1: APLACOPHORA

1. These are primitive forms with worm like body
2. They are without foot and shell
3. Body is covered by mantle provided with calcareous spicules
4. Simple radula is present
5. Eyes, statocyst and tentacles are absent
   Ex: *neomenia, chaetoderma*

CLASS 2: POLYPLACOPHORA

1. These animals are commonly called as Chitons
2. They are bilaterally symmetrical and dorso ventrally flattened
3. Shall is dorsal and made up of 8 calcareous plates
4. Foot is on ventralside
5. Trochophore larva is present in the life cycle
   Ex: *Chiton, Lepidopleurida*

CLASS 3: MONOPLACOPHORA

1. Body is bilaterally symmetrical with dome shaped mantle

2. Shell is present on dorsal side as a single piece.
3. A flat foot is present on the ventral side
4. 5 to 6 pairs of gills are present
5. 6 pairs of nephridia and 2 gonads are seen
6. These forms show internal segmention
   Ex: *Neopilina galathea*

CLASS 4: SCAPHOPODA

1. These are commonly called as tusk shells or tooth shells
2. The body of these forms is seen with tubular shell. The tube is open at both ends.
3. Foot is cone like and useful for digging
4. Eyes, tentacles, gills and atria are absent
   Ex: *Dentalium, Pulsellum*

CLASS 5: GASTROPODA

1. This class includes snails and slugs. These are asymmetrical forms.
2. Shell may be present or absent. If present it is univalved and spirally coiled.
3. The torsion (coiling) of body mass is seen in the development of some of these forms
4. Eyes, tentacles and radula are present. A large flat foot is present
5. Veligar larva is seen during development
   Ex: *Pila, Aplysia*

CLASS 6: PELECYPODA OR BIVALVIA

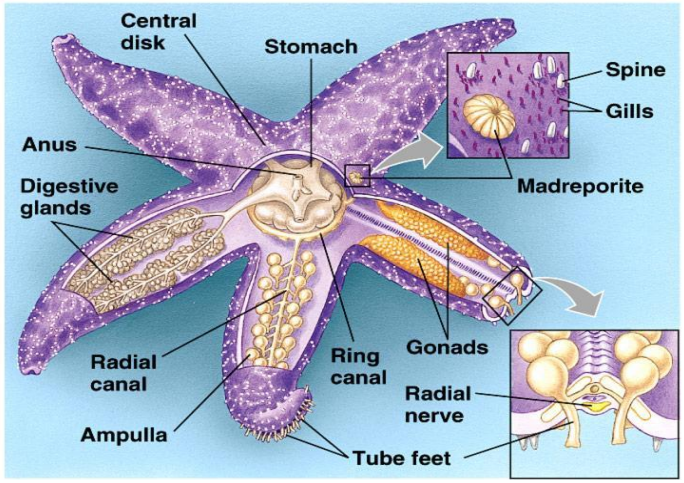
1. This class includes mussels, oysters, clams etc
2. These forms have laterally compressed body.
3. This body is enclosed in a bivalve shell
4. Head, tentacles, eyes, Jaws and radula are absent
5. Statocyst and osphradia are present
6. They are usually dioecious. Veligar or Glochidium larva occurs in developemtn
   Ex: *Mytilus, Unio*

CLASS 7: CEPHALOPODA

1. This class includes cuttle fishes, squids, octopuses etc
2. They are bilaterally symmetrical with dorsoventrally elongated body
3. The shell may be external or internal or absent
4. The head is distinct and large with well developed eyes
5. Radula is present
6. Ink gland and duct are present in some forms in mantle cavity. It emits cloudy coloured substance for protection
7. These are marine free swimming forms
   Ex: Sepia, Nautilus, octopus

ECHINODERMATA
(ECHINOS=SPINY; DERMA=SKIN)
GENERAL CHARACTERS

- All Echinoderms are exclusively marine animals with radial symmetry and adults show pentamerous symmetry.
- All of them are free living and none is parasitic. They are triploblastic and true coelomates.
- Body is differentiated into oral and aboral surfaces. The side on which mouth is present is named as oral surface.
- Body is covered by spines so they are called as spiny skinned animals.
- Spines are protective in function.
- Spines are modified into pedicellariae in some animals. Pedicellariae keep the body surface clean.
- A calcareous endoskeleton is present in the form of a shell or test or ossicles.
- Presence of water vascular system is the most characteristic feature of Echinoderms. It is originated from coelom. It consists of a system of canals and tube feet. A perforated plate called madreporite allows sea water into the canals. Tube feet help in locomotion, food capture, gas exchange and excretion.
- Alimentary canal is mostly a coiled tube with mouth on the lower side and anus on the upper side.
- Respiratory organs include dermal branchiae (star fish), peristomial gills (sea urchins), genital bursa (Brittle stars), respiratory trees (holothurians)
- Circulatory system is reduced and is open type without heart and blood vessels. It is also called as a haemal system.
- Excretory organs are absent; it is by diffusion through general body surface.
- Nervous system is poorly developed consists of circum oral ring and radial nerves. Brain is absent.
- Sense organs are poorly developed. They are in the form of eyespots, statocysts etc.
- Sexes are usually separate. Reproduction is by sexual method only.
- Fertilization is external and takes place is sea water.
- Development usually indirect, includes free swimming larvae namely Bipinnaria, Brachiolaria, ophiopluteus, Echinopluteus etc.



CHECK POINTS

- Spiny skinned animals.
- Exclusively merine
- Adults with pentamerous symmetry
- Water vascular system is present
- Pedicellariae keep the body surface clean.
- Circulatory system is also called as haemal system.

- Only sexual reproduction.

CLASSIFICATION OF PHY-EHINODERMATA

Phylum Echinodermata is classified into two sub-phyla namely
1. Pelmatozoa and
2. Eleutherozoa

SUB-PHYLUM 1: PELMATOZOA

1. They may be sessile or free swimming
2. Mouth and anus are present on the oral surface
3. Madreporite is absent
4. This subphylum includes only one class

CLASS 1: CRINOIDEA

1. This class includes sea lilies and feather stars
2. Mouth and anus are present on the oral side
3. Each arm divides into two, thus appearing as though it has ten arms
4. These is no madreporite. Tube feet are without sukers.
5. Ciliated ambulacral grooves are present on the oral side
6. Pentacrinoid larva is seen in the life history
   Ex: *Antedon, Neometra*

SUB-PHYLUM –II: ELEUTHEROZOA

1. Free moving organisms
2. Mouth is directed downwards
3. Madroporite is present
4. Ambulacral grooves are closed
5. This subphylum includes four classes.

CLASS 1: ASTEROIDEA

1. This class includes star fishes or sea stars
2. The body is compressed oro-aborally and flattened
3. They have five radiating arms with a central disc.
4. Mouth is present on the oral surface
5. Ambulacral grooves are open
6. The anus and madreporite are situated aborally
7. The tube feet are with suckers and pedicellariae are present
8. Development includes bipinnaria and brachiolaria larva
   Ex: *Asterias, Astropecten*

CLASS 2: OPHIUROIDEA

1. This class includes brittle stars, serpent stars, basket stars etc
2. They are star like with sharply marked arms from the central disc
3. Ambulacral grooves are closed
4. Tube feet lack suckers
5. Madraporite is on the oral surface
6. Anus and pedicellariae are absent
7. Development includes ophiopluteus larva
   Ex: *Ophiothrix, ophiura*

CLASS 3: ECHINOIDEA

1. This class includes sea urchins, heart urchins, Sand dollars, Sea biscuits etc
2. Their body is discoid, oval or semi-sperical, Arms are absent
3. Skeleton or test is compact bearing movable spines
4. Aristotle's lantern or chewing apparatus with teeth is present
5. Ambulacral grooves are covered by ossicles,
6. Tube feet with suckers are present
7. Echinopluteus larva is seen in the life history
   Ex: *Echinus, Clypeaster*

CLASS 4: HOLOTHUROIDEA

1. This calss includes sea cucumbers

2. Body of these animals is cylindrical and elongated on oral-aboral axis
3. Arms and spines are absent
4. Mouth is surrounded by tentacles
5. Ambulacral grooves are closed and tubefeet are with suckers
6. Respiratory trees are present near cloaca.
7. Auricularia larva is seen in the life history
   Ex: *Holothuria, Cucumaria , Synapta*

MULTIPLE CHOICE QUESTIONS

1. True coelom in mollusks is restricted to
   A. Kidneys B. Heart C. Gonads **D. All the above**
2. Glochidium larva occurs in the development of
   A. Arthropoda B. Annelids **C. Molluscs** D. Helminthes
3. The second largest phylum after Arthropoda is
   A. Annelida B. Echinodermata **C. Mollusca** D. Chordata
4. Locomotion in mollusca is carried on by
   A. Tentacles **B. Foot** C. Arms D. Suckers
5. Radula is a
   A. Organ of defence B. Excretory organ **C. Rasping organ** D. Reproductive organ
6. Water vascular system is characteristic of
   A. Echinodermata B. Annelida C. Arthropoda D. Cnidaria
7. Pedicellariae are concerned with
   A. **Cleaning of the body** B. Secretion C. Excretion D. Respiration
8. Spiny skinned animals are included in phylum
   A. Mollusca **B. Echinodermata** C. Annelida D. Arthropoda
9. rThe invertebrate phylum which includes only marine forms in
   A. Porifera **B. Echinodermata** C. Mollusca D. Coelenterate
10. Calcareous ossicles are present in the body wall of
    A. **Echinoderms** B. Sponges C. Annelids D. Arthropods
11. Water vascular system serves for111
    A. Respiration B. Locomotion C. Excretion **D. All the above**
12. In molluscans hepotopancrees helps in
    A. Excretion **B. Digestion and absorption** C. Respiraton D. Reproduction
13. In mollusca shell is secreted by
    A. **Mantle** B. Foot C. Visceral mass D. Head
14. In Echimoderms the respiratory organs are
    A. Respiratory trees B. Genital bursa C. Peristomial gills **D. All of the above**

SHORT ANSWER QUESTIONS:

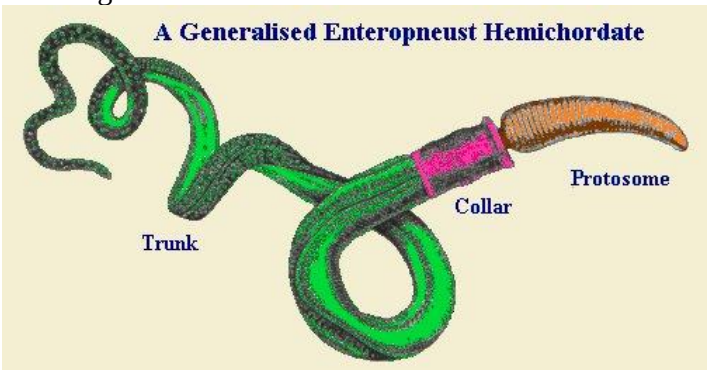
1. What is the function of osphredium
2. Where do you find true coelom in molluscs.
3. Describe water vascular system.

LONG ANSWER QUESTIONS:

1. Write the general characters of the phylum Mollusca.
2. Write the general characters of the phylum Echinodermata.

UNIT-V
ANIMAL KINGDOM
MODULE-26: HEMICHORDATA

Hemichordates mean half Chordates (Hemi means half) as they have some characters of chordates. In the beginning hemichordates were considered as pro chordates and placed as a separate sub-phylum of phylum chordata. ; Later on these hemichordates are separated from phylum chordata and included among non-chordates because they have several characters similar to Echinoderms. Hemi chordates are also important from evolutionary point of view because they link non-chordates with chordates. They are commonly called as acorn worms or tongue worms.



GENERAL CHARACTERS

1. Hemichordates live in marine water.
2. In hemichordates true notochord is absent.
3. Body is bilaterally symmetrical, unsegmented, and triploblastic animals having ectoderm, endoderm and mesoderm layers.
4. These are soft bodied worm like animals.
5. Body is divided into three regions proboscis, collar and trunk. Tail is absent.
6. The anterior end of the body is muscular it is extensible into proboscis which is used to burrow and collect food particles.
7. The trunk is behind the collar and has many pairs of small external gills slits.
8. Mouth is located at the junction of proboscis and collar, which directly leads into a pharynx, which is perforated.
9. Body wall contains epidermis, nervous tissue, muscle fibers.
10. Body does not bear appendages.
11. Proboscis has a hollow finger like out growth arising from the buccal cavity. It is called as buccal diverticulum or stomochord. In the beginning it was considered as notochord.
12. True coelom is present. Which is divided into three parts namely proboscis coelom, paired collar coelom and paired trunk coelom.
13. Respiratory organs are gills. These gills open into pharynx.
14. Digestive tract is complete. The alimentary canal is a straight tube or 'U' shaped with a terminal anus.
15. A dorsal heart with two longitudinal vessels one on the ventral side and the other on the dorsal side are present in the circulatory system. These longitudinal vessels are interconnected by lateral vessel. Colorless blood is present.
16. Excretion is by glomerulus or probocis gland present in proboscis.
17. Nervous system is diffused in epidermis, it is poorly developed. It consists of nerve plexus with dorsal and ventral nerve cords. A nerve ring is present in the collar region.
18. Reproduction normally is by sexual method. Asexual reproduction through budding takes place in some individually.
19. Sexes separate, gonads are many and paired.
20. Fertilization is external occurs in the water.
21. Development of embryo is direct or indirect with a free swimming larval stage known as tornaria.

CHECK POINTS

- Hemichordata was earlier considered as a sub-phylum under phylum Chordata. But now it is placed as a separate phylum under non-chordata.
- This phylum consists of a small group of worm-like marine animals with organ-system level of organization.
- They are bilaterally symmetrical, triploblastic and coelomate animals.
- The body is cylindrical and is composed of an anterior proboscis, a collar and a long trunk.
- Appendages are absent.
- Circulatory system is of open type.
- True coelom is present.
- Respiration takes place through gills.
- Excretory organ is proboscis gland. Sexes are separate.
- Fertilization is external.
- Development is indirect or direct.

PHYLUM HEMICHORDATA

Phylum Hemichordata is classified into two classes

CLASS-I: ENTEROPNEUSTA

They are commonly called as Tongue worms or Acorn worms. They are free, solitary and burrowing animals. A free swimming ciliated larva called Tornaria exist in the life history.
Eg: Balanoglasses

CLASS II: PTEROBRANCHIATA

These are colonial or solitary marine animals. They are sedentary individuals. Body is divisible into Proboscis, collar and Trunk
Eg: Cephelodiscus

MULTIPLE CHOICE QUESTIONS

1. Hemichordates have one truly chordate feature in its typical form. Which is that
   A. Buccal diverticulum
   B. Dorsal and ventral epidermal nerve cords
   C. 3 types of coelom
   D. Perforated pharynx
2. Hemichordates are commonly called as
   A. **Acorn worms** B. Flat worms C. Round worms D. Flukes
3. In hemichordates proboscis gland helps in
   A. Respiration **B. Excretion** C. Nutrition D. Reproduction
4. Larva of hemichordates
   A. **Torneria** B. Bipinnaria C. Amphiblastula D. None
5. Respiratory organs found in hemichordates
   A. **Gills** B. Trachea C. Lungs D. Skin

SHORT ANSWER QUESTION

1. What is stomochord
2. Describe the circulatory system of Hemichordates.

LONG ANSWER QUESTIONS

1. Write the general characters of Hemichordata?

UNIT-V
ANIMAL KINGDOM
MODULE-27: CHORDATA

All the animals with a notochord, at least at some stage in their life, are included under the phylum chordata. Chordata is the highly evolved phylum of the animal kingdom. Chordates might have originated prior to Cambrian period from echinoderm larvae like ancestors.

Chordates exhibit the following characters. All chordates exhibit four fundamental characters. They are notochord, dorsal nerve cord, pharyngeal gill slits and post anal tail, at least at some stage of their life.

NOTOCHORD

It is a stiff elastic mid dorsal longitudinal rod lying between the nerve cord and alimentary canal. It is derived from the embryonic chordamesoderm. It is made up of a core of vacuolated cells surrounded by an inner sheath of fibrous connective tissue and outer sheath of elastic connective tissue. It is a skeletal or supporting structure present in the embryonic stages of all chordates. It persists throughout life in Amphioxus and vertebrates like cyclostomes. In vertebrates, the notochord is replaced by vertebral column. In mammals, notochord is in the form of vestigeal swellings in the vertebral column. They are called Nuclei pulposi

DORSAL TUBULAR NERVE CORD:

The nerve cord in chordates is a single hollow tubular structure, situated dorsal to both the alimentary canal and notochord. It is derived from embryonic neurectoderm. In higher chordates, the nerve cord is differentiated into an anterior brain and a posterior spinal cord.

PHARYNGEAL GILL-SLITS

These are paired perforations present on each side of the pharynx leading to the exterior. Gills are situated in pharyngeal slits. Gill slits are derived from ectoendoderm. Gill slits may be retained throughout life as in protochordates, fishes and some amphibians and help in respiration. In Reptiles, Aves and Mammals, only non functional , externally closed pharyngeal slits appear during embryonic stage

POST ANAL TAIL

Tail of chordates is post anal. It is the posterior elongation of the body extending beyond the anus or cloaca. It is reduced or absent in some adults. Tail has no coelom and viscera, but has muscles, nerve cord and notochord.

OTHER CHORDATE CHARACTERS

1. Chordates are bilaterally symmetrical
2. The coelom of chordates is an enterocoelus coelom as it develops from archenteron
3. Among the chordates metamerism (linear repetetion of the body organs) is visible only internally. The body musculature, the nervous sysem, the circulatory system, the excretory system etc. are atleast at the time of origin thoroughly segmented.
4. Heart of chordates is ventral to gut and is myogenic situated in between the lungs. The heart is surrounded by double walled pericardium. The blood vascular system is of closed type
5. Hepatic portal system is present in all the chordates. Blood that is collect from various parts of alimentary canal is not carried directly to heart but to liver. The blood then goes to heart.

6. In higher chordates the respiratory pigment haemoglobin is always found in redblood cropuscles
7. Higher chordates posses two paired appendages in the form of fins or limbs
8. Blastopore of the gastrula develops into anus in chordates. Hence all chordates are referred to as deuterostomous animals
9. The muscle phosphagen in the chordates is creatine phosphoate.

