UNIT – I: DIVERSITY OF LIVING ORGANISMS

CHAPTER-1

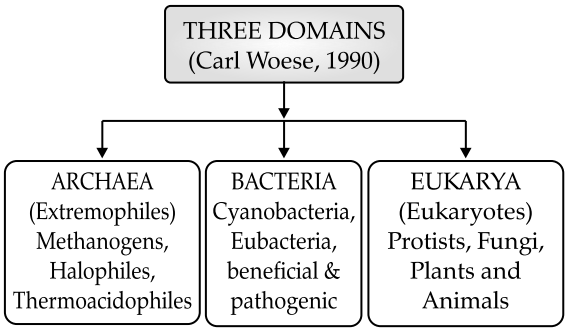
THE LIVING WORLD

Topic-1 Diversity in the Living World

Revision Notes

- The number of species that are known and described range between 1.7-1.8 million. This refers to biodiversity. Biodiversity can be defined as the number and types of organisms present on earth.
- **Nomenclature**:
  - Name of an organism in local language of a region is called common name or vernacular name. The use of common name has some problems. For example, in different countries different languages are spoken and hence, common name of an organism will be different in different countries.
  - It is difficult to learn all common or regional names of an organism that it has all over the world. Therefore, biologists assign standard names which are used all over the world. The process of assigning a standard name or scientific name to an organism is called nomenclature.
  - For assigning scientific names to plants, principles and criteria are provided in International Code for Botanical Nomenclature (ICBN) and for assigning scientific names to animals, principles and criteria are provided in International Code of Zoological Nomenclature (ICZN).
  - Each scientific name has two components: the generic name and the specific name or specific epithet. The generic name is always placed first followed by specific name. For example, the scientific name of mango is *Mangifera indica*. In this name, the first component that is, *Mangifera* represents the generic name while second component that is *indica* is the specific name. This system of providing a name with two components is called Binomial nomenclature. This was given by **Carolus Linnaeus**.
- **Rules for Writing Scientific Names:**
  - Biological names are generally in Latin or Latinised.
  - The first word in a scientific name denotes the generic name while the second word represents the specific epithet.
  - The first word representing the generic name starts with a capital letter while the specific name is written with a small letter. It can be illustrated with the example of *Mangifera indica*.
  - Both the words in a scientific name when handwritten are separately underlined or printed in italics.
  - At the end of the biological name, i.e., after the specific epithet, name of the author is written in an abbreviated form, e.g., *Mangifera indica* Linn. It indicates that this species was first described by Linnaeus.
- **Classification:**
  - To study a vast number of different organisms found on the earth, scientists on the basis of similar characteristics systematically categorised all organisms into various groups and classes. This process is called **classification.**
  - The earliest classifications were based on the 'uses' of various organisms.
  - Classification helps in identification of an organism, study of fossils and finding evolutionary pathways. It also helps in knowing features of a group if we know features of any organism belonging to this group.
- **Three domains of life: (Bacteria, Archaea and Eukarya)**

  The three-domain system is a biological classification given by Carl Woese in 1990 that shows the division of cellular life forms into archaea, bacteria, and eukarya. The key difference from earlier classifications is the splitting of archaea from bacteria due to changes in the structure of their cell wall.

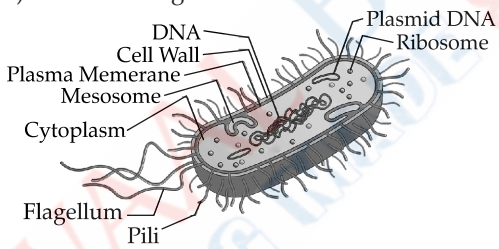


Mnemonics

Concept: Three Domains
Mnemonics: **E**at **A**ll **B**ananas
Interpretation: **E**ukarya, **A**rchaea, **B**acteria

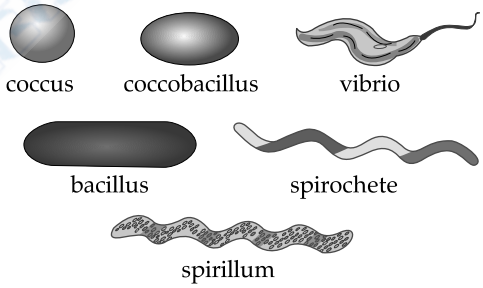
- **Archaebacteria**

These bacteria are special since they live in some of the harshest habitats such as extreme salty areas (halophiles), hot springs (thermoacidophiles) and marshy areas (methanogens). Archaebacteria differ from other bacteria in having a different cell wall structure and this helps to survive them in extreme conditions. Methanogens are present in the gut of several ruminant animals such as cows and buffaloes and they are responsible for the production of methane (biogas) from the dung of these animals.