In addition to the above characters chordates also exhibit characters like cephalization and triploblastic condition

CLASSIFICATION OF CHORDATA

Phylum Chordata is divided into three sub phyla. They are

1. Urochordata
2. Cephalochordata
3. Vertebrata or craniata

SUB-PHYLUM-1: UROCHORDATA (TUNICATA)

1. They are generally referred to as ascidians or sea sqirts.
2. Body is covered by a test or tunic made up of tunicin (cellulose like material). So they are commonly called as tunicates
3. The notochord is only present in the tail of the larva and disappears in the adult
4. Nerve cord is found only in the larval stage, but absent in adults.
5. The larval form is called Tadpole and it exhibits retrogressive metamorphosis
   Ex: *Ascidia, Doliolum, Salpa*

SUB-PHYLUM-2: CEPHALOCHORDATA

1. They are commonly called as lancelets
2. These are small fish like transparent, marine animals.
3. Notochord extends the entire length of the body from the posterior end to the anterior end. Notochord persists throughout life.
4. Pharynx is perforated by numerous gill slits
5. Nerve cord is tubular and dorsal
6. Nephridia are the excretory organs
   Ex: *Amphioxus*

SUB-PHYLUM-3: VERTEBRATA (CRANIATA)

1. They are highly evolved chordates with distinct head
2. Notochord is partially or totally replaced by vertebral column. Hence the name vertebrata
3. The anterior part of the nerve cord is enlarged to form the brain. The brain is protected by brain box or cranium and hence called as craniata.
4. They have two pairs of appendages in the form of fins (in fishes) or limbs (in other vertebrates), which help in locomotion
5. Endoskeleton is cartilagenous or bony or both, derived from mesoderm.
6. Heart is ventral, muscular with two, three or four chambers. Hepatic and renal portal systems are present.
7. Mesonephric or Metanephric kidneys are the organs of excretion and osmoregulation
8. Head contains paired organs of smell, sight and hearing
9. Almost all are unisexual

Vertebrata is classified into two Superclasses-Agnatha and Gnathostomata.

SUPER CLASS-1: AGNATHA

This includes Jaw less vertebrates. Paired appendages are absent. This super class is classified into two classes

1. Ostracodermi and
2. Cyclostomata

CLASS-1: OSTRACODERMI

These are extinct Jaw less vertebrates

Ex: *Cephlaspis*

CLASS-2: CYCLOSTOMATA

1. These are living fish-like Jaw less vertebrates
2. Paired fins are absent. Body is long, scale less and eel like
3. Endoskeleton is cartilagenous
4. Mouth is circular and suctorial. Tongue bears horny teeth
5. Respiratory organs include 6 to 15 pairs of gill slits.
6. Heart is 2 chambered
7. Renal portal system is absent
8. Kidneys are mesonephric
9. Development may be direct or indirect. The larval form of lampreys is called Ammocoetus.
   Ex: *Petromyzon (Lamprey)*
   Myxine (Hag fish)

SUPER-CLASS-2: GNATHOSTOMATA

They are Jawed vertebrates. They possess paird appendages and paired nostrils. The endoskeleton is well developed

This super class is divided into 7 classes. They are

1. Placodermi-Extinct fishes
2. Chondrichthyes –Cartilagenous fishes
3. Osteichthyes-Bony fishes
4. Amphibia-organisms with dual amphibious life
5. Reptilian –organisms which have dry scale covered body
6. Aves –organisms with feathered body
7. Mammals-organisms with milk producing glands.

The animals of the classes Placodermi, Chondrichthyes and Osteichthyes are collectively called Pisces. The animals of the remaining four classes are known as tetrapods because they have 2 pairs of pentadectyl limbs.

MULTIPLE CHOICE QUESTIONS

1. The only living Jawless vertebrates are
   A. Ostracoderms
   B. Placoderms
   C. Cyclostomes
   D. Cephalochordates
2. Restrogressive metamorphosis is exhibited by
   A. Ammocoetus larva
   B. Tadpole larva
   C. Ascidian Tadpole
   D. Tornaria
3. Nerve cord of chordates develops from
   A. Ectoderm
   B. Endoderm
   C. Mesoderm
   D. Endomesoderm
4. Incephalochordata
   A. Notochord is small
   B. Notochord is absent in the adult
   C. Notochord is present only in the tail region of the adult
   D. Notochord is present and is extended into the snout region
5. Origin of Notochord

A. Ectoderm
B. Endoderm
C. Mesoderm
D. Chordamesoderm

6. Gill slits are derived from
   A. Ectoderm
   B. Endoderm
   C. Mesoderm
   D. Ecto endoderm

SHORT ANSWER QUESTIONS

1. Describe Notochord
2. What are the four fundamental characters of chordates
3. Write short notes on cyclostomes
4. Describe the characters of vertebrates

LONG ANSWER QUESTIONS

1. Describe the general characters of chordates
2. Describe the classification of Phylum chordates

UNIT-V
ANIMAL KINGDOM
MODULE-28: PISCES AND AMPHIBIANS

PISCES
GENERAL CHARACTERS

- The class Pisces includes fishes.
- Fishes are the first true jawed vertebrates.
- Fishes are cold blooded or Poikilotherms or Ectothermal vertebrates, found in fresh water, marine water and brackish water.
- Body is spindle shaped, laterally compressed, stream lined and pointed at both the ends. (Offer least resistance during swimming)
- The body is divided into head, trunk and tail. Neck is absent.(It is an adaptation to aquatic mode of life.)
- Body is covered by exoskeleton like scales, dermal denticles or bony plates.
- The skin contains slime glands and their secretions help to reduce the friction with surrounding water during locomotion.
- External nostrils do not communicate with the pharynx, except in lung fishes.
- The eyes are covered by the transparent nictitating membrane. Eye lids are absent .
- Both median (Dorsal, caudal & ventral), and paired fins (pectoral and pelvic) are present supported by fin rays and serve for locomotion and balance. Candal fin functions as a rudder.
- Endoskeleton may be cartilaginous (as in chondrichthyes) or bony (as in osteichthyes fishes). Vertebrae are amphicoelous. Skull is mono condylic.
- Jaws are provided with homodont (similar)and acrodont teeth. (Fused to Jaw bone)
- Mouth is either terminal or ventral. Digestive tract leads into cloaca (cartilaginous fishes) or anus (bony fishes)
- Respiratory organs are gills. Some fish (Bony fishes) have air bladder as respiratory organ, which help as hydrostatic organ. (serves as a float)
- Heart is S- shaped and two chambered having one auricle and one ventricle. Sinus venosus and conus arteriosus are present. Red blood corpuscles(RBC) are present.
- The heart is venous heart as it contains only impure blood.
- Blood vascular system has both the hepatic and renal portal systems.
- Brain is small and has 10 pairs of the cranial nerves.
- Fishes have specialized organs called lateral-line sense organs situated on the head and along the trunk to detect the pressure of water against the sides of the body and enable the animal to adjust its position in water. (Rheoreceptors)
- Kidney is mesonephric; urinary bladder is absent (cartilaginous fishes). Excretory product is ammonia (bony fishes) or Urea (cartilaginous fishes).
- Sexes are separate, no sexual dimorphism, male posses claspers which help in copulation.
- Fertilization is external (bony fishes) or internal (cartilaginous fishes).. Fishes are oviparous (egg laying) but sharks are viviparous. (producing living young that develop form egg retained within the mothers body and nourished by her)
- Development is direct- embryonic membranes are not formed during the development, hence they are called as an-aminiotes.

PISCES

1. Evolved during Ordovician period of palaeozoic era
2. Devonion period is the Golden age of fishes.
3. The branch of science deals with fishes is Ichthyology.

Super class – Pisces is classified into three classes.

CLASS I: PLACODERMI:

This class includes extinct fishes.

E.g.: Bothryolepis

CLASS II: CHONDRICHTHYES:

This class includes cartilaginous fishes. Some of the important characters are

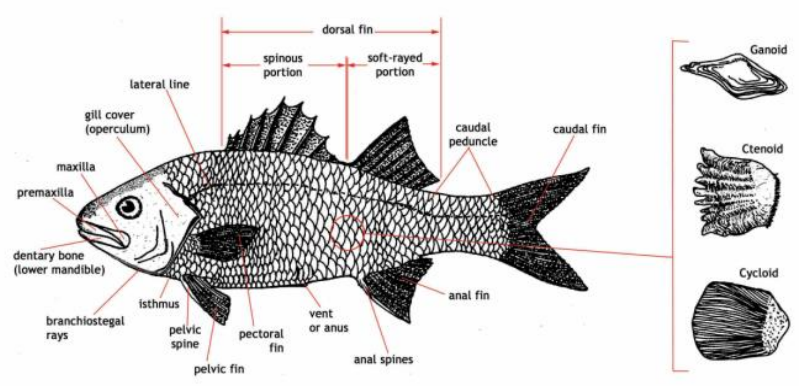
1. Endo skeleton is entirely cartilaginous
2. Pelvic fins bear claspers. Coudalfin is heterocercal
3. Skin covered with placoid scales
4. Urea is the excretory product (ureotelic). They store urea in their blood to maintain osmotic concentration of body fluids.
5. Five to seven pairs of gills are present. Grills are lamelliform, without operculum
6. Air bladder is absent.
7. Fertilization is internal. They are mostly viviparous
   Eg: Scoliodon, Pristis, Trigon, Rhinobatis.

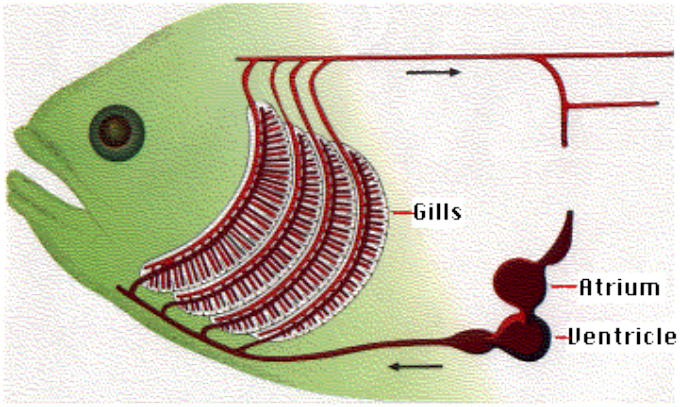
CLASS III: OSTEICHTHYES:

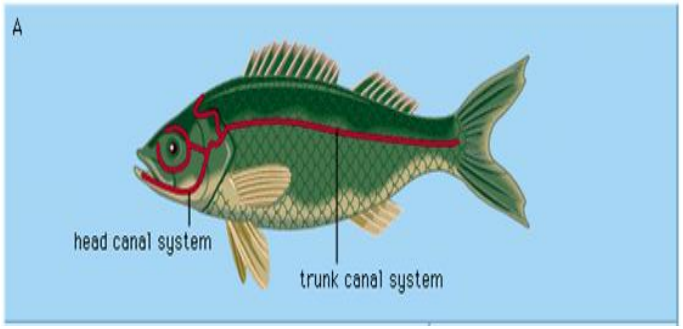
They are commonly called as Bony fishes. Some of the important characters are

- Live in freshwater, saltwater, and brackish water.
- Caudal find is homocercal (Teleost fishes) or diphycercal (lung fishes and Latimeria)
- 4 pairs of gills are present, covered by operculum
- Ammonia is the excretory product. (Ammonotelic)
- Scales present may be cycloid, ctenoid and ganoid.
- Usually Air bladder is present which acts as buoyancy organ.
- Cloaca is absent
- Fertilization is external. Fins are supported by bony fins rays.
  E.g.: Pretopterus, Lepidosiren, Neoceratodus, Exocoetus, Labeo

EXTERNAL MORPHOLOGY OF FISH.







CHECK POINTS:

- First true jawed vertebrates.
- Spindle shaped body covered by scales or bony plates.
- Median and paired fins are present help in locomotion.
- Amphicoelous vertebrae.
- Homodont and Acrodont teeth.
- Two chambered S-shaped heart.
- 10 pairs of cranial nerves.
- Lateral line sense organs to detect the change of pressure of water.
- Mesonephric kidneys.
- Males with claspers.

CLASS-AMPHIBIA

Introduction:

The first major groups of amphibians evolved during Devonian Period from fish. They are the first terrestrial vertebrates. They are the first tetra-pods with two pairs of pentadactyl limbs. First vertebrates, which made transition from aquatic to terrestrial life. Frogs, toads, salamanders, newts are included under this class.
Carboniferous period is regarded as the age of Amphibra.

GENERAL CHARACTERS

- They live on land (Moist places) as well as in water, hence they are called amphibians.
- They are poikilothermic or ectothermal or cold blooded animals.
- Body is divided into head and trunk, tail is present in the larva but absent in adults. Tail present in urodeles throughout the life.
- Two pairs of pentadactyl limbs are present for leaping or swimming. But they are absent in Apoda.
- Mouth is provided with homodont teeth (teeth are all of the same type) mostly in upper jaw.
- Skin is generally slimy, moist and glandular without scales (except in Apoda) . The moist scale less skin serves as an organ of respiration.
- External ear is absent and the tympanum (outer membranous covering of the middle ear) and middle ear are present. Columella auris is the only ear ossicle present in the middle ear.
- Skeleton is bony. Skull is dicondylic (having two occipital condyles). Vertebrae are procoelus (centrum is concave in front) or Amphicoelous (centrum is concave at both the ends) or Acoelous (centrum without concavities). Sternum is first developed in Amphibia
- Eyes are provided with upper eye lid and lower eye lid, a third eye lid called nictitating membrane is also present.
- External nostrils open into the bucco-pharyngeal cavity through internal nostrils which help in the respiration (bucco-pharyngeal respiration).
- Digestive system is well developed.
- Respiration takes place by skin, lungs, or by bucco-pharyngeal cavity. In larvae and some adult amphibians respiration takes place by gills. The voice box in Amphibia is laryngo tracheal chamber.
- Heart is three chambered with two auricles and one ventricle. Truncus arteriosus and sinus venosus are present.
- Red blood corpuscles (RBC) are oval biconvex and nucleated.
- Hepatic and Renal portal systems are present.
- Brain is developed with ten pairs of cranial nerves.
- Kidney is mesonephric, urinary bladder is present. They are ureotelic.(urea is the chief excretory product)
- The sexes are separate. Males do not posses copulatory organs.
- Amphibians are oviparous. Fertilization is mostly external. (Internal in caecilians).
- They are an-amniotes because fetal membranes are absent.
- Development is indirect as the larval stages are present.
- Larva undergoes metamorphosis (rapid transformation from the larval to the adult form) to become an adult.

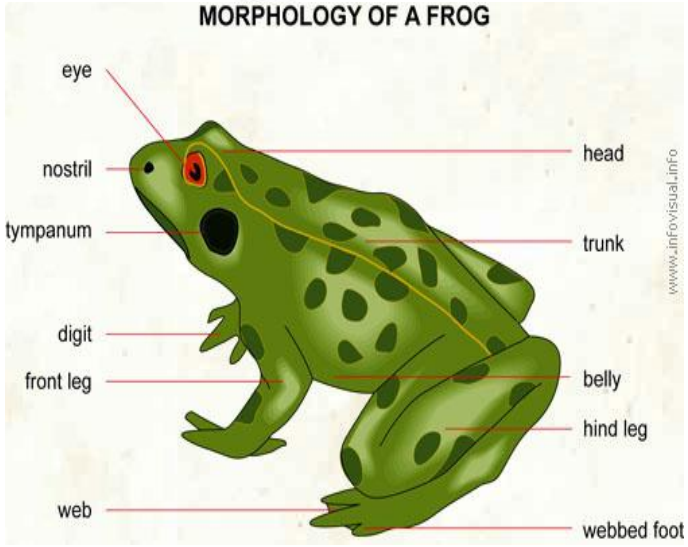
CHECK POINTS:

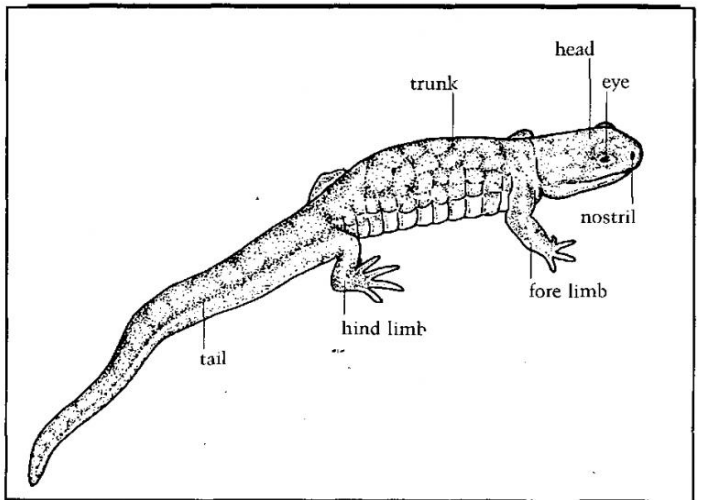
- Cold blooded animals.
- First tetrapod vertebrates.
- Two pairs of pentadactyl limbs are present.
- Dicondylic skull.

- Vertebrae – Procoelous, Amphicoelous or Acoelous.
- 3 chambered heart with two auricles and one ventricle.
- Mesonephric kidneys.
- Larva undergoes metamorphosis to become adult.

Amphibians

- toad





CLASSIFICATION: CLASS-AMPHIBIA

The class amphibia is classified into three sub-classes

SUB-CLASS: LABYRINTHODONTIA

Extinct amphibians are included in the subclass
Eg: Ichthyostega

SUB-CLASS: LEPOSPANDYLI

Extinct salamander like amphibians
Eg: Diplocaulus

SUB-CLASS: LISSAMPHIBIA

All living amphibians are included in the sub – class. It is divided into three orders

ORDER I APODA

Limbless, tailless, blind amphibions adopted for burrowing life
Eg: Ichthyophis

ORDER II URODELA

Lizard like amphibians. Tail is present in the adult stage
Eg: Siren, Salamander

ORDER III ANURA

Includes frogs and toads. Tail is absent in adults.
Eg: *Rana tigrina* (Indian Bull frog), *Bufo melanosticus* (common toad), Hyla (Tree frog), Rhacophorus (Flying frog)

1. The study of frogs is called Batracology.
2. Amphibians are first terrestrial vertebrates, first tetra pods with two pairs of limbs, sternum, tympanum developed first time, voice appeared for the first time,

MULTIPLE CHOICE QUESTIONS

1. Notochord is present throughout the life in
   A. Urochordata **B. Cephalo chordata** C. Amphibia D. Hemi chordata
2. The distinctive character of chordates is
   A. Presence of notochord
   B. Presence of haemoglobin
   C. Presence of myosenic heart
   D. Presence of tail
3. The distinctive feature of urochordata is
   A. Presence of Notochord along the entire length of body
   B. Presence of notochord in the head of the adult
   C. Presence of notochord in the tail of the larva
   D. Presence of notochord in the tail region of the adult
4. Vertebrae in fishes are
   A. Procoelous **B. Amphicoelous** C. Acoelous D. Heterocoelous
5. Lateral line sense organs in fishes are
   A. Chemo receptors B. Thermo receptors **C. Rheo receptors** D.Olfactory receptors
6. The kidneys in fishes
   A. Pronephric **B. Mesonephric** C. Metanephric D. Archaeonephric
7. The paired fins in fishes are
   A. **Pectoral** B. Dorsal C. Anal D. Caudal
8. Endo skeleton is made up of cartilage in
   A. Osteichthyes **B. Chondrichthyes** C. Teleost D. Dipnoi

9. Airbladder is mainly
   A. **Hydro static organ of fishes** B. Excretory organ of fishes
   C. Respiratory organ of Birds D. None of the above
10. First formed tetrapods are
   A. Reptiles B. Fishes **C. Amphibians** D. Aves
11. Scales occur in the skin of
   A. **Apoda** B. Anura C. Urodela D. All the above
12. Amphibians were evolved in the period
   A. Silurian **B. Devonian** C. Carboniferous D. Permian
13. Vertebrae in amphibian
   A. Procoelous B. Amphicoelous C. Acoelous **D. All the above**
14. Number of chambers present in the heart of Amphibians
   A. One B. Two **C. Three** D. Four
15. Number of cranial nerves present in Amphibians
   A. 8 pairs B. 9 pairs **C. 10 pairs** D. 12 pairs
16. Teeth of amphibians
   A. **Homodont** B. Thecodont C. Acrodont D. Diphyodont
17. Tree frog is
   A. Buto **B. Hyla** C. Rhacophorus D. Siren
18. Limbless amphibians belong to the order
   A. **Apoda** B. Urodela C. Anula D. None
19. Amphbians are _____animals
   A. Homeothermic **B. Poikilothermic** C. Stenothermic D. None
20. The vertebrates where urinary bladder appeared first time are
   A. Fishes **B. Amphibians** C. Reptiles D. Aves

SHORT ANSWER QUESTIONS:

1. What are the median and paired fins present in fishes
2. What is the functions of airbladder in fishes
3. Explain the excretory products are formed in fishes
4. List out three differences between cartilageneous and bony fishes
5. What are the respiratory organs of amphibians
6. What type of vertebrae are found in Amphibians

LONG ANSWER QUESTIONS:

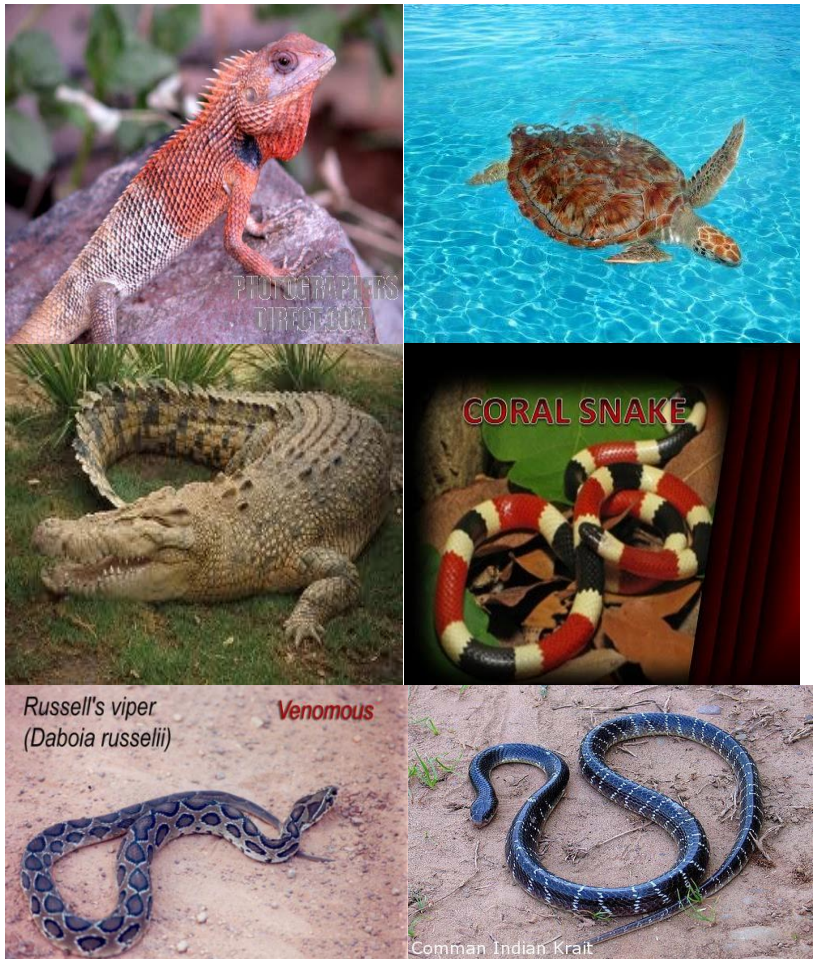
1. Describe the general characters of Pisces
2. Describe the general character of Amphibia

UNIT-V
ANIMAL KINGDOM
MODULE-29: REPTILIA

The class Reptilia includes lizards, snakes, turtles, tortoises, crocodiles and alligators. The reptiles flourished in the Mesozoic era and it was the Golden age when they were the dominant animals on the earth. Reptiles are the first group of vertebrates adapted for the life on dry places like land. The dry horny skin with scales resists loss of moisture from the body and facilitates living on rough surfaces. The study of reptiles is called Herpetology, the study of lizards is Saurology and the study of snakes is ophiology.

GENERAL CHARACTERS

- Reptiles are cold blooded vertebrates
- Reptiles are the first vertebrates adapted for terrestrial mode of life.
- Body is covered with horny, epidermal scales or scutes. Body is divided into head, neck, trunk and tail.
- Skin is dry and skin glands are absent.
- Two pairs of pentadactyl limbs, each with five toes, ending with horny claws are present. Limbs are absent in snakes, and paddle like in turtles.
- Tympanum, middle and internal ears are present. But in snakes only internal ear is present.
- Teeth are present in both the jaws, except in turtles. Teeth are acrodont, polyphyodont and homodont type. Digestive system is well developed with digestive glands. The rectum is divided into three parts namely coprodaeum, urodaeum and proctodaeum
- Skull is monocondylic. Vertebrae are procoelus. Temporal region of the skull bears temporal fossae. Fossae enables the animal to open the mouth widely. T-shaped inter clavicle is present in the sternum.
- Heart imperfectly four chambered with two auricles and partially divided ventricle.. In crocodiles heart is 4 chambered. Both hepatic and renal portal systems are well developed.
- Respiration is pulmonary, turtle have cloacal respiration.
- There are twelve pairs of the cranial nerves arising from brain. In snakes 10 pairs of cranial nerves are present.
- Organs of Jacobson are present on the roof of the buccal cavity in lizards and snakes to detect the sense of smell. (olfactory receptors)
- Excretory organs are metanephric kidneys. Uric acid is the excretory product. Urinary bladder is absent in some lizards, crocodiles and snakes.
- Copulatory organs are present in males, except in *Sphenodon*.
- Sexes are separate, Fertilization is internal. Mostly oviparous.
- Eggs are large sized with much amount of yolk (megalecithal) and are covered with shells. Eggs are laid on land.
- The embryo is protected by extra embryonic membranes like amnion, chorion, allantois, and yolk sac. They help in nutrition, respiration, protection and excretion of the developing embryo. Development is direct.



CHECK POINTS

- Mesozoic era is the golden age of reptiles
- Cold blooded vertebrates
- First vertebrates adapted for terrestrial life
- Skull Monocondylic. Vertebrae procoelous
- Skull with temporal fossae
- 12 pairs of cranial nerves
- Jacobson's organs are present to detect the sense of smell
- Metanephric kidneys.
- Uric acid is the excretory product
- Sphenodon is the living fossil

CLASSIFICATION OF REPTILIA

Living reptiles are grouped into

SUB CLASS I: ANAPSIDA

ORDER: CHELONIA

It includes Turtles, Tortoises and Terrapins. Primitive reptiles, limbs paddle like, Trunk enclosed in bony shell composed of dorsal carapace and a ventral plastron. Sternum is absent. Cloacal respiration.
Eg: Testudo, Trionix, chelonia

SUB CLASS II: LEPIDOSAURIA

ORDER I: RHYNCHOCEPHALIA

Sphenodon is a living fossil. With primitive characters. Notochord is present.
Eg: Sphenodon

ORDER II: SQUAMATA

It includes two suborders

SUB ORDER I: LACERTILIA

It includes Lizards
Eg: Varanus, Heloderma, Draco

SUB CLASS II: OPHIDIA

It includes snakes. Limbs and girdles are absent. Tympanum and middle ear are absent. Tongue is bifid. Snakes are insensitive to air borne sounds but highly sensitive to earth borne vibrations due to attachment of columella auris to quadrate. One pair of elongated fangs found in poisonous snakes.
Eg: python, naja, bungarus, anaconda

SUB CLASS III: ARCHOSAURIA

ORDER: CROCODILIA

It includes crocodiles, alligators and gavialis. These are the largest living reptiles.
Eg: Crocodylus, Alligator

MULTIPLE CHOICE QUESTIONS

1. Golden age of Reptiles
   A. **Mesozoic era** B. Paeleozoic era C. Jurassic period D. Cretaceous priod
2. Jacob son's organs are
   A. Rheo receptors B. **Olfactory receptors** C. Auditory receptors D. Thermo receptors
3. 'T' shaped interclavicles is present in
   A. Amphibians B. Aves **C. Reptiles** D. Fishes
4. The type of vertebrae found in reptiles
   A. **Procoelous** B. Amphicoelous C. Hetero coelous D. Acoelous
5. The number of cranial nerves in snakes
   A. **10 pairs** B. 12 pairs C. 8 pairs D. 13 pairs
6. Paddle like limbs are found in
   A. Crocodiles B. Sea snake **C. Turtle** D. Lizards
7. Number of chambers in the heart of crocodile
   A. 2 B. 3 **C. 4** D. 1
8. In reptiles the cloaca is differentiated into how many parts
   A. 1 B. 2 **C. 3** D. 4
9. The chief excretory product of Reptiles
   A. Ammonia B. Urea **C. Uric acid** D. Trimethyl amino oxide

SHORT ANSWER QUESTIONS

1. Which is the Golden age of Reptiles
2. What is the function of Jacob son's organ

LONG ANSWER QUESTIONS

1. Describe the general characters of Reptilia.

UNIT-V
ANIMAL KINGDOM
MODULE-30: AVES

INTRODUCTION

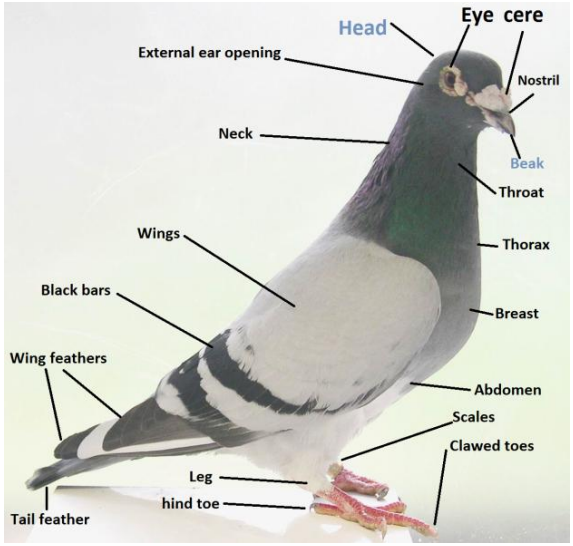
Birds are the best known and easily recognized of all animals, because they are common flying animals. They are unique in having feathers that cloth and insulate their bodies, making them possible to regulate body temperature and aiding in flight. No other animals possess this character. They are colored animals with different voices. Their external and internal body organization is modified in correlation with their aerial mode of life.

There are around 10,000 living species. Birds range in size from the 5 cm (2 in) Bee Hummingbird to the 2.7 m (9 ft) Ostrich. They inhabit ecosystems across the globe, from the Arctic to the Antarctic. The only place where birds have not been found is the South Pole (the coldest spot of the world). The fossil record indicates that birds evolved from theropod dinosaurs during the Jurassic period of Mesozoic era about 180 million years ago. And the earliest known bird is the Late Jurassic *Archaeopteryx*, 155–150 Million years ago. Archaeopteryx and Archaeornis are connecting links between reptiles and birds. Study of Aves is called Ornithology.

Huxley described "birds as the glorified reptiles"

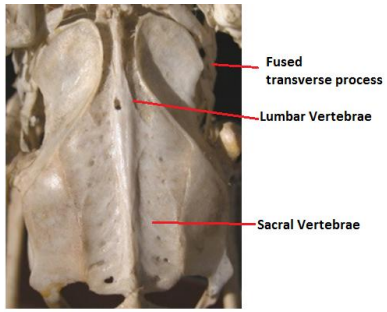
GENERAL CHARACTERS

- Birds are the first warm-blooded or homoeothermic or endothermic bipedal vertebrates, with flying mode of life.
- Body is spindle shaped, stream lined and designed to offer minimum resistance to the air.



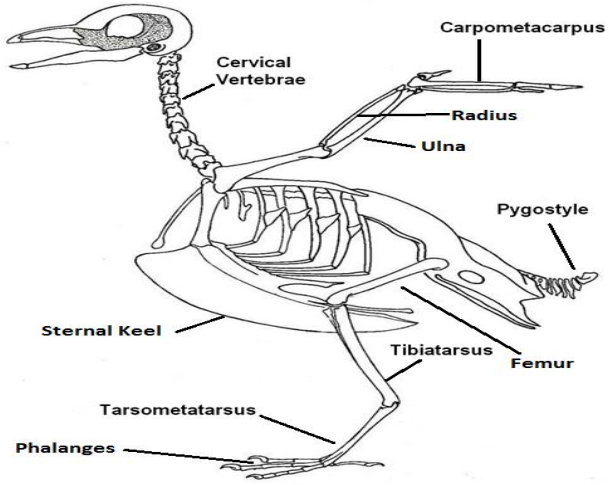
- Body is divided into head, neck, trunk and short tail. Jaws prolonged into toothless beak. Tail help in balancing, steering and lift during flight.
- External ears are absent.
- Eyes contain vascular pectin and sclerotic plates. Eye sight is keen.
- Skin is dry and devoid of glands with the exception of oil gland or preen gland or uropygeal gland present at the root of the tail, useful for preening of feathers.

- Exoskeleton is present and represented by feathers on the body, scales on the legs, claws on the toes and sheath on the beak. Feathers form thermal insulation around the body.
- Fore limbs are modified into wings for flying, hind limbs have four clawed toes and adopted for walking, running, scratching, perching, food capturing, swimming etc.
- Bones are pneumatic as they contain air cavities. There is fusion of bones. Skull is monocondylic.
- Cervical and free thoracic vertebrae are heterocoelous.
- Last thoracic, lumbar, sacral and anterior five caudal vertebrae are fused to form synsacrum (1+6+2+5=14), posterior caudal vertebrae are fused into plough shaped bone called pygostyle which support tail feathers. Sternum is broad and provided with a triangular ventral keel for attachment of flight muscles. Ribs are double headed. Two clavicles of the pectoral girdle are fused to form V-shaped furculum, which keeps the wings apart.
- Carpals and metacarpals are fused to form carpometacarpus. Similarly distal row of tarsals and metatarsals are fused to form tarsometatarsus. The proximal row of tarsals fused with the tibia to form tibiotarsus.
- Pelvic girdle is strong, large fused with the synsacrum throughout the length.
- Pectoral muscles of flight are very well developed.
- The posterior part of the Oesophogus is dilated into a crop for storage of food. Gizzard helps in grinding the food. Stomach is divided into glandular proventriculus and muscular gizzard. Gallbladder is absent. Cloaca is three chambered.
- Heart is four chambered with two auricles and two ventricles. Only right systemic arch is present. Renal portal system is vestigial. The RBC are oval, biconvex and nucleated. Hepatic portal system is well developed. Truncus arteriosus and sinus venosus are absent.
- Respiration is pulmonary, lungs are small, spongy continuous with thin walled airsacs. The air sacs communicate with pneumatic cavities of bones. Larynx is without vocal cords. Syrinix produce sound, present at the junction of tracheae and bronchii. Air sacs provide lightness and buoyancy. They are reservoirs of air. Double oxygenation can be seen in birds. Alveoli are absent in lungs.
- Nervous system contains large brain with large cerebral hemispheres and cerebellum. Twelve pairs of the cranial nerves are present
- Kidneys are metanephric. Urinary bladder is absent and urine is semisolid. Uric acid is the chief excretory product.
- Sexes are separate and sexual dimorphism is well developed. A copulatory organ is absent. Female has a single functional left ovary and oviduct. Fertilization is internal. Birds are oviparous. Eggs are megalecithal. (large quantity of yolk) Development is direct. Extra embryonic membranes like amnion, allontois, chorion and a large yolk sac appear during development.
- All are oviparous.
- Parental care is well developed.
- National bird of India is *Pavo cristatus* (pea cock). The state bird of Andhra Pradesh is *Coracias bengalensis* (blue jay)

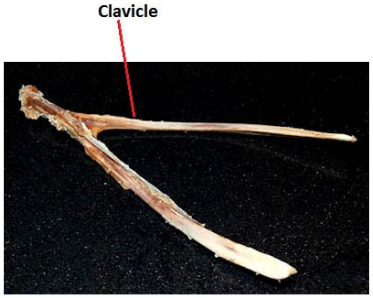


Synsacrum

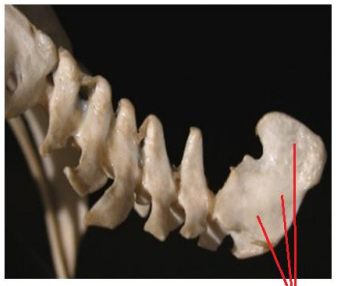
Sternum



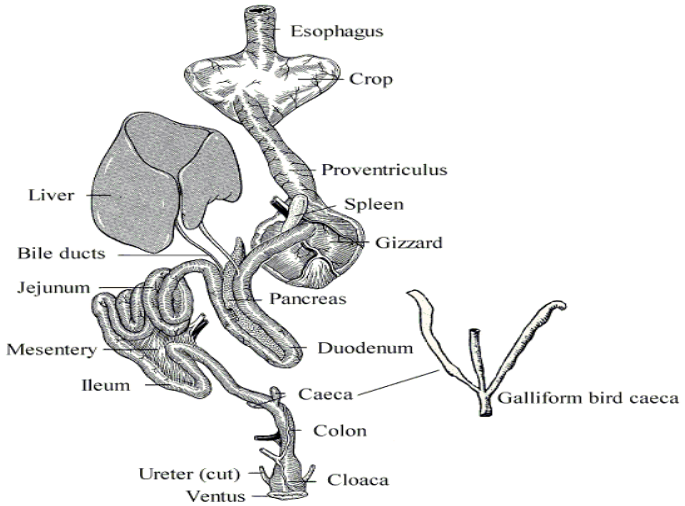
Complete Skeleton



Furcula of Fowl



Pygostyle



CHECK POINTS

- First warm blooded, bipedal vertebrates with flying mode of life.
- Body is covered by feathers.
- Only skin gland present is preen gland or uropygeal gland.
- Forelimbs are modified into wings.
- Bones are pneumatic.
- Vertebrae are hetereoelous.
- Syrinx produce sound.
- Four chambered heart.
- Metanephric kidneys
- 12 pairs of cranial nerves.
- Eyes are provided with pecten and sclerotic plates
- All are oviparous.
- Parental care is well developed.

CLASSIFICATION

Class Aves is classified into

SUB – CLASS I: ARCHAEORNITHES

Eg: Archaeopteryx, Archaeornis.
They show the characters of reptiles and birds. Connecting link of reptiles and birds.

SUB – CLASS II: NEORNITHES

This sub – class is divided into four super orders

SUPER ORDER - I: ODONTOGNATHAE,

E.g.: Icthyornis
Extinct, marine, flightless birds are included.

SUPER ORDER - II: IMPENNAE

E.g.: Penguins
Wings are modified to form flippers and help in swimming.

SUPER ORDER – III: PALAEOGNETHEA

E.g.: Ostrich, Emu, Kiwi
Modern, flightless, running birds are included, wings are reduced or absent.