- **Bacteria**

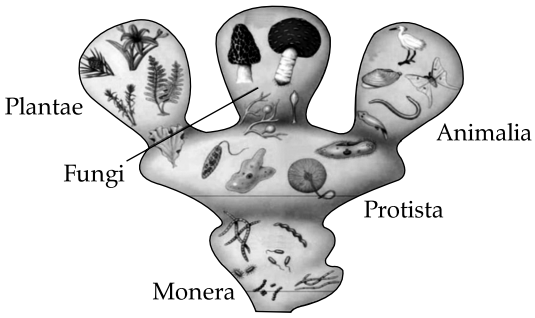
Bacteria are the sole members of the Kingdom Monera. They are the most abundant micro-organisms. Bacteria occur almost everywhere. Hundreds of bacteria are present in a handful of soil. They also live in extreme habitats such as hot springs, deserts, snow and deep oceans where very few other life forms can survive. Many of them live in or on other organisms as parasites. Bacteria are grouped under four categories based on their shape: the spherical Coccus (pl.: cocci), the rod-shaped Bacillus (pl.: bacilli), the comma-shaped Vibrium (pl.: vibrio) and the spiral Spirillum (pl.: spirilla)



Though the bacterial structure is very simple but they show complexity in their behaviour. When compared to many other organisms, bacteria as a group show the most extensive metabolic diversity. Some of the bacteria are autotrophic, i.e., they synthesise their own food from inorganic substrates. They may be photosynthetic autotrophic or chemosynthetic autotrophic. The vast majority of bacteria are heterotrophs, i.e., they depend on other organisms or on dead organic matter for food.

- **Eukaryotes**

Eukaryotes are the organisms with true nucleus i.e., their cell body contains a well-defined nucleus and other membrane-bound organelles. They may be unicellular (single-celled) or multicellular (many cells). Some have flagella or cilia. Protists reproduce asexually and sexually by a process involving cell fusion and zygote formation. e.g., Animals, plants, fungi, protists, etc.



- **Taxonomy:**
  - The process of classifying living organisms into different taxa is called **taxonomy.**
  - External and internal structure, structure of cell, development process and ecological information of organisms are the basis of modern taxonomic studies.
  - Characterisation, identification, classification and nomenclature are the processes that are basic to taxonomy.
- **Systematics:**
  - The word systematics is derived from the Latin word 'systema' which means 'systematic arrangement of organisms'.
  - Linnaeus used 'Systema Naturae' as the title for publication.
  - The branch of science in which different features of species, diversities, and relationships with other species are studied is referred to as **systematics**. It also deals with identification, nomenclature, classification and evolutionary relationships between species.

Topic-2 Taxonomic Categories

Revision Notes

- Classification involves hierarchy of steps in which each step represents a rank or taxonomic category or taxon. All categories together constitute the taxonomic hierarchy.
- Each taxon represents a unit of classification.
- **Species:** Species is the basic unit of classification. It is a group of individual organisms with fundamental similarities.
- **Genus:** Genus is the aggregate of closely related species. It consists of a group of related species which has more characters in common in comparison to species of other genera. e.g., Potato, tomato and brinjal are species of the genus *Solanum.*
- **Family:** It is a group of related genera with less number of similarities as compared to genus and species. e.g., Family Felidae includes Genus *Panthera* and Genus *Felis*.
- **Order:** It is the assemblage of related families. e.g., Order Carnivora includes family Felidae and canidae (dog).
- **Class:** It is the assemblage of related orders. e.g.,Order Primata, Carnivora, etc., is placed in class Mammalia.
- **Phylum (in animals) or Division (in plants):** It is the assemblage of related classes. e.g., Classes Amphibia, Reptilia, Aves, Mammalia, etc., come under Phylum Chordata.
- **Kingdom:** It is the assemblage of various phyla. It is the highest category. e.g., Kingdom Plantae, Kingdom Animalia, etc.

Organisms with their taxonomic categories:

Common name	Man	Housefly	Mango	Wheat
Biological name	*Homo sapiens*	*Musca domestica*	*Mangifera indica*	*Triticum aestivum*
Genus	*Homo*	*Musca*	*Mangifera*	*Triticum*
Family	Hominidae	Muscidae	Anacardiaceae	Poaceae
Order	Primata	Diptera	Sapindales	Poales
Class	Mammalia	Insecta	Dicotyledonae	Monocotyledonae
Phylum/Division	Chordata	Arthropoda	Angiospermae	Angiospermae

Key Words

- **Systematics:** The branch of science which deals with different features of species, their diversities, and relationships with other species is referred to as systematics.
- **Taxonomy:** It is the process of classifying living organisms into different taxa.
- **Identification:** Recognition of a species, by studying easily observable characteristics is called identification.
- **Nomenclature:** The process of assigning a standard name or scientific name to an organism is called nomenclature.
- **Classification:** It is a method by which organisms on the basis of some easily observable characteristics are categorised into different groups and classes.
- **Taxon:** The unit of classification or taxonomic category is commonly termed as taxon.
- **Phylum:** It is a taxonomic category higher than class and lower than Kingdom.
- **Class:** It is a taxonomic category which includes related orders.
- **Order:** It is a taxonomic category which includes related families.
- **Family:** It is a taxonomic category which includes related genera.
- **Genus:** It is an aggregate of related species.
- **Species:** It is the lowest category of biological classification which comprises of related organisms or populations potentially capable of interbreeding.