SUPER ORDER - IV: NEOGNATAE

Modern, small sized flying birds are included.
E.g.: Columba (pigeon), *Pavo cristatus* (Peacock – It is the National bird), *Coracious bengalensis* (Blue jay – AP state Bird)

ADDITIONAL INFORMATION

- **Heterocoelous Vertebra:** Centrum is concave from side to side and convex dorsoventrally in front and concave dorsoventrally and convex from side to side behind.
- The largest living bird is the flightless African ostri ch (2.5 meters height)
- Smallest bird is humming bird of Cuba (4 cms long)
- Fastest bird is spine tailed swift of Japan
- Birds blood is regended as the richest blood in the animal kingdom (10,000,000/square inch)

MULTIPLE CHOICE QUESTIONS

1. Birds evolved during
   A. Devonian period **B. Jurassic period** C. Ordovician period D. Cretaceous period
2. The grinding organ of birds is
   A. Crop B. Stomach C. Buccal cavity **D. Gizzard**
3. The sound producing organ in birds is

A. Larynx **B. Syrinx** C. Trachea D. Bronchus

4. Type of vertebrae in modern birds is
   A. Amphicoelous B. Acoelous C. Procoelom **D. Heterocoelous**
5. V – shaped furcula in birds is formed by the union of
   A. Scapula B. Pubis **C. Clavicles** D. Ischia
6. Archaeopteryx is the connecting link between
   A. Amphibia and Reptilia **B. Reptilia and Aves** C. Aves and mammalian D. Reptilia and mammalian
7. Stomach is divided into proventriculus and Gizzard in
   A. Reptiles **B. Birds** C. Amphibians D. Fishes
8. Excretory product in Birds is
   A. Ammonia B. Urea **C. Uric acid** D. Trimethyl amine
9. The plough shaped bone present in the tail of birds is
   A. Synsacrum **B. Pygostyle** C. Keel D. Furculum
10. Hindlimb of birds show
    A. Two toes B. Three toes **C. Four toes** D. More than four toes
11. In birds the flight muscles are attached to
    A. Synsacrum **B. Sternum** C. Pygostyle D. Furculum
12. Bones of bird are
    A. Strong and solid B. Weak and solid **C. Pneumatic** D. Calcareous
13. Our national bird is
    A. Coracious bengalensis
    B. Pavo cristatus
    C. Columba
    D. Kiwi
14. A.P state Bird is
    E. Coracious bengalensis
    F. Pavo cristatus
    G. Columba
    A. Kiwi

SHORT ANSWER QUESTIONS

1. Describe the exoskeleton of birds
2. How synsacrum is formed in Birds.
3. How pygostyle is formed and what is its function.
4. Describe the endo skeleton of birds.
5. Name the skin gland present in birds and what is its function.

LONG ANSWER QUESTIONS:

1. Describe the general characters of Aves.

UNIT-V
ANIMAL KINGDOM
MODULE-31: MAMMALIA

INTRODUCTION

Mammals are the highly evolved tetrapods with mammary glands. They include the moles, bats, rodents, cats, monkeys, whales, horses, deer, man, etc, beside a host of extinct species and orders. They evolved from group of reptiles (Therapsids) during Jurassic period about 225 million years ago. Coenozoic era considered as golden age of mammals.

Linnaeus (1758) named vertebrate possessing mammary glands as mammals. The name mammal came from the mammary glands present in the females that supplies milk for nourishing the young ones.

Mammals are more or less covered with hair or fur. Parental care is highly developed in this class and reaches its climax in the human species. Study of mammals is known as Mammalogy. Mammals are highly evolved and most intelligent of all animals.

GENERAL CHARACTERS

- Mammals are adapted to all habitats-terrestrial, arboreal, aquatic, and aerial.
- Mammals are homoeothermic or warm blooded vertebrates.
- Body is divided into head, neck, trunk and tail.
- Two pairs of pentadactyl limbs are present but absent in whales and sea cows. They are variously modified for walking, running, climbing, burrowing, flying and swimming. The digits are provided with claws, nails etc. In aquatic mammals forelimbs are modified into flippers and help in swimming.
- The body is covered with hair, which is epidermal in origin. Presence of hair is the important characteristic feature of mammals. Hair prevents loss of heat from the body. In aquatic mammals hair is absent. A thick fatty layer called blubber is present below the skin and acts as thermal insulator.
- The skin is glandular has two types of glands, sweat glands and sebaceous glands. Sweat glands secrete sweat and regulate the body temperature and also help in excretion. Sebaceous glands secrete sebum which keeps the hair and skin soft and smooth. In the pectoral region sebaceous glands are modified into mammary glands. Mammary glands secrete milk in female after child birth, where as in males they are non-functional.
- Head bears a definite nose and eyes. Posses lips and cheeks.
- Eyes have movable eye lids with eyelashes to prevent entry of dust particles. Miebomian, Harderian and lacrymal glands are present in the eyes.
- External ears are present but absent is aquatic mammals and prototherians. The middle ear contains bony ear ossicles, namely malleus, incus and stapes.
- Body cavity is divided into anterior thoracic cavity and posterior abdominal cavity by a diaphragm.
- Buccal cavity is divided into upper nasal passage and lower food passage by a palate. The respiratory aperture or glottis is guarded by a flap like epiglottis.
- Four types of teeth- incisors, canines, premolar, and molars are present. Teeth are Thecodont (teeth fixed in sockets), Heterodont (different types of teeth) and Diphyodont (two sets of teeth). The canines are absent in herbivorous mammals.
- The skull has a large cranial cavity. Skull is dicondylic.

- Mammal's posses 7 cervical vertebrae in the neck region. Vertebrae are platycoelous or amphiplatyon type. Inter vertebral discs are present between the vertebrae. Lower jaw is composed of a single bone called dentary on each side. The ribs are double headed.
- Alimentary canal terminates by anus. Four pairs of salivary glands open into buccal cavity. They are parotid, sublingual, submaxillary and infra orbitals. In man only 3 pairs of salivary glands are present. Infra orbitals are absent in man. Liver is five lobed but four lobed in man. Cloaca is absent in mammals except in prototheria.
- Respiration is always by a pair of lungs. A larynx with vocal cords is present. diaphragm helps in breathing.
- Heart is four chambered with double circulation, only left systemic arch is present, renal portal system is absent. Blood has blood platelets, RBC are round, biconcave without nucleus.
- Brain is most advanced and has two cerebral hemispheres, four optic lobes (corpora quadrigemina) and a cerebellum with twelve pairs of cranial nerves. Two cerebral hemispheres are connected by a transverse nerve band called corpus callosum. The cerebellum bears pons varoli.
- Kidneys are metanephric, and Bean shaped. Urea is the chief excretory product. (ureotelic) Urinary bladder is present.
- The testes in mammals are situated outside the abdomen in scrotal sacs, except prototherians. Males possess a muscular copulatory organ called penis.
- Ovaries are situated in the posterior part of the abdominal cavity. Oviduct is divided into anterior fallopian tube, median uterus and posterior vagina. Clitoris which is homologous to penis of males is present in females near the urinogenital aperture. Fertilization takes place in the fallopian tube.
- Mammals are viviparous. Except prototherians. They give birth to young ones.
- Embryo develops in the uterus, and attached to mother by placenta. Placenta serves for nutrition, respiration and excretion. The period of development in the uterus is called as gestation period. In man it is 270 days.
- Fetal membranes like amnion (for protection), chorion (for respiration), allantois (respiration and Excretion) and yolk sac (for nourishing the embryo) are formed during development.
- Parental care is very well developed in mammals.
- National animal of India is a *Panthera tigris* (tiger).

CLASSIFICATION OF MAMMALS:

Class Mammalia is classified into three sub classes.

SUB CLASS I: PROTOTHERIA OR MONOTREMATA

Primitive, unfinished mammals, mammary glands are present both in males and females. Testes are abdominal. Oviparous. Teeth are present in young ones. Body temperature is low and ranges from 25 – 28^{o}C. Hence they are described as heterothermus mammals. Feeding of young with milk by father and mothers is called gynaecomastism. Females are oviparous. Prototherians posses a number of reptilian characters in addition to the mammalian characters. They act as connecting link between Reptiles and mammals.

Eg: Ornithorhynchus (Duck Billed Platypus), Echidna (Spiny Anteater)

SUB CLASS II: METATHERIA OR MARSUPIALIA

They are pouched mammals. Brood pouch or marsupium is present in females, inwhich the immature young ones are fed with the milk of the mother. Mammary glands are present in marsupium Females have two oviducts, two uteri and two vagina. (Didelphic condition) which separately open into urinogenital sinus. They are viviparous but young ones are born in an immature stage. Yolk sac plecenta in present. Exhibits discontinuous distribution.

Eg: Macropus (kangaroo)

SUB-CLASS III: EUTHERIA OR PLACENTALIA

Highly evolved mammals. Allantoic plancenta is found, young one are born in relatively advanced state, viviparous, commonly known as placental mammals. E.g.: Macaca (monkey), Dog, Lion, Leopard, *Panthera tigris* (Tiger – National animal). Elephant, man etc.

CHECK POINTS

- Coenozoic era is the golden age of mammals.
- Warm blooded animals.
- Body is covered by hair.
- Blubber is present in aquatic mammals.
- Two pairs of pentadoctyl limbs.
- Thecodont, heterodont and diphyodont teeth.
- Dicondylic skull.
- Only 7 cervical vertebrae.
- 4 chambered heart and double circulation.
- Metanephric kidneys.
- Ureotelic.
- Placenta and foetal membranes are formed during development.
-

ADDITIONAL INFORMATION

- **Platycoelous Vertebrae-** In mammals, the centrum of the vertebrae is flat. Such vertebrae with flat centrum are called platycoelous or amphiplatyan vertebrae
- The largest mammal is the blue whale (*Balaenoptera musculus*)
- The largest land mammal is African elephant
- The tallest mammal is Giraffe
- Bat is good example for flying mammal
- The fastest animal is cheetah (speed= 70mph)
- The smallest of all the mammals is the recently discovered Ketti's hognosed bat/Bumblebee bat in Thailand.

MULTIPLE CHOICE QUESTIONS

1. Coenozoic era is regarded as
   A. **Age of mammals** B. Age of birds C. Age of Reptiles D. Age of Man
2. Mammary glands are the modification of
   A. Sweat glands **B. Sebaceous glands** C. Parotid glands D. scent glands
3. Corpora quadrigemina are related to
   A. Cerebral hemispheres **B. Optic lobes** C. Diencephalon D. Medulla oblongata
4. In mammals the two cerebral hemispheres are connected by
   A. Corpora quadrigemina **B. Corpus callosum** C. Aqueduct of sylvius D. Pons varolii
5. The time taken for the development of embryo inside the uterus of mother in mammals is called
   A. Latency period B. Incubation period **C. Gestation period** D. Prepatent period
6. The ancestors of mammals
   A. Anapsids **B. Therapsids** C. Archaeopteryx D. Dinosaurs
7. The term mammal was coined by
   A. Hyman B. Huxley **C. Linnaeus** D. Darwin
8. The glands which keep the hair and skin smooth and soft
   A. Mammary glands B. Sweat glands **C. Sebaceous glands** D. Scent glands
9. The number of salivary glands in man
   A. 2 pairs **B. 3 Pairs** C. 4 Pairs D. 1 Pairs
10. The function of placenta in mammals
    A. Nutrition B. Respiration C. Excretion **D. All**
11. The number of cervical vertebrae in mammals
    A. **7** B. 8 C. 9 D. 10
12. Chief excretory product of mammals
    A. Ammonia **B. Urea** C. Uric acid D. Trimethyl amine
13. Type of vertebrae in mammals
    A. **Amphiplatyon** B. Procoelous C. Amphi coelous D. Hetero coelous
14. Renal portal system is absent in

A. Amphibians B. Reptiles C. Birds **D. Mammals**

15. The gland which regulate the body temperature
    A. Sabaceous glands **B. Sweat glands** C. Mammary glands D. Scent glands
16. Our National animal
    A. ***Panthera tigris*** (tiger) B. Macropus (kangaroo) C. Macaca (monkey) D. Lion

SHORT ANSWER QUESTIONS

1. Explain the functions of foetal membranes
2. What are the functions of placenta
3. What is blubber and what is its function
4. Name the ear ossicles present in the middle ear
5. What type of teeth are present in mammals
6. Explain the functions of skin glands present in mammals.

LONG ANSWER QUESTIONS

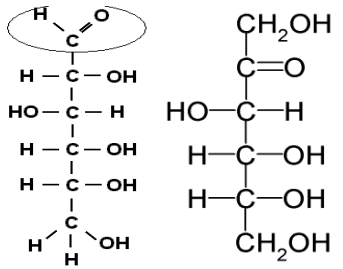
1. Describe the general characters of mammalia.

UNIT-VI
BIOMOLECULES
MODULE-32: CARBOHYDRATES

Carbohydrates may be defined as polyhydroxy aldehydes or ketones or as substances that yield one of these compounds on hydrolysis. Carbohydrates are the organic compounds consisting of carbon, hydrogen and oxygen, the last two in a 2:1 ratio as in water. Carbohydrates are a group of universally occurring compounds having the general formula $(CH_2O)_n$, in which 'n' is 3 or greater. Carbohydrates serve as the chief source of energy in the food of many animals. The carbohydrates are widely distributed both in animal and plant tissues. In animal cells they occur chiefly in the form of glucose and glycogen, where as in plants cellulose and starch are the main representatives. Carbohydrates are also important structural components.

STRUCTURE

Carbohydrates are aldehydes and ketone derivatives of Polyhydroxy alcohols. Each carbohydrate therefore contains an aldehyde or a ketonic group and is known as aldose or a ketose.



Glucose (Aldose)

Fructose (Ketose)

CLASSIFICATION

Carbohydrates are classified into three groups.

1. Mono Saccharides
2. Oligo Saccharides and
3. Poly Saccharides

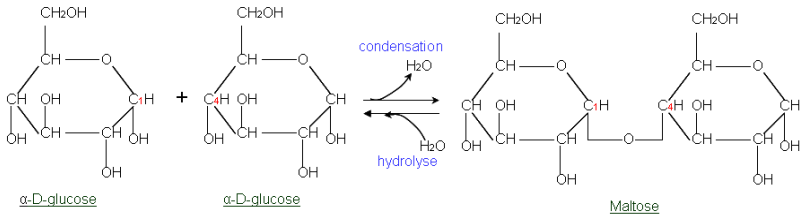
MONO SACCHARIDES (SIMPLE SUGARS):

Monosaccharides are the simplest carbohydrates which cannot be hydrolyzed to smaller molecules. The monosaccharides are divided into two categories, based on the functional group and the number of carbon atoms. When the functional group in monosaccharides is an aldehyde, they are known as aldoses Ex: glyceraldehyde, glucose. When the fuctional group is a keto (-c=o) group, they are referred as ketoses ex: fructose.

Based on the number of carbon atoms, the mono saccharides are regarded as trioses (3c), tetroses (4c), pentoses(5c), hexoses (6c), heptoses (7c) and octoses (8c). Pentose sugars (ex. Ribose, deoxy ribose) are important constituents of nucleic acids. Hexoses are physiologically the most important of the monosaccharides. The important hexoses are Glucose, fructose and galactose. Glucose is the principal sugar in blood, serving the tissue as a major metabolite fuel.

OLIGO SACCHARIDES:

The Oligo saccharides are those Carbohydrates which on hydrolysis give two to ten simple mono saccharide molecules. During union of monosaccharide units water molecule is eliminated and the units are linked through an oxygen bridge known as glycosidic linkage.



Glycosidic bond
Formation of Maltose

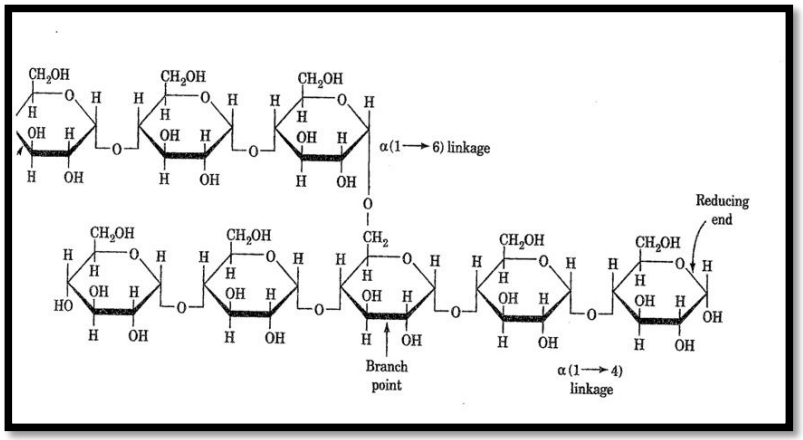
The oligo saccharides are further classified depending upon the number of monosaccharide units formed on hydrolysis into Disaccharides, tri-, tetra-, and penta saccharides, respectively. Disacharieds on hydrolysis produce two molecules of the same or different mono saccharides.

Maltose ⟶ Glucose + Glucose
Sucrose ⟶ Glucose + Fructose
Lactose ⟶ Glucose + Galactose

Tri, tetra and penta saccharides on hydrolysis produce, three, four and five mono saccharide units respectively. The natural source of oligo saccharides are green plants.

POLY SACCHARIDES:

Majority of the carbohydrates found in nature occur as polysaccharides of high molecular weight. Polysaccharides yield more than 10 molecules of monosaccharides on hydrolysis. Some Polysaccharides are linear polymers and others are highly branched. In all cases the linkage that unites the monosaccharide units is the glycosidic bond. They are tasteless, colourless and insoluble in water. Because of insolubility and large size they form colloidal solutions and will not pass across natural animal membranes. They are represented by a general formula $(C_6H_{10}O_5)_n$.



Structure of amylopectin (Branched Starch)

Polysaccharides are of two types

a. HOMO POLYSACCHARIDES (HOMOGLYCANS):

They contain mono saccharide units of a single type.

Ex: starch, inulin, cellulose, glycogen

b. HETERO POLYSACCHARIDES (HETROGLYCANS):

They possess two or more different types of mono saccharide units or their derivatives.

Ex: chitin, heparin, chondroitin sulfate etc.

FUNCTION OF CARBOHYDRATES:

Carbohydrates participate in a wide range of functions.

1. They are the most abundant dietary source of energy (4 cal/g) for all organisms. About 60% of the total energy requirement of man is provided by the breakdown of carbohydrates.

2. Carbohydrates play a key role in the metabolism of amino acids and fatty acids.
3. Carbohydrates serve as an important structural material in some animals and in all plants, where they constitute the cellulose frame work, Monsaccharides are important constituents of nucleic acids, co- enzymes, Flavo proteins etc. Heparin prevents the clotting of blood. Chondroition sulphates are found in cornea, cartilage tendons, skin, heart valves and saliva. Glycosides are components of steroid hormones.
4. Some carbohydrates are essential for normal oxidation of fats.
5. Carbohydrates are utilized as raw materials for several industries. Ex: paper, plastic, textiles, alcohol etc.