CHAPTER-2

BIOLOGICAL CLASSIFICATION

Topic-1 Need for Classification and Five Kingdom Classification

Revision Notes

System of Classification:

- Aristotle was the first who classified organisms on the scientific basis. He, on the basis of morphological characters, divided plants into three groups – trees, shrubs and herbs. He also classified animals into two groups – **enaima** (animals having red blood) and **anaima** (animals lacking red blood).
- **Two kingdom system of classification**
  - Linnaeus classified all the organisms into two kingdoms – **Plantae** and **Animalia**. Kingdom Plantae included all plants while Kingdom Animalia included all the animals.
  - Although, this system of classification was popular for long time but with the discovery of some new organisms it was found inadequate. Some of the demerits of the two kingdom system of classification are as follows:
    1. Organisms with contrasting characters like eukaryotes and prokaryotes, unicellular and multicellular organisms and photosynthetic (green algae) and non-photosynthetic (fungi) organisms were placed together.
    2. A large number of organisms did not fall into either category.
- **Three Domain System:**
  - The three domain system was developed by **Carl Woese**.
  - It is a system for classifying biological organisms.
  - Under this system, organisms are classified into three domains and six kingdoms. The domains are Archaea, Bacteria and Eukarya. Kingdoms are Archaebacteria, Eubacteria, Protista, Fungi, Plantae and Animalia.
- **Five Kingdom system of classification**
  - In 1969, **R.H. Whittaker** proposed a Five Kingdom Classification. **Monera, Protista, Fungi, Plantae** and

Animalia are the five kingdoms defined by him. The main criteria used by him for classifying organisms were as follows:

1. Cell structure
2. Body organisation
3. Mode of nutrition
4. Reproduction
5. Phylogenetic relationships

- **In Five Kingdom Classification System:**
  - All prokaryotic organisms were grouped together under **Kingdom Monera**.
  - The fungi were placed in a separate kingdom – **Kingdom Fungi.**
  - The unicellular eukaryotic organisms were placed in a separate kingdom – **Kingdom Protista.**
  - It has put together organisms which, in earlier classifications, were placed in different kingdoms. For example, Kingdom Protista has brought together *Chlamydomonas* and *Chlorella* (earlier placed in Algae within plants and both having cell walls) with *Paramoecium* and *Amoeba* (which were earlier placed in the animal kingdom).

Topic-2 Kingdom Monera and Protista

Revision Notes

Kingdom Monera:

- They are **unicellular prokaryotes.** Bacteria are the only members of the Kingdom Monera. They are the most abundant micro-organisms found on the earth. They occur almost everywhere – in air, water, soil, snow and even in or on other organisms as parasites.
- On the basis of shape, bacteria are grouped under four categories:
  - **Coccus** (pl.: cocci): They have spherical shape.
  - **Bacillus** (pl.: bacilli): They are rod-shaped bacteria.
  - **Spirillum** (pl.: spirilla): They have long and spirally coiled bodies.
  - **Vibrium** (pl.: vibrio): These bacteria have short and slightly curved bodies which appear like a shape of a comma.

Mnemonics

Concept: Shapes of Bacteria
Mnemonics: **V**aluable things **C**an **B**e **S**aved
Interpretation: **V**ibrium, **C**occus, **B**acillus, **S**pirillum

- Monerans have a cell wall which is made up of peptidoglycan. They lack nuclear membrane. Their genetic material is present in the form of a coiled circular DNA which lies in the cytoplasm. This is called **nucleoid**.
- Monerans utilise different strategies to get their food.
  - Some of the monerans (bacteria) are autotrophic that is, they synthesise their own food from inorganic substrates. They may be photosynthetic autotrophic or chemosynthetic autotrophic.
  - Chemosynthetic bacteria oxidise various inorganic substances such as nitrates, nitrites and ammonia and use the released energy for their ATP production.
  - Bacteria that derive their nutrients from dead remains of plants and animals are called **saprophytes**.
  - Bacteria that draw nutrients from the body of other living organisms are called **parasites**.
  - Bacteria that live in association with other living organisms and derive nutrients from them without causing them harm are called symbiont. During this association, both the organisms are mutually benefitted to each other.
- The most common method of reproduction found in bacteria is **fission**. Besides this, they also reproduce by a type of sexual reproduction which involves a primitive type of DNA transfer from one bacterium to the other. This method of sexual reproduction is called **conjugation**. Under unfavourable conditions, bacteria produce spores.
- Bacteria are further grouped into two groups– Archaebacteria and Eubacteria.
  - **Archaebacteria**
    1. They are primitive prokaryotes.
    2. They are found in harsh habitats, such as extreme salty areas-halophiles; hot springs (thermoacidophiles and marshy areas methanogens.

3. Their cell wall consists of non-cellulosic polysaccharides or proteins and lacks peptidoglycan. This allow them to survive in extreme conditions.

- **Eubacteria**
  1. These are the true bacteria.
  2. They have a rigid cell wall, and if motile, a flagellum.
- **Cyanobacteria**
  1. They are also known as blue-green algae. They are found in a wide range of habitats where sufficient moisture and suitable temperature are present. They bloom in polluted water bodies.
  2. They show different morphological forms. Some of them are unicellular (e.g., *Chroococcus*), some are colonial (e.g., *Microcystis*) while some are filamentous (e.g., *Nostoc, Anabaena*). Their colonies are generally surrounded by gelatinous sheath.
  3. Some of cyanobacteria like *Nostoc* and *Anabaena* have special cells called heterocysts to fix atmospheric nitrogen.
  4. Because of the presence of chlorophyll – a, these organisms are photosynthetic autotrophs.
- **Mycoplasmas**
  1. They are the smallest living cells known. They completely lack a cell wall and can survive without oxygen.
  2. Most of the mycoplasma are pathogenic and cause diseases in animals and plants.