CARBOHYDRATES OF PHYSIOLOGIC IMPORTANCE

1. **Ribose:** It is a structural element of ATP, nucleic acids(RNA) and coenzymes (NAD, NADP, Flavo proteins)
2. **Deoxy Ribose:** It is a structural element of Nucleosides, Nucleotides and DNA
3. **Glucose:** Glucose is the sugar of the body.It is the principal sugar in blood, serving the tissue as a major metabolic fuel. Structural unit of cellulose in plants.
4. **Fructose:** It occurs naturally in fruit juices and honey.
5. **Galactose:** It is synthesized in mammary glands and hydrolysed to make the lactose of milk.
6. **Sucrose:** Most commonly used table sugar.
7. **Lactose:** Major sugar in milk.
8. **Maltose:** Product of starch hydrolysis.
9. **Cellulose:** It is the chief constituent of plant cell wall. It is absent in animal body.
10. **Starch:** Starch is the carbohydrate reserve of plants which is the most important dietary source for higher animals, including man. It is found in cereals, potatoes, legumes, roots, tubers, vegetables etc.
11. **Glycogen:** Glycogen is the carbohydrate reserve in animals, hence often referred to as animal starch. It is present in high concentration in liver, followed by muscle ,brain etc. Glycogen is a readily mobilized storage form of glucose.
12. **Chitin:** It is an important structural Polysaccharide in invertebrates. Ex: The exoskeleton of insects and crustaceans.
13. **Inulin:** It is a polymer of fructose found in dahlia bulbs, garlic, onion etc. It is used for assessing kidney function through measurement of glomerular filteration rate (GFR).

CHECK POINTS

- Carbohydrates are the polyhydroxy aldehydes or ketones or compounds which produce them on hydrolysis.
- Carbohydrates are the major dietary energy sources.
- Carbohydrates are classified into 3 groups namely mono saccharides, oligo saccharides and Polysaccharides.
- Monosaccharides are further classified on the basis of presence of functional groups(into aldoses and ketoses) and the number of carbon atoms (trioses, tetroses, pentoses, hexoses and heptoses)
- Oligo saccharides on hydrolysis give 2 to 10 mono saccharide units.
- Among the oligosaccharides, disaccharides are the most common. These include lactose (milk sugar), maltose (malt sugar) and sucrose (table sugar/ cane sugar).
- Polysaccharides are the polymers of monosaccharids or their derivatives , held together by glycosidic bonds.
- Homopolysaccharides are composed of a single type of monosaccharide units (e.g., starch, Glycogen etc)

- Hetero polysaccherides contain a mixture of few monosaccharide units or their derivatives (e.g., chitin, heparin etc).

Object type Questions:

1. The sugar present in the blood
   A. **Glucose** B. Fructose C. Galactose D. Manose
2. Carbohydrates which are not found in plants
   A. Inulin B. Cellulose C. Starch **D. Galactose**
3. Major metabolic fuel of the tissue is
   A. Galactose B. Sucrose C. Fructose **D. Glucose**
4. Monosaccharide units are linked with each other with the help of
   A. Hydrogen bonds B. Covalent linkages C. Ionic bonds **D. Glycosidic linkages**
5. Maltose is a
   A. **Disaccharide** B. Monosaccharide C. Oligosaccharide D.Polysaccharide
6. One of the following statement is not correct with regards to polysaccharides
   A. They are represented by a general formula $(C_6H_{10}O_5)_n$
   B. They are tasteless, colourless and insoluble in water
   C. They form colloidal solutions
   D. On hydrolysis they give 2 to 10 monosaccharide units
7. Animal starch is
   A. Glucose **B. Glycogen** C. Chitin D. None
8. Important structural polysaccharide present in the exoskeleton of some invertabrates is
   A. Inulin B. Glycogen **C. Chitin** D. Cellulose

SHORT ANSWER QUESTIONS

1. Define carbohydrates
2. Explain the significance of carbohydrates
3. Write notes on disaccharides
4. Write short notes on monosaccharides
5. Explain polysaccharides
6. List out some important functions of carbohydrates

LONG ANSWER QUESTIONS

1. Describe the classification of carbohydrates
2. What are mono and oligo saccharides. Describe the important monosaccharides and disaccharides of physiological importance?

UNIT-VI
BIOMOLECULES
MODULE-33: LIPIDS

INTRODUCTION

The lipids are a heterogeneous group of substances which have the common property of being relatively insoluble in water and soluble in non- polar solvents such as ether, chloroform and benzene. The lipids include fats, oils, waxes and related compounds. All lipids consist of combinations of carbon, hydrogen and oxygen. In the body, fat serves as an efficient source of energy when stored in adipose tissue. In animals, these are stored in adipose tissue, bone marrow and nervous tissue. In case of plants, seeds, nuts and fruits contain them.

Classification: Lipids are classified into

A. Simple lipids
B. Compound lipids
C. Derived lipids and
D. Hydro Carbons

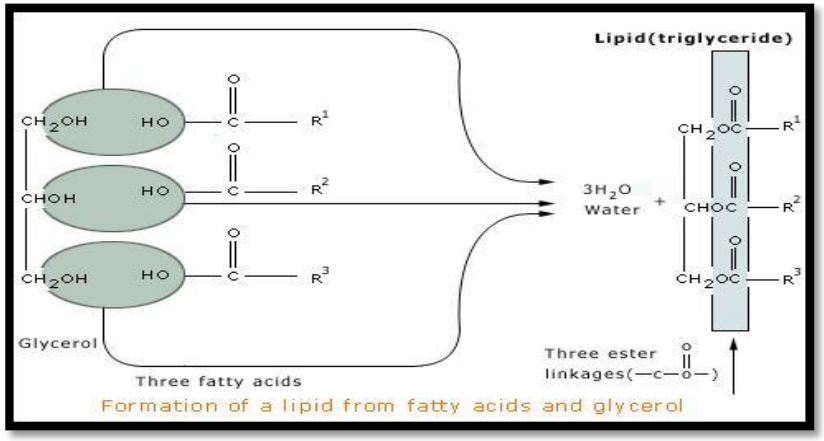
1. SIMPLE LIPIDS

Simple lipids are esters of fatty acids with alcohols or the tri glycerides containing fatty acids and alcohol. These are mainly two types

A. FATS AND OILS:

These are esters of fatty acids with glycerol. Oil is a liquid while fat is a solid at room temperature. The fatty acids are grouped into saturated and unsaturated fatty acids. In saturated fatty acids all the carbon atoms are provided with two 'H'atoms but in unsaturated acids some or all the carbon atoms are not fully saturated with hydrogen atoms and possess double bonds. The unsaturated fatty acids are more common in animals.

Glycerol + 3 Fatty acids $\xrightarrow[H_2O]{\text{Lipase}}$ Triglyceride



Formation of a Triglyceride

B. WAXES

Esters of fatty acids (usually long chain) with alcohols other than glycerol. In the human body the commonest waxes are the cholesterol esters.

2. COMPOUND LIPIDS

Esters of fatty acids with alcohol contains additional groups such as phosphates, nitrogenous base, carbohydrate, protein etc. They are further divided into

A. PHOSPHOLIPIDS

Lipids containing phosphoric acid and a nitrogen base in addition to alcohol and fatty acids. Glycerophospholipids contain glycerol as

the alcohol ex: lecithin, cephalin, sphingophospholipids (contain sphingosine as the alcohol eg: Spingomyelin). Lecithins play an important role in permeability, osmotic tension and surface condition of cells. Cephalins are important factors in blood coagulation. Sphingomyelin is a common constituent of brain, nerve and myelin sheath and is there fore absent in plants and micro organisms.

B. GLYCOLIPIDS

These are the compounds of the fatty acids with carbohydrates, containing nitrogen but phosphoric acid and glycerol are absent. The alcohol in sphingosine. Cerebrosides and gangliosides are common. They are found in nervous tissue.

C. LIPOPROTEINS

These are the complexes of lipids and proteins. They are found in cell membrane, egg yolk etc .

D. OTHER COMPLEX LIPIDS

Sulfolipids, amino lipids and lipopoly- saccharides are among the other complex lipids.

3. DERIVED LIPIDS

Derived lipids include substances derived from simple and compound lipids on hydrolysis. These include fatty acids, glycerol, steroids, alcohols, fatty aldehydes and ketone bodies .

4. HYDROCARBONS:

These are substances which don't have any structural relation ship to fatty acids but yet are grouped with lipids only because of their similar solubility properties. These are Carotenoids, vitamin A,E, and K etc.

FUNCTIONS OF LIPIDS

1. Lipids provide food of high caloric value (1 gram fat produces about 9.3 kilo calories of heat)
2. These serve as the structural components of cellular membranes.
3. These serve as intra cellular storage deposits of metabolic fuel.
4. Many enzymes require lipid molecules for maximal activation.
5. Adrenal corticoid, sex hormones and vitamin D_2 are synthesized from lipid derivatives.
6. Much of the lipid of mammals is located sub cutaneously and acts as an insulator against excessive heat loss to the environment.
7. As compounds of the inner mitochondrial membrane, lipids (Phospolipids) participate in electron transport chain.
8. Edible oils extracted from many seeds are used in cooking
9. Myelin sheath around nerve fibers take part in insulation
10. Phospholipids play an important role in the absorption and transportation of fatty acids.
11. Lipids act as a solvent for fat soluble vitamins A, D and E.
12. In animals the fat produce a shock absorbing cushion around eyeballs, gonads, kidneys and other vital organs.

CHECK POINTS

- Lipids are insoluble in water but soluble in solvents like ether, chloroform, benzene etc.
- Lipids consists of carbon, hydrogen and oxygen
- Lipids are classified into simple lipids, compound lipids, derived lipids and hydrocarbons.
- Simple lipids are esters of fatty acids with alcohols.
- Fats, oils and waxes are simple lipids.

- Compound lipids on hydrolysis yield in addition to fatty acids, and alcohol other groups such as phosphate, nitrogenous base, carbohydrates, proteins etc.
- Derived lipids include substances derived from simple and compound lipids on hydrolysis.
- Important function of lipids includes – mechanical protection, heat insulation, hormone synthesis, enzyme activation, carrier of essential compounds, rich source of respiratory energy, structural components of cells and chief food storage compounds.

OBJECT TYPE QUESTIONS

1. The lipids present in brain, nerve and myelin sheath are
   A. **Phospholipids** B. Glycolipids C. Lipoproteins D.Hydrocarbons
2. One of the following are complexes of lipids and carbohydrates
   A. Phospholipids **B. Glycolipids** C. Lipoproteins D. Hydrocarbons
3. Cerebrosides and gangliosides are
   A. Phospholipids **B. Glycolipids** C. Lipoproteins D. Derived lipids
4. Cerebrosides and gangliosides are found in
   A. **Nervous tissues** B. Egg yolk C. Gonads D. Kidneys
5. Lipids
   A. Serve as the structural components of cellular membranes
   B. Provide food of high caloric value
   C. Serve as intracellular storage depots
   D. All

SHORT ANSWER QUESTIONS

1. Write notes on fats and oils?
2. Write notes on phospholipids?
3. What are glycolipids?
4. List out some important functions of lipids?
5. What are derived lipids?

LONG ANSWER QUESTIONS

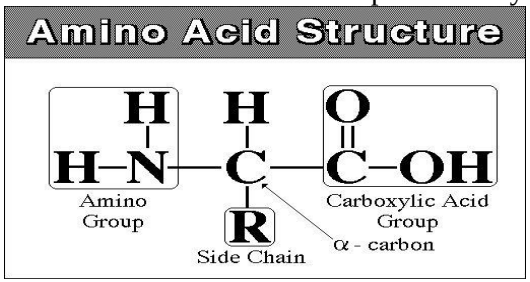
1. Classify lipids, giving examples?
2. Define lipids. Discuss their functions in details?

UNIT-VI
BIOMOLECULES
MODULE-34: PROTEINS

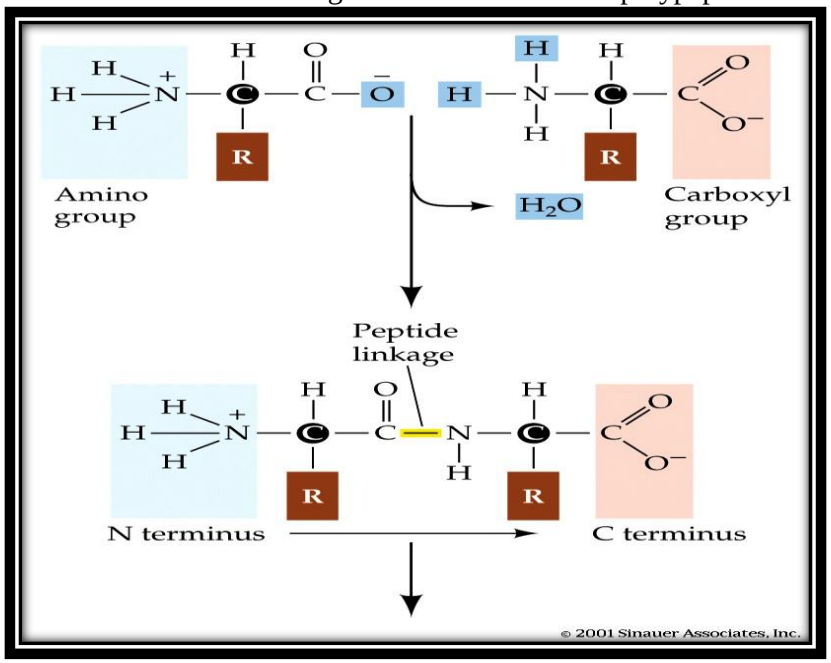
AMINO ACIDS

Amino acids are essential components of all living cells as building blocks of proteins. Amino acids are a group of organic compounds containing two functional groups amino and carboxyl. The amino group being basic combines with acids and the carboxyl group being acidic combines with the bases. Thus proteins serve as biological buffers against excess bases or acids that might harm the protoplasm.

The general structure of an amino acid is represented by the formula



Where $-NH_2$ is an amino group, -COOH a carboxylic group and –R an organic group referred to as a side chain which varies in structure from one amino acid to the other. The carbon atom to which 'R' group is bonded is called the α – carbon. The amino acids present in proteins have both an amino and a carboxylic group attached to α – carbon, hence they are described as α – amino acids. The simplest amino acid is glycine where R = H, and if R = CH_3 the amino acid is alanine. There are 20 different 'R' groups and hence there are 20 different amino acids found in proteins. These amino acids incorporate in any combination and sequence and form a vast number of proteins. A bond is formed between the amino group of one amino acid and carboxylic group of other amino acid is called peptide bond. With the help of such peptide bonds a variety of amino acids can form a long chain molecule called polypeptide.



ESSENTIAL AMINO ACIDS

Higher animals including man can synthesize only about 10 of the 20 or so naturally occurring amino acids from the metabolic intermediates. The other 10 amino acids that cannot be synthesized in sufficient quantities and that are needed for the normal functioning of the animal are called nutritionally essential amino

acids. These must be obtained from the diet, a deficiency in any one prevents growth in young animals and may even cause death. The essential amino acids are – arginine, histidine, isoleucine, leucine, lysine, methionin, threonine, phyenyl alanine, tryptophan and valine.

NON ESSENTIAL AMINO ACIDS

Those amino acids that can be synthesized in the body from alpha – keto acids are designated nutritionally non – essential amino acids. These amino acids are Tyrosine, serine, alanine, asparagine, proline, hydroxy proline, aspartic acid, glycine, glutamine, glutamic acid and cystine.

USES OF AMINO ACIDS

1. They are used as nutritional supplements in foods.
2. In food processing they used as flavor enhancers and additives.
3. As precursors they are used in chemical and pharmaceutical industries for the manufacture of detergents, polyaminoacids, and agricultural chemicals.

STRUCTURE OF PROTEIN MOLECULES

Proteins are natural polymers that are ranked first amongst the chemical substances essential for the growth and maintenance of life. These are the compounds of carbon, oxygen, hydrogen and nitrogen. Some proteins contain additional elements such as phosphorus, iron, zinc and copper. The proteins are very large compact molecules often referred to as macro molecules. Each protein is made up of numerous simpler units called the amino acids which are joined together by peptide bonds. When many amino acids are linked together, the combination is called polypeptide. The polypeptide chains unite to form very large molecule called proteins. Various functions of proteins will be discussed in the next module.

STRUCTURE OF PROTEINS

Four basic structural levels are assigned to proteins. These are primary, secondary, tertiary and quaternary structures.

1. PRIMARY STRUCTURE:

The primary structure of a protein refers to the linear sequence of amino acids in the polypeptide chains and location of disulphide bridges, if there are any. The amino acids are linked with each other by peptide bonds only. The primary structure is thus a complete description of the covalent connection of a protein.**[** Primary structure of the protein hormone insulin contain two chains, α and β, joined together by two disulphide bonds. α – chain contains 21 and β chain contain 30 amino acids**.]**

2. SECONDARY STRUCTURE:

All protein molecules are not simple long polymeric chains. Instead the chains are coiled into a spiral called an α – helix and β-pleated sheet . The folding of a linear polypeptide chain into a specific coiled structure is referred to as the secondary structure of a protein. Such coiling or folding is produced or maintained by hydrogen bonds formed between the CO and NH groups of adjacent coils. Each turn of α – helix contains 3.6 amino acids and travels a distance of 0.54 nm. The spacing of each amino acid is 0.15 nm. The right handed α – helix is more stable than left handed helix.The secondary structure of protein is a characteristic of fibrous and contractile proteins such as keratin of hair, fibrin of blood clots, myosin of muscle, collagen and elastin of connective tissue.

3. TERTIARY STRUCTURE:

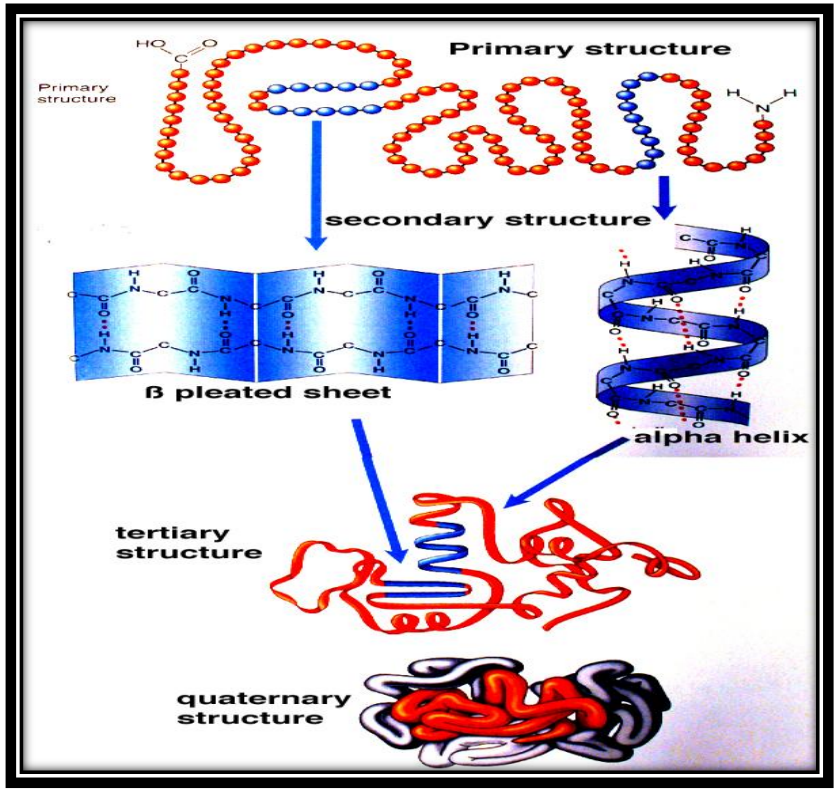
The tertiary structure of a protein results when a helix folded in specific fashions to give three dimensional or tertiary structure. It is

a compact structure with hydrophobic side chains held interior while the hydrophilic groups are on the surface of the protein molecule. This type of arrangements ensures stability of the molecule. Tertiary structure is maintained chiefly by 4 kinds of bonds – Hydrogen bonds, Ionic bonds, Hydrophobic bonds and Disulphide bonds.

4. QUATERNARY STRUCTURE:

In proteins that are made up of two or more polypeptide chains, the quaternary structure refers to the specific orientation of these chains with respect to one another and the nature of the interactions that stabilize this orientation.

Many proteins contain more than one polypeptide chain. The individual polypeptides fold to yield secondary and tertiary structures but also bind to one another in precise ways through hydrogen bonds, vander waals forces, ionic bonds, disulphide bridges and hydrophobic interaction. The organization of two or more polypeptide chains into one unit is called the quaternary structure of protein.



CLASSIFICATION

The classification of proteins is based upon three general properties namely-shape, chemical composition and solubility.

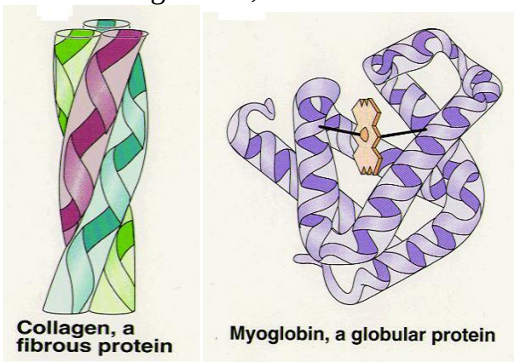
I. BASED ON THE SHAPE OF THE MOLECULE:

Based on the shape of the molecule proteins are classified into two major classes.

FIBROUS PROTEINS

Fibrous proteins consists of linear, thread like molecules (polypeptide chains) which lie side by side to form fibres. Fibrous proteins are the basic structural elements in the connective tissue of higher animals.

Ex: Keratin of hair, horn, nails and feathers. Collagen of tendons and Cartilage Elastin of ligaments, Bone matrix etc



GLOBULAR PROTEINS

Globular proteins are made of polypeptide chains that are tightly folded into compact, spherical or globular shapes. Most of them are soluble in water.

Ex: Serum albumins, Haemoglobin, All enzymes, Antibodies
Few hormones etc

II. BASED ON COMPOSITION:

Based on the composition, proteins are divided into two major classes,

1. SIMPLE PROTEINS:

These on hydrolysis yield only amino acids. No other organic or inorganic hydrolysis products are formed.

Ex. Egg albumins, serum albumins, Globulins (tissue globulin, serum globulin) and glutelins (glutenin in wheat)

2. CONJUGATED PROTEINS:

Conjugated proteins are those which on hydrolysis yield aminoacids along with other organic or inorganic components (non-protein part). The term prosthetic group is generally used to designate the non-aminoacid moiety.

On the basis of chemical nature of their prosthetic groups, conjugated proteins are classified into following classes.

S.No	Class	Prosthetic Group	Examples
1	Glycoproteins	Carbohydrates (Hexosamine, Galactose, Mannose Etc)	Albumins, Globulins
2	Lipoproteins	Lipids	Cholesterol Lipovitelline Of Egg Yolk Etc
3	Nucleo Proteins	Nucleic Acids	DNA,RNA
4	Phosphoproteins	Phosphoric Acid	Casein (Milk)
5	Flavo Proteins	Flavin Nucleotide	Succinate Dehydro Genase, D-Amino Acid Oxidase
6	Chromoproteins	Coloured Pigment	Haemoglobin, Cytochrome-C

7	Metallo Proteins	Iron, Copper, Zinc	Ferritin, Tyrosine Oxidase

III. BASED ON SOLUBILITY

Based on solubility, proteins are classified into

1. **Albumins:** Soluble in water, dilute salt solutions, dilute acids and bases
   Ex. Egg white (ovalbumin), Serum albumin
2. **Globulins:** Insoluble in water but soluble in dilute salt solution, dilute acid or bases
   Ex: Globulins of egg white, Serum globulins, Fibrinogen, Myosin of muscle
3. **Histones:** They are basic proteins that are soluble in water and in most common salvents. Insoluble in Ammonium hydroxide.
   Ex. Found in Thymus, Pancreas, Spleen, Nucleic acids
4. **Protamines:** Soluble in Ammonium hydroxide solution.
   Ex. Found in Nucleic acids, Sperm cells of fish (salmin from salmon sperm)
5. **Glutelins:** Insoluble in distilled water or alcohol but soluble in dilute acid or base solutions.
   Ex. Found in plant seeds (Glutenin from wheat, oryzenin from rice)
6. **Prolamines:** Insoluble in absolute alcohol and water but soluble in 70 to 80% alcohol, dilute acids or bases
   Ex. Plant seeds (Zein from maize and gliadin from wheat)
7. **Scleroproteins**: Insoluble in distilled water and any of the other common solvents.
   Ex. Fibrous proteins

FUNCTIONS OF PROTEINS:

Proteins are indispensable for life and perform a number of funcitons

1. Proteins primarily serve as structural proteins by contributing towards the building of cell organelles, tissue protective coverings etc. Exapmles of structural proteins are myosin of muscles, keratin of skin and hair in mammals and collagen of connective tissue.
2. The most important class of proteins are the enzymes. They catalyze different kinds of chemical reactions. Most enzymes are characterized by a high degree of specificity, i.e, they will catalyze one particular reaction but not another and require an optimum pH and temperature to work.
3. Many hormones are proteins and play important role in metabolic reactions.
   Ex. Insulin, oxytocin etc.
4. The blood contains a number of proteins with different functions.
   a. Serum albumins-Control the osmotic pressure and the pH of the blood
   b. Fibrinogen- play important role in blood coagulation
   c. Haemoglobin –transport oxygen from the lungs to all tissues of the body
5. Immunoglobulins of the blood plasma (β-and Y-globulins) in mammals and other animals act as antibodies that neutralize the harmful effects of such foreign agents as viruses, bacteria and cells from other organisms.
6. Proteins like actin and myosin are directly involved in the contraction of muscles through which the mechanical work is performed

7. Proteins of our food serve as a source of the aminoacids. These essential amino acids are readily synthesized in plants and in some animals and are ingested as proteins by man.
8. The visual purple pigment, rhodopsin is made up of retinene (an aldehyde derivative of vitamin A) and a protein opsin. Melanin, the pigment of skin, hair and choroid layer of eye is derived from the amino acid tyrosine.

CHECK POINTS

- Amino acids are a group of organic compounds containing two functional groups – amino and carboxyl.
- Twenty different types of amino acids are found in proteins.
- Peptide bond link the two amino acids.
- The amino acids which cannot be synthesized by the body and need to be supplied through the diet are called essential amino acids.
- Those amino acids that can be synthesized in the body and need not be consumed in the diet are called non – essential amino acids.
- Proteins are natural polymers often referred to as macromolecules made up of numerous amino acids which are joined together by peptide bonds.
- Four levels of protein structure may be described. They are primary structure, secondary structure, tertiary structure and quaternary structure.
- The linear sequence of amino acids forming the back bone of proteins is called its primary structure.
- The folding of a linear polypeptide chain into a specific coiled structure is known as the secondary structure.
- The three dimensional structure of a protein is its tertiary structure.
- Some proteins are composed of two or more polypeptide chains referred to as submits. The spacial arrangement of these subunits is called an quaternary structure.

MULTIPLE CHOICE QUESTIONS

1. The bond formed between the amino group of one amino acid and carboxylic group of other amino acid is called.
   A. Ionic bond B. Covalent bond C. Hydrogen bond **D. Peptide bond**
2. Which type of protein structure is shown in the myosin of muscle
   A. Primary **B. Secondary** C. Tertiary D. Quaternary
3. Which of the following statements about amino acids is not true
   A. They are the building blocks of proteins
   B. They contain amino and carboxylic groups
   C. They are used as nutritional supplements in foods
   D. Bond formed between the amino group of one amino acid and carboxylic group of other amino acid is covalent bond
4. The following is an essential amino acid
   A. Threonine B. Tryptophan C. Valine **D. All**
5. One of the following is a non – essential amino acid.
   A. Tyrosine B. Serine C. Alanine **D. All**
6. The simplest amino acid is
   A. **Glycine** B. Alanine C. Serine D. Leucine
7. Peptide bonds are present between
   A. Pyrimidine base **B. Amino acids** C. Purine bases
   D. Purine and Pyrimidine bases

SHORT ANSWER QUESTIONS:

1. Explain the structure of an amino acid?
2. What are essential and non – essential amino acids?
3. List out the uses of amino acids?

4. Explain the quaternary structure of proteins?
5. Describe the tertiary structure of proteins?
6.

LONG ANSWER QUESTIONS:

1. Describe the structure of protein molecules?
2. What are amino acids? Explain their general structure and add a note on essential and non essential amino acids?

UNIT-VI
BIOMOLECULES
MODULE-35: NUCLEIC ACIDS

WHAT ARE NUCLEIC ACIDS

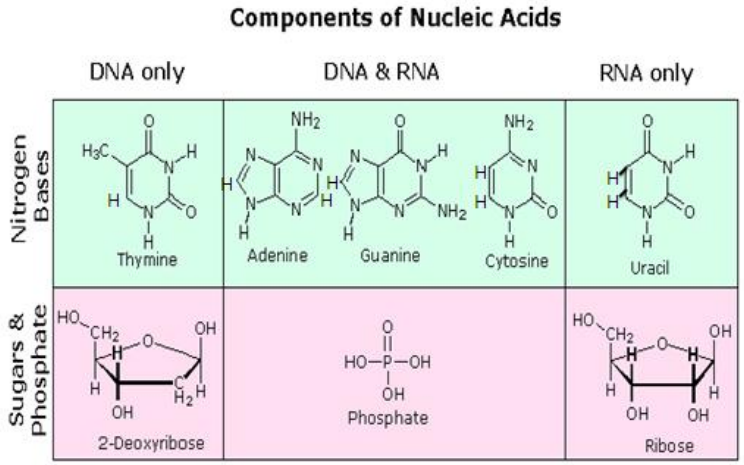
Nucleic acids are present in all living organisms, whether plants, animals or viruses. They are generally associated with proteins to form nucleoproteins. Nucleic acids were first isolated by **Fredrich Mieshier** 1871 from the nuclei of pus cells (WBC) and named them as nuclein. **Altmann** (1899) used the term nucleic acid to replace nuclein.

There are two types of nucleic acids, Deoxyribose nucleic acid (DNA) and Ribose nucleic acid (RNA). They derive their name because of their primary occurrence in the nucleus and acidic in nature.

DNA is localised mainly in the nucleus as a part of chromosomes, it is also found in mitochondria, chloroplast and in other self reproducing cell organelles. RNA's bulk is found in the cytoplasm though some is also found in nucleus particularly in nucleolus with smaller amounts on the chromosomes and the nuclear sap. DNA is the hereditary material. RNA was in some way involved in protein synthesis and that DNA was involved in RNA synthesis. DNA is the genetic material of most organisms, including many viruses. Some viruses, however, have RNA as their genetic material.

CHEMICAL COMPOSITION OF NUCLEIC ACIDS

Elements taking part in the constitution of nucleic acids are C,H,O,N and P. Nucleic acids are made up of monomeric units called nucleotides, hence they are designated as polynucleotides. These nucleotides are the building blocks of nucleic acids and are the structural units of nucleic acids. Nucleotides are not stable units and can be further hydrolysed to nitrogen bases, pentose sugar and a molecule of phosphoric acid

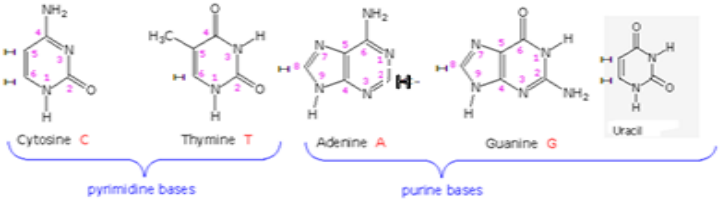


NITROGEN BASES:

These are organic compounds which possess nitrogen in them.

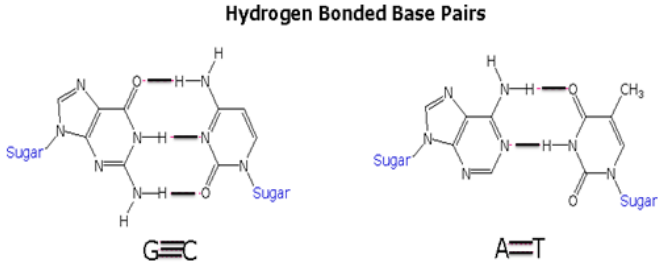
- These bases are classified as **purines** (These are two - ringed nitrogen compounds) and **pyrimidines** (a single ringed nitrogen compounds).
- In DNA, there are four different bases: **Adenine** (A) and **Guanine** (G) the purines. **Cytosine** (C) and **Thymine** (T) are the pyrimidines. These are frequently symbolized by their single letter abbreviations.

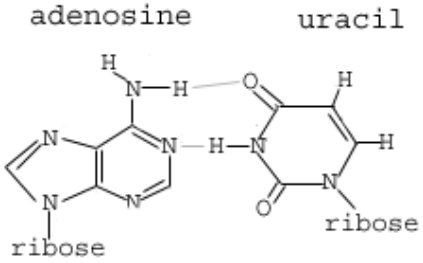
- RNA also contains four different bases. Three of these are the same as in DNA: Adenine, Guanine, and Cytosine. RNA contains **Uracil** (U) instead of Thymine (T).



BASE PAIRING

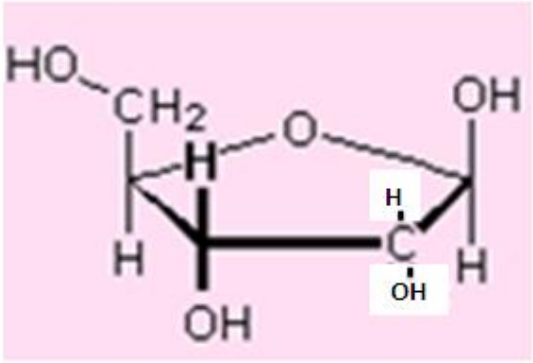
In DNA, Adenine always pairs with Thymine, and Guanine always pairs with Cytosine. The pairing is the same in RNA except Uracil replaces Thymine. As a consequence of this pairing in DNA, there are always the same number of A and G residues and T and C residues. This is known as Chargaff's rule. The base ratio A=T/G=C is constant for a species. The result of this pairing is that two different nucleic acid molecules with complementary sequences wrap around each other to form a double helix. This is shown schematically in the picture.





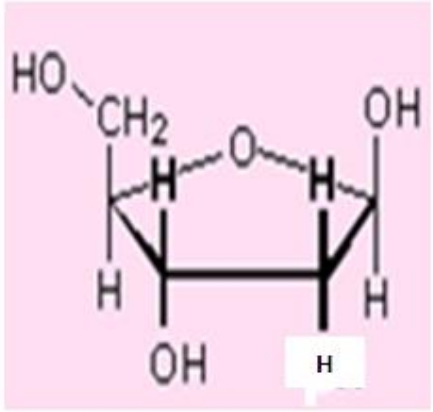
PENTOSE SUGAR:

- The sugars found in nucleic acids are pentose sugars, with five Carbon atoms.
- Ribose, found in Ribonucleic acid (RNA), is a "normal" sugar, with one oxygen atom attached to each carbon atom.



***α*–D Ribose sugar**

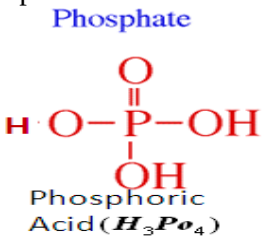
- Deoxyribose, found in Deoxyribonucleic acid (DNA) contains one oxygen atom lesser (at 2nd Position) than the ribose sugar present in RNA.



***α* -2-Deoxyribose sugar**

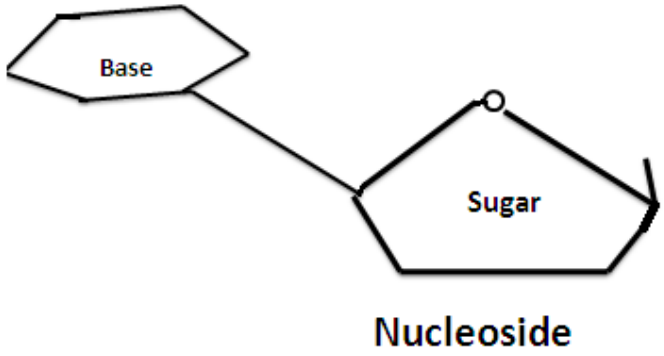
PHOSPHORIC ACID (H3PO4):

It links the consecutive nucleotides by joining their pentose sugars with a phosphate diester bond. This bond links carbon 3^{l} in one nucleoside with carbon 5^{l} in the next. The molecular structure of phosphoric acid may be represented as follows:



NUCLEOSIDES

A combination of a nitrogenous base and a molecule of sugar is called a **nucleoside**. Sugar +Nitrogen base = Nucleoside

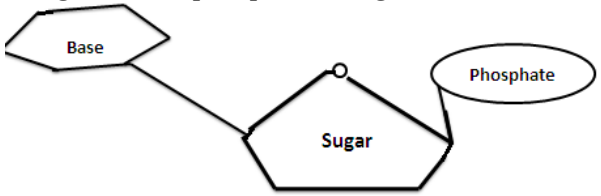


Nucleoside

Adenine linked to ribose or deoxyribose is called adenosine and the guanine nucleoside is called guanosine. The pyrimidine nucleosides are uridine, cytidine and thymidine. Deoxyribose sugar also forms nucleosides in a similar way as deoxy adenosine, deoxy guanosine, deoxy cytidine and deoxythymidine.

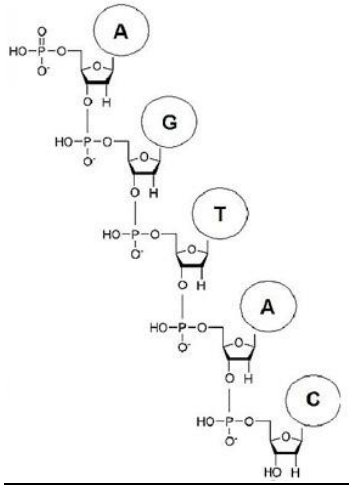
NUCLEOTIDES

A nucleoside and a phosphate molecule combine to form a nucleotide Nitrogen base + phosphate + sugar = nucleotide



Nucleotide

- Nucleotides formed with ribose are termed ribonucleotides, while those formed with deoxyribose are termed deoxyribonucleotides. There are four kinds of nucleotides in DNA.
    a. Deoxy adenylic acid
    b. Deoxy gyanylic acid
    c. Deoxy cytidylic acid
    d. Deoxy thymidylic acid
- The nucleotides bind to each other to form polynucleotide in DNA and RNA. Nucleic acids are linear polymers in which the nucleotides are linked together by means of phosphate diester bridges with the pentose sugar. These bonds link the 3 carbon in one nucleotide to the 5′ carbon in the pentose of the adjacent nucleotide. The back bone of nucleic acid consists of alternating phosphates and pentoses. The nitrogen bases are attached to the sugars of this backbone. The phosphoric acid uses two of its three acid groups in the 3`-5` diester links.