Kingdom Protista

- This kingdom includes all those organisms which are **unicellular eukaryotes**. Being eukaryotes, the protistans contain a well defined nucleus and other membrane-bound cell organelles. This kingdom acts as a link between the kingdom Monera and other kingdoms (Fungi, Plantae and Animalia).
- Protistans are primarily aquatic. Some of them have flagella or cilia for movement. They reproduce asexually and sexually by a process involving cell fusion and zygote formation.
- The kingdom Protista includes Chrysophytes, Dinoflagellates, Euglenoids, Slime moulds and Protozoans.

(i) Chrysophytes

1. **Diatoms** and **desmids** (golden algae) are included under chrysophytes.
2. They are microscopic and aquatic organisms which are found in both freshwater and marine habitats.
3. Most of the chrysophytes are photosynthetic. Infact diatoms are the chief 'producers' in the oceans.
4. The cell walls of diatoms form two thin overlapping shells, which fit together as in a soap case.
5. Cell wall of diatom are also rich in silica. Because of this, the walls of diatoms are indestructible. They pile up at the bottom of water body and leads to formation of **'diatomaceous earth'** over billions of years. Diatomaceous earth is used in polishing, filtration of oils and syrups.

(ii) Dinoflagellates

1. They are mostly marine and photosynthetic organisms.
2. Depending upon the pigment present in their cell, they may appear yellow, green, brown, blue or red.
3. Their cell wall is made up of cellulose plates.
4. Most of the dinoflagellates have two flagella.
5. Red dinoflagellates such as *Gonyaulax* undergo rapid multiplication. Due to the presence of a large number of red dinoflagellates, the sea appears red (*red tides*).
6. Red dinoflagellates also release toxins in water which may kill other marine animals.

(iii) Euglenoids

1. Most of them are freshwater organisms found in stagnant water.
2. Their body is covered by a protein rich layer called **pellicle**. It provides flexibility to the body.
3. They have two flagella, out of which one is long and other is short.
4. They have chlorophyll and hence in the presence of sunlight they can prepare their food by the process of photosynthesis. In absence of sunlight, they behave like a predator and feed on other smaller microorganisms.

(iv) Slime Moulds

1. They are saprophytic protists which are found in cool, moist and shady places rich in decaying twigs and leaves.
2. Under favourable conditions, they form an aggregation called plasmodium which does not have a definite shape.
3. Plasmodium can move by forming pseudopodia.
4. During unfavourable conditions, plasmodium transforms into fruiting bodies which bear spores at their tips.
5. The spores are extremely resistant and survive for many years, even under adverse conditions.

(v) Protozoans

They are heterotrophs and live as predators or parasites. Four major groups of protozoans are given below:

(a) Amoeboid protozoans

1. They are found in fresh water, sea water or moist soil.

2. They have pseudopodia to move and capture their prey.
   Example: *Amoeba* and *Entamoeba*

(b) Flagellated protozoans

1. They are either free-living or parasitic.
2. They have flagella.
3. The parasitic forms cause diseases like sleeping sickness.
   Example: *Trypanosoma.*

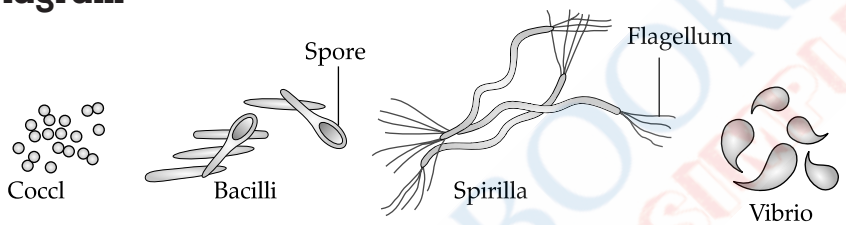
(c) Ciliated protozoans

1. They are aquatic organisms.
2. Their body is covered with thousands of cilia which help in movement and capturing of food.
3. A cavity called gullet is present which opens to the outside of the cell surface and is the site of ingestion.
   Example: *Paramoecium*.

(d) Sporozoans

1. All sporozoans have an infectious spore-like stage in their life cycle.
   Example: *Plasmodium* (malarial parasite)

Important Diagram



Bacteria of different shapes

Topic-3 Kingdom Fungi and Kingdom Plantae

Revision Notes

Kingdom Fungi

- Fungi prefer to grow in warm and humid places.
- Except the Yeast, which is a unicellular organism, all fungi are filamentous. Their bodies consist of long, slender thread-like structures called hyphae. The network of hyphae is called mycelium.
- In some fungi, hyphae are continuous tubes filled with multinucleated cytoplasm. This type of hyphae is called **aseptate hyphae** or **coenocytic hyphae.** In contrast to this in some fungi septae or cross walls are present in the hyphae. Such type of hyphae is called **septate hyphae. Coenocytic** means something having multinuclei.
- The cell wall is made up of **chitin** and polysaccharides. **Chitin** is long-chain polymer of N-acetylglucosamine.
- All fungi are heterotrophic. They take their food by following methods:
  - Most of the fungi absorb soluble organic matter from dead substrates. Such fungi are called **saprophytes**.
  - Some of them depend on living plants and animals and are called **parasites.**
  - Some fungi live in association with other living organisms as symbionts, e.g., in lichen. Fungi live as symbiont with algae and in mycorrhiza with plant roots.
- **Fungi reproduce by three modes:**
  - **Vegetative means:** It occurs through fragmentation, fission and budding.
  - **Asexual reproduction:** This type of reproduction involves formation of spores which may be of different types like conidia, sporangiospores and zoospores.
  - **Sexual reproduction:** Sexual reproduction involves formation of fruiting bodies inside which various types of spores (like oospores, ascospores and basidiospores) are produced.
  - In fungi, the sexual cycle involves three steps which are given below:
    (i) Plasmogamy: Fusion of the protoplasms of two motile or non-motile gametes is called plasmogamy. It is the first step of sexual reproduction.
    (ii) Karyogamy: After plasmogamy, nuclei of both gametes fuse together. This is called karyogamy.
    (iii) Meiosis: The last step of sexual reproduction involves meiotic division in zygote. As a result of this haploid spores are formed.