CHECK POINTS

1. The nucleic acids are very large molecules.
2. Deoxyribonucleic acid and ribonucleic acid are two types of nucleic acids found in living organisms.
3. Each nucleic acid is composed of three main parts. Sugar, nitrogenous bases and Phosphate.
4. The ribose or deoxyribose is the sugar component, purines and pyramidines are Nitrogenous bases, and phosphate is a salt of Phosphoric acid.
5. One purine form hydrogen bond with one pyramidine.
6. Adenine and guanine are purines and have two ringed structures.
7. Cytosine, thiamine and uracil are pyramidines and are made up of one ring structures.
8. Adenine always forms bond with thiamine or uracil and guanine with cytosine.
9. The sugar molecule bonds with base to form nucleoside.
10. The nucleoside bonds to phosphate with phosphate ester bonds and forms a nucleotide.

SHORT ANSWER QUESTIONS

1. Give an account of the components of nucleic acid.
2. What are the different nitrogen bases of a nucleotide?
3. How the structure of sugar is different in both nucleic acids.
4. Which bases are purines and Pyrimidines?
5. Write briefly about the different sugars which account for the structure of nucleic acids.
6. What is the role of phosphates in the structure of nucleic acids?
7. What is a nucleic acid and give types of nucleic acids.

LONG ANSWER QUESTIONS

1. What are the bases present in nucleic acids and explain them.
2. Give details on the components of Deoxyribonucleic acid.
3. Explain about the structural importance of sugar, phosphate, purine and pyrimidines of ribonucleic acids.

MULTIPLE CHOICE QUESTIONS

1. DNA is made up of the bases A, T, ___, and cytosine.
   A. Guanine
   B. Lysine
   C. Glycine
   D. Glutamic acid
2. Components of DNA are
   A. Phosphate, ribose, pyrimidines, and purines
   B. Sulfate, ribose, pyrimidines, and purines
   C. Phosphate and nucleotides
   D. Phosphate, deoxyribose, pyrimidines, and purines
3. With which of the following does thymine form hydrogen bonds in DNA?
   A. Adenine
   B. Guanine
   C. Cytosine
   D. Uracil
4. With which of the following does Ademine form hydrogen bonds in RNA?
   A. Adenine
   B. Guanine
   C. **Uracil**
   D. Cytosine
5. The sugar that is found in DNA but not in RNA is _____.
   A. Ribose
   B. Deoxyribose
   C. Hexose
   D. None of the above
6. The combination of base and sugar is called _____.
   A. Nucleotide
   B. Nucleoside
   C. Nitrogen base
   D. None of the above
7. Purine bases are
   A. G & C
   B. A & T
   C. A & G
   D. T & C
8. RNA doesn't have
   A. Thymine
   B. Uracil
   C. Guanine
   D. Cytosine
9. Which of the following found only in RNA
   A. Adenine
   B. Uracil
   C. Cytosine
   D. Guanine
10. RNA differs from DNA is having
    A. Thymine in place of uracil
    B. Uracil in place of adenine
    C. Uracil in place of thymine
    D. Both thymine and uracil

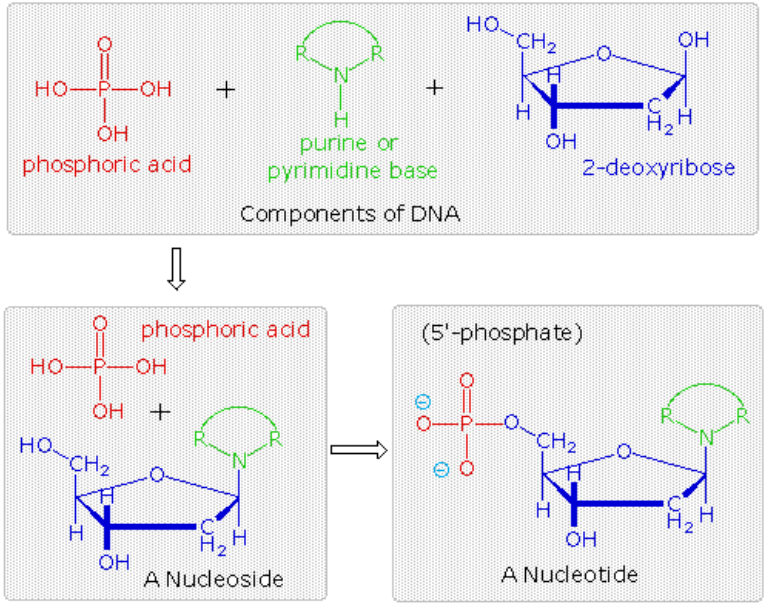
UNIT-VI
BIOMOLECULES
MODULE-36: DNA

DNA STRUCTURE

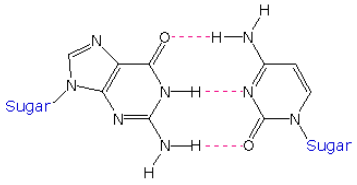
The widely accepted molecular model of DNA is the double helix structure proposed by **Watson and crick** in the year 1953 for which they were awarded noble prize in the year 1962. It is composed of two strands which are spirally coiled around one another. The strands are antiparallel to one another and are held closely by hydrogen bonds. It is coiled around its own axis.

DNA is a macro molecule formed by the linking of several thousand nucleotides. These are called monomers or building blocks of DNA. Hence, it is called polynucleotide strand. The two strands are complimentary to one another and are linked by nitrogen base pairs which appear as steps (rungs). The nucleotides are chemically composed of three parts – **phosphate group, deoxyribose sugar ($C_5H_{10}O_4$)** and **nitrogen bases.** Nitrogen bases are of 4 types namely **Adenine**, **Guanine, Cytosine** and **Thymine**. Adenine and Guanine are called **Purines** while Cytosine and Thymine are called **Pyrimidines**. In DNA molecule, the association of a sugar molecule and a base is known as a **'nucleoside'** and the association of phosphate group, sugar and a base is called a **'nucleotide'**.

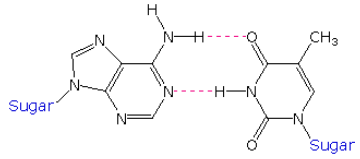
The nitrogen bases A, T and G, C are complimentary to each other. **Erwin Chargaff** discovered purines (A, G) and pyrimidines (C, T) exist in 1:1 ratio. Adenine (A) is complimentary to Thymine (T) and vice versa. They attract each other by two weak hydrogen bonds (A=T). Guanine (G) and Cytosine (C) are complimentary to each other and attract by forming three hydrogen bonds (G≡C).Due to this type of base pairing the two strands are complementary to each other. The base pair interaction leads to the formation of double helix with stacked base pairs. This is called annealing.



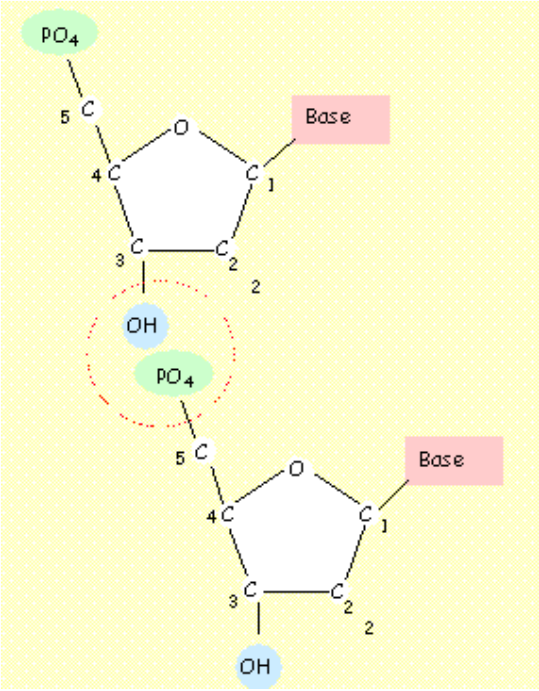
Hydrogen Bonded Base Pairs



G≡C

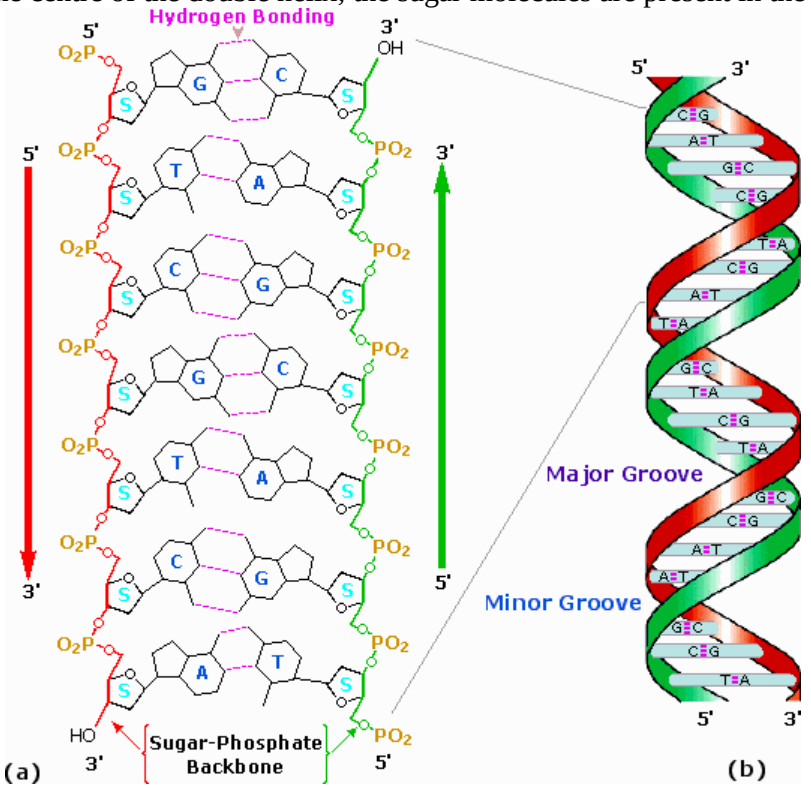


A=T



The back bone of DNA polynucleotide strand is formed by alternately arranged phosphate and sugar groups. They are linked with each other by phosphate – diester bonds. With these bonds the DNA molecules is formed by helical coiling of two antiparallel strands running one from 5′……3′ and other from 3′ …….. 5′. Or in opposite direction so that the 3′ end of one strand lies opposite to the 5′end of another strand. One end of the poly nucleotide chain has a sugar residue with c-3 carbonatom which is not linked to another nucleotide and the other end sugar residue c-5 is also not linked. These are known as 3′ and 5′ end respectively.

The DNA double helix can be compared to a twisted ladder. The steps are formed by the nitrogen bases and the side walls by the sugar and phosphate molecules. In fact the nitrogen bases occupy the centre of the double helix, the sugar molecules are present in the



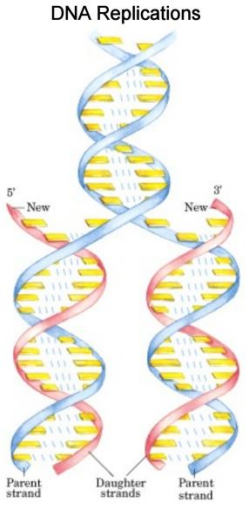
middle while phosphate molecules are outside of the sugar molecules.

DNA consists of two complementary chains twisted around each other. The strands completes a turn each 34A^{o}. Each nucleotide occupies 3.4 A^{o} . Thus, there are 10 nucleotides per turn. Each successive nucleotide turns 36 degrees in horizontal plane. The width of the DNA molecule is 20 A^{o}. The twisting of the strands results in the formation of minor and major spiral grooves. The narrow groove (minor groove) is the distance between the paired molecules while the wide groove (major groove) is the space between successive turns when the pair is wound into helix.

FUNCTIONS OF DNA

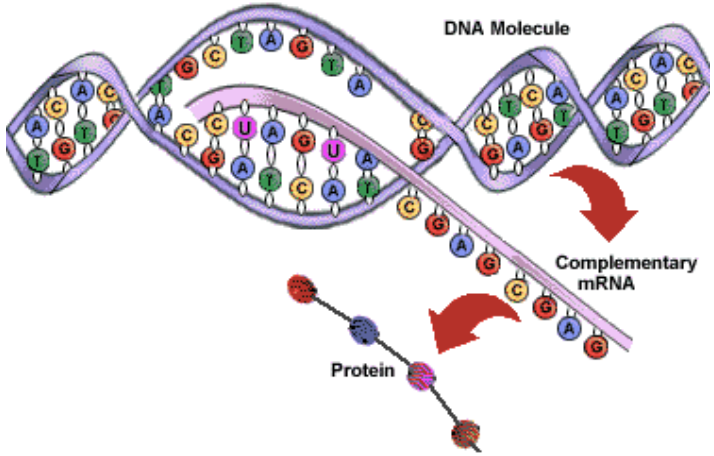
1. REPLICATION:

DNA has the ability to replicate. (formation of new molecules of daughter DNA from parent DNA).The replication of DNA takes place at every cell division to ensure the equal distribution of DNA in daughter cells. Through its replication, DNA acts as the key to heredity.



2. SYNTHESIS OF RNA (TRANSCRIPTION):

All the three types of RNA (m RNA, r RNA and t RNA) which take part in protein synthesis, are synthesized under the control of DNA by the process known as transcription.



3. SYNTHESIS OF PROTEINS (TRANSLATION):

Translation is the guiding of amino acid sequence in proteins. Thus, DNA controls protein synthesis via RNA. Due to this ability of DNA, specific proteins and enzymes are synthesized by the cell.

DNA —Transcription→ RNA —Translation→ Proteins

This scheme is called the "central Dogma" of molecular biology. By so controlling protein manufacture, DNA ultimately controls the entire structural and functional make up of every cell.

4. DNA AND MUTATIONS:

Under certain conditions, the nitrogen base sequence of a particular amino acid gets altered. Such alterations then are stable

and persist into succeeding molecular generations of DNA. When such changes occur, the structural and functional traits of a cell also change correspondingly, leading to mutations. Through changes in its cells, a whole animal and its progeny may thus become changed in the cause of successive generations; this is equivalent to evolution.

CHECK POINTS

1. Nucleotides can serve as monomers for the assembly of polymeric nucleic acids.
2. The nucleotides contain deoxyribonucleotides; the polymer is deoxyribonucleic acid, or DNA. DNA is normally double-stranded (although some viruses contain single-stranded DNA).
3. The DNA is a double helix with two strands running opposite to one another.
4. Each strand of DNA consists of a "backbone" of alternating units of phosphate and deoxyribose.
5. Purine or pyrimidine bases are attached to the 5-C deoxyribose sugar, and form base pairs with purine or pyrimidine bases from the opposite strand.
6. The only effective pairs are Adenine with Thymine (A-T pairs) and Guanine with Cytosine (G-C pairs).
7. DNA condenses to form chromatin. It consists of histone proteins wrapped by DNA called nucleosomes.
8. DNA functions include replication, synthesis of RNA and proteins and transmission of genetic information from generation to generation.

SHORT ANSWER QUESTIONS:

1. How many strands make up a DNA double helix?
2. What is a "strand" of DNA?
3. What holds one strand against the other in the double helix?
4. What are the four pairs of DNA bases that form in the double helix?
5. Which DNA double helix do you think would be harder to separate into two strands: DNA composed predominantly of AT base pairs, or of GC base pairs? Why?
6. What are the properties of DNA?

LONG ANSWER QUESTIONS:

1. What was basis for discovery of DNA structure by Watson and crick? Describe the model given by them.
2. Write in detail about the functions and types of DNA.

MULTIPLE CHOICE QUESTIONS

1. DNA strands are antiparallel because of
   A. H bonds
   B. Phospho-diester bonds
   C. disulphide bonds
   D. Phospho-ester bonds
2. The number of base pairs in one complete turn of DNA helix is
   A. 12
   B. 10
   C. 11
   D. 8
3. What is a "double helix"?
   A. Two Y-shaped strand
   B. Two loops, like a figure eight
   C. Two spirals, like a twisty ladder
   D. Two X-shaped strands
4. DNA is constructed by repeating units. What are these units called?
   A. Amino acids
   B. Nucleotides

C. Monosaccharides
D. Fatty acids

5. To whom is the discovery of the structure of DNA credited?
   A. Gregor Mendel
   B. Charles Darwin
   C. James Watson
   D. Hargobind Khorana
6. What part of DNA is found at the centre of the molecule?
   A. Amino acids
   B. Nitrogen Bases
   C. Phosphates
   D. Sugars

7. What process is used to copy DNA to produce another identical strand?
   A. Replication
   B. Translation
   C. Transcription
   D. Annealing
8. The most important molecule involved in long-term storage of genetic information is
   A. protein
   B. lipid
   C. deoxyribonucleic acid or DNA
   D. ribonucleic acid or RNA
9. The primary chemical structure of DNA includes
   A. a phosphorylated sugar backbone
   B. Individual components called amino acids
   C. Individual components called triglycerides
   D. Complete structural symmetry
10. Double-stranded DNA, when it occurs, is
   A. Antiparallel
   B. parallel
   C. complementary
   D. Both A and C
11. The base pairing arrangements that occur in double-stranded DNA as determined by hydrogen bonding include
   A. A with C and G with T
   B. A with U and G with C
   C. A with T and G with C
   D. C with T and A with G
12. The complementary strand of DNA strand having nucleotide sequence as GAT CAA is
   A. TTGATG
   B. AGAAUU
   C. CUAGUU
   D. CTAGTT
13. The diameter of DNA molecule is
   A. 20 A^0
   B. 50 A^0
   C. 100 A^0
   D. 200 A^0

UNIT-VI
BIOMOLECULES
MODULE-37: RNA

INTRODUCTION:

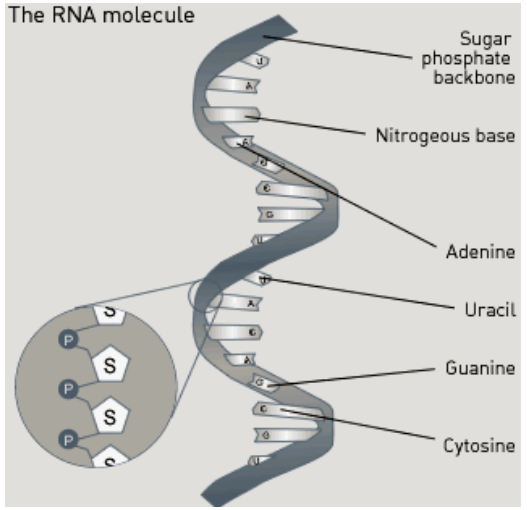
Ribonucleic acid (RNA) is the predominant nucleic acid in the cytoplasm, but all cytoplasmic RNA is of nuclear origin. In the nucleus it is present in the nucleolus, nucleoplasm , chromatin and in the cytoplasm. RNA is the main component of the ribosomes and also found in plastids and mitochondria in traces.