- Dikaryophase is a condition of having dikaryon in an intervening dikaryotic stage (i.e. two nuclei per cell) between plasmogamy and karyogamy in fungi.
- On the basis of morphology of the mycelium, mode of spore formation and fruiting bodies, kingdom fungi is divided into four classes.

(i) Phycomycetes

- Fungi belonging to this class are found in aquatic habitats and on decaying wood, in moist and damp places or as **obligate** parasites on plants. A **Parasitic** organism which cannot complete its life-cycle without exploiting a suitable host is called **obligate parasite.**
- They have **aseptate mycelium** with **coenocytic condition.**
- They reproduce asexually either by means of zoospores (motile) or by aplanospores (non-motile). These spores are produced in sporangium endogeneously.
- Sexual reproduction involves fusion between two gametes which is of the following three types:
  1. **Isogamous:** Fusion of two gametes which are similar in size.
  2. **Anisogamous:** Fusion of two gametes which are dissimilar in size.
  3. **Oogamous:** Fusion between one large, non-motile female gamete and a smaller, motile male gamete.
- Fusion of two gametes leads to formation of **zygospores.**
- *Mucor, Rhizopus* and *Albugo* are the common examples of fungi belonging to class phycomycetes.

(ii) Ascomycetes

- Members of this class are commonly known as sac-fungi.
- Some of them are unicellular, e.g., yeast (*Saccharomyces*) while most of them are multicellular, e.g., *Penicillium*.
- They are saprophytic, decomposers, coprophilous (growing on dung) or parasitic.
- They have branched and septate mycelium.
- They reproduce asexually through conidia which are produced on the special mycelium called conidiophores. Each conidia on germination gives rise to mycelium.
- Sexual reproduction occurs through special types of spores called ascospores. Ascospores are endogenously produced in sac like structures called asci and asci are arranged in fruiting bodies called ascocarps.
- *Aspergillus, Claviceps* and *Neurospora* are the common fungi belonging to the class Ascomycetes.

(iii) Basidiomycetes

- They grow in soil, on logs and tree stumps and in living plant bodies as parasites.
- They have branched and septate mycelium.
- They do not reproduce asexually, but vegetative reproduction by fragmentation is observed in them.
- Sexual reproduction is by fusion of vegetative or somatic cells to form basidium produced in basidiocarp.
- Basidium produces four basidiospores exogenously after meiosis.
- *Agaricus* (mushroom), *Ustilago* (smut) and *Puccinia* (rust fungus) are some common fungi belonging to class basidiomycetes.

(iv) Deuteromycetes

- Sexual or perfect stages of deuteromycetes are not known. Only asexual or vegetative stages are known. Because of this, they are commonly known as imperfect fungi.
- They reproduce only by asexual spores called conidia.
- They have septate and branched mycelium.
- Most of them are decomposers of litter and help in mineral cycling.
- Common examples of deuteromycetes are *Alternaria, Colletotrichum* and *Trichoderma*.

Kingdom Plantae

- The members of this kingdom are called plants. They are photosynthetic autotrophs, exceptionally insectivorous plants such as Bladderwort and Venus fly trap. *Cuscuta* is a parasite.
- They have eukaryotic cells with prominent chloroplasts. They also have cell wall made up of cellulose.
- Plants have two distinct phases in the life cycle– the diploid sporophytic phase and haploid gametophytic phase. These two phases alternate with each other. This is called alternation of generation.
- Kingdom Plantae includes algae, bryophytes, pteridophytes, gymnosperms and angiosperms.

Topic-4 Kingdom Animalia and Viruses Lichens and Virods

Revision Notes

Kingdom Animalia

- The members of this kingdom are eukaryotic multicellular organisms. Their cells lack cell wall.
- They are heterotrophic and ingest complex organic matter in the form of solid food. The food taken inside the body is digested into simple substances in an internal cavity. The digested food is absorbed and utilised by the body. This type of nutrition is called **holozoic nutrition.** The food reserves are in the form of **glycogen** or fat.
- They grow in a definite pattern and adults have a definite shape and size.
- Most of them are capable of locomotion.
- They reproduce through sexual reproduction.