RNA plays an important role in protein synthesis and is non – genetic.

However, in many plant viruses (TMV) it acts as the genetic material. DNA contains all the information but RNA does all the work. There are several important differences between DNA and RNA. The first is the sugar of DNA is deoxyribose, where as RNA contains ribose. The second difference is that RNA contains no thymine but instead contains Uracil, and the third difference is that RNA is not a regular double helix.

STRUCTURE

RNA is a polymer, the monomer units of which are ribonucleoside mono phosphates. RNA is made up of a single polynucleotide strand, where in nucleotide units linked by 3^1-5^1 phosphate diester bonds. The nucleotides of RNA comprise of three components as in DNA, the phosphate group, and ribose sugar ($C_5H_{10}O_5$) and nitrogen bases. The nitrogen bases are Adenine, Guanine, Cytosine and Uracil. These nitrogen bases do not show complimentarity, hence there is no 1:1 ratio between purines and pyrimidines as in DNA. This suggest that RNA does not possess a regular hydrogen bonded structure.



Although each RNA molecule has only a single polynucleotide chain, it is not a smooth linear structure. However, the RNA strand may be twisted around itself to produce DNA-like helices at several places. In the region of helix formation, the bases are hydrogen bonded i.e., adenine pairing with uracil, and guanine with cytosine. Non helical region of RNA contain many non bonded bases. RNA is synthesized within the nucleus by using only one strand of DNA as template.

TYPES OF RNA:

There are two types of RNA are known namely genetic RNA and non-genetic RNA.

I. GENETIC RNA:

Genetic RNA is present in the plant viruses when DNA is absent. In many bacteriophases also, genetic material is RNA. This RNA controls the genetic activities. It may be single stranded or double

stranded. When RNA is double stranded it generally follows the same rules of base pairing as in case of DNA.

II. NON-GENETIC RNA:

This RNA does not serve as a genetic material. This non-genetic RNA is synthesized on DNA template and is of following five types.

a) Messenger RNA (m RNA)
b) Transfer RNA (t RNA)
c) Ribosomal RNA (r RNA)
d) Small, nuclear RNA (sn RNA)
e) Heterogeneous nuclear RNA (hn RNA)

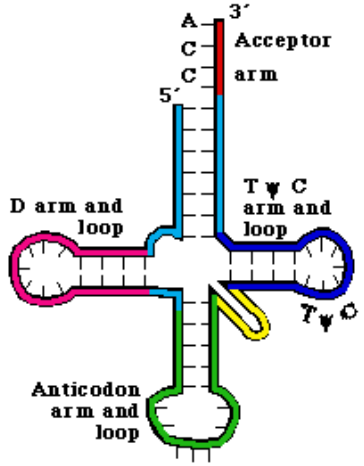
a) MESSENGER RNA (M RNA):

Messenger RNA molecules are synthesized in the nucleus by DNA. It consists of only 3 to 5% of the total cellular RNA. The sequence of bases in m RNA is determined by complementary sequence on DNA. Messenger RNA carries the information specifying a particular protein product. Each three m RNA bases in a row forms a genetic code word or codon, that specifies a particular amino acid. Thus mRNA acts as template for the translation of the DNA code into specific protein.

b) TRANSFER RNA (T RNA) OR SOLUBLE RNA (S RNA):

It constitutes about 10-20% of the total RNA of the cell. It is a relatively small RNA made up of 73-93 nucleotides. These RNA molecules work as adaptor molecules for carrying amino acid molecules to the site of protein synthesis. The t RNA molecule bends on itself and forms as a double stranded **clover leaf model**. The nitrogen bases of the two strands may be paired similar to that of DNA double helix. There are at least 20 species of t RNAs corresponding to 20 amino acids present in protein structure. The t RNA contains mainly four arms, each arm contains a base paired stem.

1. **The acceptor arm:**
   The amino acid is attached to this arm.
2. **The anticodon arm:**
   This arm contain three unpaired bases forming anticodon and is responsible for the recognition of triplet codon of mRNA.
3. **The D-arm:**
   It is involved in binding to the specific activating enzyme (amino acyl synthetase).
4. **The T φ C arm or ribosomal binding arm:**
   Binds to ribosomal surface during proteins synthesis.



Transfer RNA helps in transportation of amino acids from cytoplasm to the surface of larger sub units of ribosomes during protein synthesis.

c) RIBOSOMAL RNA (R RNA):

Ribosomal RNA, as the name suggests, is found in the ribosomes. It comprises about 80% of the total RNA of the cell. This type of RNA associates with certain proteins to form a ribosome. A ribosome is a structural support for protein synthesis. Ribosomal RNA plays a significant role in the binding of m RNA and t RNA to ribosomes and protein synthesis.

d) SMALL, NUCLEAR RNA (SN RNA):

The small, nuclear RNA is a metabolically stable RNA molecules found in the nucleus of the cell. It occurs predominantly in ribonucleo protein particles. However, much of this RNA never leaves the nucleus and thus never participates directly in protein synthesis. However, they are involved in processing of hn RNA into m RNA.

e) HETERO GENEOUS NUCLEAR RNA (HN RNA):

It is found in nucleus. Heterogeneous nuclear RNA refers collectively to the variety of RNAs which include primary transcripts, partially processed RNAs and sn RNA. The term hn RNA is often used just for the unprocessed primary transcripts.

FUNCTIONS

1 It is an adapter molecule in protein synthesis and a structural molecule incellular organelles.
2 RNA can function as a carrier of genetic information, a catalyst of biochemical reactions.
3 One of the primary functions of RNA is to facilitate the translation of DNA into protein.

CHECK POINTS

- When ribonucleotides serve as monomers, the resulting polymer is ribonucleic acid, or RNA.
- RNA is normally single-stranded (although some viruses contain doublestranded
- Many bases in RNA molecules such as ribosomal RNA and transfer RNA are chemically modified after polymerization, a process which makes these molecules more stable.
- RNA consists of a "backbone" of alternating units of phosphate and ribose sugar. Purine or pyrimidine bases are attached to the 5-C ribose sugar.
- The only effective pairs in RNA are Adenine with Uracil (A-U pairs) and Guanine with Cytosine (G-C pairs).
- tRNA, mRNA, rRNA, hnRNA and snRNA are different types of RNA. Each type of RNA has a different role in various cellular processes.
- RNA acts as a messenger between DNA and the protein synthesis complexes known as ribosomes.

MULTIPLE CHOICE QUESTIONS

1. RNA doesn't have
   A. Thymine
   B. Uracil
   C. Guanine
   D. Cytosine
2. Which of the following is NOT true?
   A. RNA contains the bases adenine, uracil, guanine and cytocine
   B. RNA synthesis proceeds in a 5' to 3' direction
   C. RNA is proof read during synthesis
   D. RNA can be synthesised without a DNA template

3. For the protein synthesis, which type of RNA molecule is essential?
   A. m-RNA
   B. r-RNA
   C. t-RNA
   D. All the above.
4. Which of the following distinguishes RNA from DNA?
   A. Presence of phosphate in the nucleotide
   B. Formation of phosphodiester bonds in the strands
   C. Presence of hydrogen bonds between two helical strands
   D. Presence of adenine, uracil, guanine and cytosine as bases.
5. A strand of DNA with the sequence AACGTAACG is transcribed. What is the sequence of the mRNA molecule synthesized?
   A. AACGTAACG
   B. UUGCAUUGC
   C. AACGUAACG
   D. **TTGCATTGC**
6. Which of the following is found only in RNA
   A. Adenine
   B. Uracil
   C. Cytosine
   D. Guanine
7. RNA that exhibits clover leaf model
   A. m-RNA
   B. t-RNA
   C. r-RNA
   D. sn-RNA
8. Function of t-RNA molecules
   A. Carries the information specifying a particular protein product.
   B. Carrying amino acid molecules to the site of protein synthesis
   C. Binding m-RNA to Ribosomes.
   D. Processing of hnRNA into m-RNA
9. RNA molecule is composed of
   A. Pentose sugar, phosphoric acid, pyrimidines
   B. Pentose sugar, phosphoric acid, pyrimidines and Purines
   C. Pentose sugar, phosphoric acid
   D. Pentose sugar, pyrimidines and Purines

SHORT ANSWER QUESTIONS

1. What are the components of RNA?
2. What is the location of RNA in a cell?
3. What is the role of RNA?
4. Write about the base pairing in RNA.
5. Name different types of RNA.
6. Give an account of (a) hn RNA and (b) sn RNA
7. Describe briefly the m-RNA and its role in protein Synthesis.
8. What is the function of t-RNA?
9. What is the difference between base pairing of DNA and RNA?
10. Explain the structure of t-RNA?

LONG ANSWER QUESTIONS

1. Give detailed account on the structure of RNA.
2. What are the types of RNA? Mention about their individual functions?

UNIT-VI
BIOMOLECULES
MODULE-35: ENZYMES

INTRODUCTION

One of the most important functions of proteins in living cells is to act as enzymes.

"An enzyme may be defined as a complex biological catalyst that is produced by a living organism in its cells to regulate the various physiological processes of the body."

The substance on which an enzyme acts is called the "substrate". A catalyst is any organic or inorganic substance that accelerates a chemical reaction without affecting the end products of the reaction and without being destroyed in the course of the reaction.

Enzymes are produced by living cells but can act independently of living cells. Enzymes are biological catalysts which accelerate the rate of biochemical reactions. They are effective in very small concentrations. They are unchanged by the reaction. They exert their physiological effects by changing the rate at which equilibrium is reached, not by changing the equilibrium of the reaction. Enzymes only change the rate of the chemical reaction. In the absence of enzymes, the chemical reaction proceeds very slowly. These, infact, lower the energy of activation. Enzymes are highly specific because each enzyme usually catalyzes one particular kind of reaction. Each enzyme can combine with a specific substrate to form enzyme - substrate complex. This is called substrate specificity. All enzymes are proteins with large molecular weights having one or more active sites for the binding of the substrate molecules. The enzyme proteins undergo denaturation when the natural conditions are altered. This results in the loss of enzyme activity.

CLASSIFICATION

According to International union of Biochemistry (IUB) , the present system of classification of enzymes is based on their reaction specificity. Six classes have been recognized.

1. OXIDO REDUCTASES:

These are the enzymes which catalyze biological oxidations and reductions. The important subclasses are:

a. Dehydrogenases
b. Oxidases
c. Peroxidases
d. Oxygenases

2. HYDROLASES:

These enzymes are instrumental in the cleavage of complex molecules in the presence of water. These fall into 3 categories.

a. PROTEASES:
They attack the peptide bonds of proteins and peptides

b. ESTERASES:
They catalyze hydrolysis of ester linkages

c. CARBOHYDRASES:
They hydrolyze the glycosidic linkages

3. TRANSFERASES:

These are the enzymes that catalyze the transfer of a chemical group from one molecule to another.
Ex. Transaminases, transphosphorylases etc

4. LYASES:

These are a group of enzymes that reversibly catalyze the removal of groups from substrates non hydrolytically. These enzymes act on C-C, C-O,C-N,C-S and C-halide bonds. This group includes.

a. Hydrases (carbon-oxygen lyases)
b. Aldehyde –lyases
c. Decarboxylases (remove Co_2 from carboxylic acids)

5. ISOMERASES (OR MUTASES):

These include enzymes that catalyze reactions to bring about intramolecular rearrangement of atoms in susbstrates. Ex. The inter conversion of aldose and ketose sugars.

6. LIGASES OR SYNTHETASES:

These are the enzymes that catalyze the linking together of two separate molecules in which pyrophosphate bond of ATP is broken down. These enzymes catalyze reactions forming C-O,C-S,C-N and C-C bonds.

Thus X+Y+ATP ⇌ X-Y+AMP+P-P (pyrophosphate)

CLASSIFICATION OF ENZYMES

Group of Enzyme	Reaction Catalysed	Examples
1. Oxidoreductases	Transfer of hydrogen and oxygen atoms or electrons from one substrate to another.	Dehydrogenases Oxidases
2. Transferases	Transfer of a specific group (a phosphate or methyl etc.) from one substrate to another.	Transaminase Kinases
3. Hydrolases	Hydrolysis of a substrate.	Estrases Digestive enzymes
4. Isomerases	Change of the molecular form of the substrate.	Phospho hexo isomerase, Fumarase
5. Lyases	Nonhydrolytic removal of a group or addition of a group to a substrate.	Decarboxylases Aldolases
6. Ligases (Synthetases)	Joining of two molecules by the formation of new bonds.	Citric acid synthetase

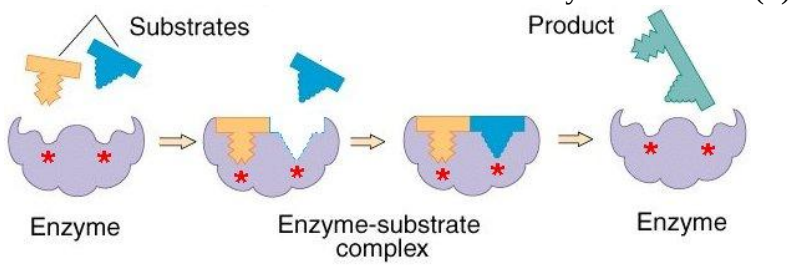
MECHANISM OF ENZYME ACTION

The enzyme promotes a given reaction, but, itself remains unchanged at the end of the reaction. In 1913 Michaelis and Menten proposed that an intermediate enzyme-substrate complex is formed during enzymatic activity.

Enzyme (E) + Substrate (S) ⇌ Enzyme substrate complex (ES)

↓

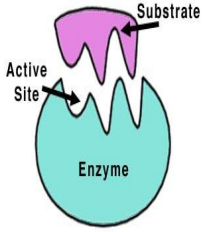
Enzyme +Products (P)



The enzyme itself remains almost passive. It merely provides a "platform" on which certain molecules could react with each other. Such an enzyme –platform brings reacting molecules into contact much faster than chance collisions at that temperature. The result is that the reactions are accelerated.

Enzymes being proteins molecules have a definite surface geometry. These have substrate specificity i.e, there is close structural similarity between the molecular surface of enzyme and its substrates. In other words, the functional groups of the enzyme and the substrate are complementary. Therefore, only specific enzyme can combine with the specific substrate to form the enzyme –

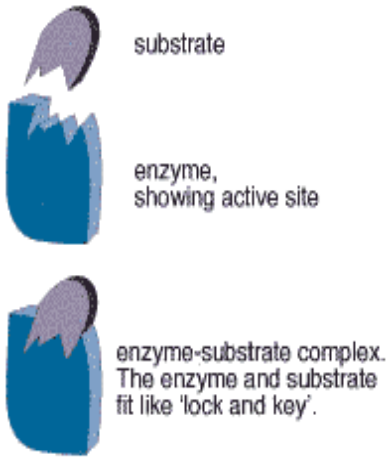
substrate complex. Every enzyme is supposed to have a definite site in which specific substrate molecule with complementary functional groups can fit in. This site is called the active site or catalytic site of the enzyme.



The mechanism of enzyme action has been explained by two theories.

1. Lock and key theory of Emil Fischer and
2. Induced fit theory of Koshland.

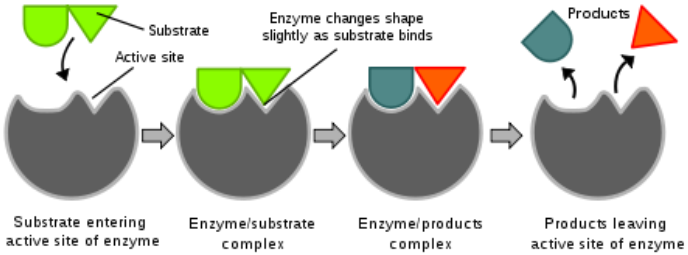
1. LOCK AND KEY THEORY (RIGID MODEL OF THE CATALYTIC SITE)



According to this model, the catalytic site of enzyme has a definite shape where only specific shaped substrate molecules can fit in. just as only particular shaped keys fit into particularly shaped locks. This concept was developed to explain the great specificity of enzymes. According to this concept, a structurally well defined catalytic site will accept only those substrate molecules which have a matching shape and will repel others that differ structurally. In other words, the catalytic site of the enzymes by itself is complementary in shape to that of the substrate. This fitting results in the formation of enzyme substrate complex which breaks down to give rise to products of the chemical reaction and the enzyme is released for its subsequent use.

2. INDUCED FIT THEORY (FLEXIBLE MODEL OF THE CATALYTIC SITE)

According to this model, the substrate induces a conformational change in the enzyme. According to this model, the catalytic sites of some enzymes are not rigid. In these enzymes, the shape of the catalytic site is modified by the binding of substrate. The catalytic site has a shape complementary to that of the substrate only after the substrate is bound. This process of dynamic recognition is called induced fit. It brings amino acid residues or other groups on the enzyme in the correct spatial orientation for substrate binding, catalysis or both.



CO ENZYMES AND CO-FACTORS:

Coenzymes are small molecules which enhances the action of an enzyme. They cannot by themselves catalyze a reaction but they can help enzymes to do so.

Some enzymes like pepsin and trypsin are made up entirely of protein (simple enzymes), but many others have two parts –a protein part called the apoenzyme and a non protein part, called the cofactor (conjugated enzymes). The combination of the two can be referred to as the holoenzyme.

Apoenzym + Co-Factor ⟶ Holoenzyme (Active Enzyme)

Thus, only when apoenzyme and cofactor are present together, catalysis will occur. Neither of the two can produce catalytic action by itself. The cofactor may be either a metal ion (ex. Ca,Mg,Zn, Co etc) or sometimes a non protein organic compound.

If the cofactor is firmly bound to the apoenzyme, it is called prosthetic group. If, instead of being more or less permanently bound to the apoenzyme the cofactor attaches itself to the apoenzyme only at the time of reaction, it is called a coenzyme. Based on the above finding "co enzyme may be defined as a particular kind of co-factor, i.e a non protein organic compound or a carrier molecule functioning in conjunction with a particular enzyme"

Coenzymes geberally act as acceptors or donors of a functional group. Types of reactions that frequently require the participation of co- enzymes are oxido reductions, group transfer, isomerization reactions and reactions resulting in the formation of covalent bonds.

The majority of co enzymes are chemical derivatives of the nucleotides. In most co enzymes, the nitrogen base portion of nucleotides is replaced by another chemical unit. This unit is usually a derivative of a B-vitamin

ISOZYMES:

An enzyme which has multiple molecular forms in the same organism catalyzing the same reaction is called isozymes or iso enzymes. For instance, lactic dehydrogenase (LDH) exists in five different forms (isozymes) in the tissues of rat. These different forms have been found to catalyze the same overall reaction. The

enzyme lactic dehydrogenase has two different types of polypeptide chains designated as M and H chains. The lactate dihydrogenase present in muscles has M polypeptide chains where as the one predominating in heart has H polypeptide chains. The total four polypeptide chain present in lactate dehydrogenase in different combinations form five different molecular forms of it. Generally, isozymes of closeby related species show greater similarity than those of distant species. Thus isozymes provide a basic clue to the genetic inter relationships of organisms.

QUESTIONS

1. What are enzymes? Describe the classification of enzymes
2. Discuss the mechanism of enzyme action
3. Write notes on –Coenzymes and Isozymes.