Viruses

- They are non-cellular organisms which remain in inert crystalline form outside the living cell. They are obligate parasites. As they infect a cell, they take over the machinery of the host cell to replicate themselves, killing the host.
- **W.M. Beijerinck** called fluids as '*contagium vivum fluidum*' as extracts of infected plants of tobacco that could cause infection in healthy plants.
- Virus means venom or poisonous fluid. Pasteur gave the term 'virus'.
- **D.J. Ivanowsky** found that certain microbes caused Tobacco Mosaic Disease in tobacco plant.
- **W.M Stanley** showed viruses could be crystallised to form crystals of protein, which are inert outside their specific host.
- A virus consists of a protein coat called capsid and a genetic material which may be either RNA or DNA. The genetic material of virus is infectious. Generally viruses which infect plants have single stranded RNA and viruses which infect animals have either single or double stranded RNA or double stranded DNA. Viruses which infect bacteria are known as **bacteriophages**. They have double stranded DNA as genetic material.
- The capsid is made of small sub-units called capsomeres which protect the nucleic acid. The number of capsomere varies in different viruses. For e.g, Tobacco Mosaic Virus (TMV) has 2130 capsomeres. The capsomeres may be arranged in helical or polyhedral geometric forms.
- Various diseases like mumps, small pox, herpes, influenza and AIDS are caused by viruses. Infection of viruses leads to development of diseases in plants also. Some common symptoms of plant viral diseases are formation of mosaic, rolling and curling of leaf, yellowing and vein clearing, dwarfing and stunted growth.

Viroids

- They are infectious agents of plants which are similar to virus but consist of only a short single stranded RNA. They are smaller than viruses and lack protein coat. The RNA of the viroids is of low molecular weight. One of the disease caused by viroids is potato spindle tuber disease.

Lichens

They are symbiotic associations between algae and fungi. The algal component is called **phycobiont** and fungal component is known as **mycobiont.** In this symbiotic association both partners are mutually benefitted. Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for its partner. As lichens are very sensitive to air pollution and do not grow in polluted area, they are very good pollution indicators.

Key Words

- **Nucleoid:** The irregularly-shaped region within the cell of a prokaryote which contains genetic material is called nucleoid. It is not surrounded by a nuclear membrane.
- **Saprophytes:** The organisms which obtain their food from the dead and decaying organic matter are called saprophytes.
- **Parasites:** The organisms which obtain their food from other living organisms without killing them are called parasites.
- **Heterocysts:** These are the specialised cells which are involved in nitrogen fixation in *Nostoc*, *Anabaena* and other cyanobacteria.

- **Pellicle:** It is a protein rich layer which covers the entire body of members of Euglenoids.
- **Hyphae:** The long thread-like structures which constitute vegetative body of fungi are called hyphae.
- **Mycorrhiza:** It is a symbiotic association of the mycelium of a fungus with the roots of certain plants.
- **Ascospores:** A type of spores which are formed as a result of sexual reproduction in class Ascomycetes.
- **Basidiospores:** A type of spores which are formed as a result of sexual reproduction in class Basidiomycetes.
- **Capsid:** A proteinaceous coat which encloses the nucleic acid of a virus is called capsid.
- **Capsomere:** Small protein subunits of a capsid is called capsomere.
- **Viroid:** An infectious agent of plants which is similar to a virus but comprises a short single stranded RNA without a protein coat is called viroid.

CHAPTER-3

PLANT KINGDOM

Topic-1 Classification of Plants: Algae, Bryophyta and Pteridophyta

Revision Notes

Types of Classification:

- **Artificial System of Classification:** It was proposed by **Carolus Linnaeus** and is based on androecium structure and vegetative characters.
- **Natural System of Classification:** Proposed by **George Bentham** and **J.D. Hooker**. It was based on natural affinities among organisms.
- **Phylogenetic System of Classification:** It is based on evolutionary relationships between the various organisms. This system of classification believes that organisms belonging to the same taxa have a common ancestor.

Taxonomy:

- **Numerical Taxonomy** is based on all the observable characteristics. In this, numbers and codes are assigned to all the characters and then data is processed by using computers and each character is given equal importance where hundreds of characters are considered at the same time.
- **Cytotaxonomy** is based on cytological information like chromosome number, structure, and behaviour.
- **Chemotaxonomy** uses the chemical constituents of the organism to classify them.

Algae

- They are simple, thalloid, autotrophic and mostly aquatic organisms. They are found in different types of habitats like moist stones, soils and wood. Some of them are found in association with fungi (lichens) and animals (e.g., on sloth bear).
- Algae show variation in form and size. Some of them are microscopic unicellular (like *Chlamydomonas*), some are colonial (like *Volvox*) while some are filamentous (like *Ulothrix* and *Spirogyra*). Some marine algae like kelps have massive plant bodies. All modes of reproduction, i.e., vegetative, asexual and sexual reproduction are found in algae.
- **Fragmentation:** A type of vegetative reproduction – is very common among filamentous algae. In this mode of reproduction, each fragment develops into a thallus.
- **Asexual reproduction** involves the production of different types of spores. Zoospores are the most common type of asexual spores. Due to presence of flagella, they are motile. They germinate to give rise to new plants.
- **Sexual reproduction** involves fusion of two gametes. On the basis of nature of gamete involved, sexual reproduction is of following three types:
  - **Isogamous reproduction:** In this type of reproduction, gametes are similar in size. Gametes may be flagellated as in *Chlamydomonas* or non-flagellated as in *Spirogyra*.
  - **Anisogamous reproduction:** This type of reproduction involves fusion of two gametes which are dissimilar in size as in some species of *Chlamydomonas*.

- **Oogamous reproduction:** This type of reproduction involves fusion between one large, non-motile (static) female gamete and a smaller, motile male gamete. *Volvox* and *Fucus* exhibit oogamous reproduction.

- Algae are economically important for us. About half of the total carbon dioxide fixation on earth is carried out by algae through photosynthesis.
- Some marine brown and red algae produce hydrocolloids (like **algin** and **carrageen**). These colloids are used commercially.
- Agar is one of the commercial products. It is used to grow microbes and in preparations of ice-creams and jellies. It is also obtained from *Gelidium* and *Gracilaria*.
- Some unicellular algae like *Chlorella* and *Spirullina* are rich in proteins and hence they are used as food supplements.
- The algae are divided into three main classes: Chlorophyceae, Phaeophyceae and Rhodophyceae.

(i) Chlorophyceae (Green algae)

- The members of this class are commonly known as **green algae**. They possess pigments chlorophyll *a* and *b* in chloroplasts. Each chloroplast contains one or more storage bodies called pyrenoids. In addition to starch, pyrenoids also contain protein. In some algae, food may be stored in the form of oil droplets. Members of chlorophyceae have a rigid cell wall consisting of an inner layer of cellulose and an outer layer of pectose.
- Common examples of green algae are *Chlamydomonas, Volvox, Ulothrix, Spirogyra* and *Chara.*

(ii) Phaeophyceae (Brown algae)

- The members of this class are found chiefly in marine habitats. Some of them are simple branched, filamentous forms (like *Ectocarpus*) while some are profusely branched reaching a height of 100 metres. They possess chlorophyll *a*, *c*, carotenoids and xanthophylls. They store food in the form of complex carbohydrates (either laminarin or mannitol). The vegetative cells are covered with a wall consisting of cellulose. On the outer side of the wall a gelatinous coating of **algin** is present. The plant body is differentiated into a **holdfast**, a stalk called the **stipe** and leaf like photosynthetic organ– the **frond**. Holdfast keeps the plant attached to the substratum.
- Common members of class phaeophyceae are *Ectocarpus, Dictyota, Laminaria, Sargassum* and *Fucus*.

(iii) Rhodophyceae (Red algae)

- They contain a red pigment, *r*-phycoerythrin in their body and hence they appear red. Most of the members of this class are marine. Some of them are found in well-lighted regions close to the surface of water while some are found at the great depths in oceans where only a little amount of light reaches. Most of the red algae have multicellular thallus with complex body organisation. They store food in the form of floridean starch which is very similar to amylopectin and glycogen in structure.
- The common members of class Rhodophyceae are *Polysiphonia*, *Porphyra, Gracilaria* and *Gelidium*.

Bryophytes:

- This group includes all mosses and liverworts which are usually found in moist and shaded areas in the hills.
- Bryophytes can live in soil but they are dependent on water for sexual reproduction. Hence, they are also known as "Amphibians of the plant kingdom".

Mnemonics

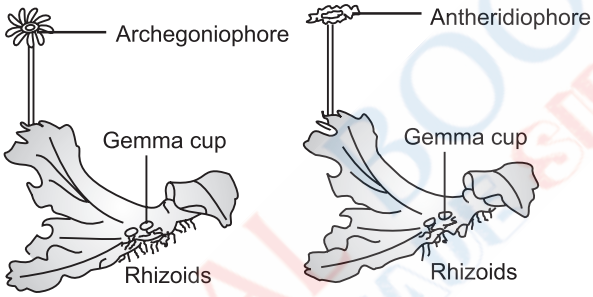
Concept: Examples of Algae
Mnemonics: PCR
Interpretation: Phaeophyceae, **C**hloraphyceae, **R**hodophyceae.

- Bryophytes have thallus-like plant body which may grow either prostrate or erect. Plant body is attached to the substratum with the help of unicellular or multicellular rhizoids. They do not possess true roots, stem or leaves but they may have root-like, leaf-like or stem-like structures. The main plant body of the bryophyte is haploid which produces gametes. Because of this, plant body is called a gametophyte.
- Bryophytes possess multicellular sex organs. The antheridium represents the male sex organ while archegonium is flask shaped and represents the female sex organ. Inside the antheridium, biflagellate antherozoids are developed and in archegonium, a single egg is developed. Mature antherozoids are released from antheridium and with the help of water they reach to archegonium. In archegonium, antherozoid fuses with the egg to produce the zygote. After fertilisation, zygote undergoes a resting period and thereafter it undergoes reduction division. As a result a multicellular body called a sporophyte develops. The sporophyte is attached to the photosynthetic gametophyte and derives nourishment from it. (i.e., sporophyte is not free-living)
- Some specialised cells of the sporophyte, called sporogenous cells, undergo reduction division (meiosis) to produce haploid spores. Each spore germinates to produce gametophyte.

- Bryophytes are of slightly less economic importance. Some mosses are the source of food for herbaceous mammals, birds and other animals. A moss, named *Sphagnum*, provides peat that were used as fuel and as packing material for trans-shipment of living material. Some bryophytes are ecologically important. Mosses along with lichens are the first organisms to colonise rocks. They also prevent soil erosion.
- The bryophytes are further divided into liverworts and mosses:

(i) Liverworts

- The liverworts grow in moist and shady places like banks of water bodies, marshy ground, damp soil, bark of trees, etc. Their plant body is thalloid which is dorsiventral and closely appressed to the substrate. Some of the liverworts are leafy. Such forms have tiny leaf-like appendages in two rows on the stem-like structures.
- Asexual reproduction is by fragmentation of thalli or by formation of gemmae. The gemmae are specialised structures which develop in small cup-shaped receptacles on the thalli. These receptacles are called gemma cups. The gemmae after detaching from the parent body germinate and form new individuals.
- The male and female organs associated with the sexual reproduction may be produced on the same thalli or on the different thalli.
- The sporophyte is differentiated into a foot, seta and capsule. In capsule, development of haploid spores takes place. The spores germinate to form free-living gametophytes.
- For e.g., *Marchantia.*



Liver wort: Female Thallus **Male thallus**

(ii) Mosses

- The life cycle of a moss involves both gametophytic phase and sporophytic phase, but the gametophytic phase is predominant one. Gametophytic phase consists of two stages - the first stage is the protonema stage and the second stage is leafy stage.
- Protonema stage develops directly from a spore. It is a creeping, green, branched and filamentous stage.
- Leafy stage develops from the secondary protonema. It consists of upright, slender axis bearing spirally arranged leaves. It bears multicellular and branched rhizoids which help the plant body to attach the soil. Leafy stage bears the sex organs.

Mnemonics

Concept: Divisions of Plant Kingdom
Mnemonics: **A** and **B** **P**lays **G**olf **A**lone
Interpretation: **A**lgae, **B**ryophyta **P**teridophyta, **G**ymnosperms, **A**ngiosperms

- Common examples of mosses are *Funaria*, *Polytrichum* and *Sphagnum*.
- The mosses exhibit following modes of reproduction:
  - Vegetative reproduction in mosses takes place by fragmentation and budding in the secondary protonema.
  - The sex organs i.e., antheridia and archegonia are produced at the apex of the leafy shoots. After fertilisation, zygote is formed which develops into sporophyte.
  - Sporophyte consists of a foot, seta and capsule. The sporophyte in mosses is more elaborate than that in liverworts. Inside the capsule, development of haploid spores takes place. Development of spores involves meiosis.

Pteridophytes

- They are the first terrestrial plants which possess vascular tissues – xylem and phloem. They are mostly found in cool, damp and shady places. The main plant body is a sporophyte which is differentiated into true root, stem and leaves. Each organ has well-differentiated vascular tissues. Some pteridophytes such as *Selaginella* bear small leaves (microphylls) while some other such as ferns bear large leaves (macrophylls).

- The sporophytic plant bears sporangia on the ventral side of leaf-like appendages called sporophylls. In some pteridophytes such as *Selaginella* and *Equisetum*, sporophylls form compact structures each called cone or strobilus. In sporangia, haploid spores are produced by meiotic division in spore mother cells. Each spore germinates and gives rise to inconspicuous, multicellular, thalloid gametophyte called **prothallus**. This prothallus is free-living, mostly photosynthetic and requires cool, damp, shady places to grow.
- The gametophyte bears male (antheridia) and female sex organs (archegonia). The transfer of antherozoids from the antheridia to the mouth of archegonium requires water. Fusion of male gamete with the egg leads to the formation of zygote.
- Later on, zygote develops into a multicellular well-differentiated sporophyte which is the dominant phase in the life cycle of the pteridophytes. Most of the pteridophytes bear same kind of spores. Such plants are called **homosporous**. Some pteridophytes such as *Selaginella* and *Salvinia* bear two kinds of spores – macrospore which are large in size and microspores which are small in size. Such pteridophytes are known as **heterosporous**. The megaspores and microspores germinate and give rise to female and male gametophytes, respectively.
- The pteridophytes are further classified into four classes:
  - **Psilopsida** e.g., *Psilotum*
  - **Lycopsida** e.g., *Selaginella and Lycopodium*
  - **Sphenopsida** e.g., *Equisetum*
  - **Pteropsida** e.g., *Dryopteris, Pteris, Adiantum*

Topic-2 Gymnospermae

Revision Notes

Gymnosperms

- In gymnosperms, ovules are naked without any covering and hence remain exposed. The seeds, which develop after fertilisation, are also naked.
- Gymnosperms are either shrub or tree. In some genera, e.g., in *Pinus*, roots are in association with fungi in the form of **mycorrhiza.** In some other genera of gymnosperms like *Cycas,* roots are associated with nitrogen-fixing cyanobacteria which are called **coralloid roots.**
- In some genera such as *Cycas,* stems are unbranched whereas in some other genera like *Pinus*, *Cedrus,* etc., stem is branched.
- The leaves may be simple or compound. *Cycas* has pinnately compound leaves which persist for a few years. Conifers such as *Pinus, Deodar,* etc., have needle-like leaves with thick cuticle and sunken stomata. All these features help to reduce water loss.
- The gymnosperms are heterosporous. They produce haploid microspores and megaspores within sporangia. Sporangia are formed on sporophylls which are arranged spirally along an axis to form compact strobili or cones.
- The strobili are of two types– male strobili/cones and female strobili/cones. Male cones bear microsporophylls with microsporangia while female cones bear megasporophylls with ovules or megasporangia. The male or female cones may be borne on the same tree as in *Pinus* or on different trees as in *Cycas*.
- The microspore or pollen grain represents reduced gametophyte. The development of pollen grains take place within the microsporangia.
- In ovule, one of the cells of the nucellus differentiates into megaspore mother cell (2n). The megaspore mother cell divides meiotically to form four megaspores (n). One of the megaspores develops into a female gametophyte or embryo sac after nuclear division. The female gametophyte is retained within megasporangium.
- Unlike bryophytes and pteridophytes, in gymnosperms the male and the female gametophytes do not have an independent free-living existence. They remain within the sporangia retained on the sporophytes.
- After the release of pollen grains from the microsporangium, they are carried in air currents. When they come in contact with the opening of the ovules borne on megasporophylls, pollen tube carrying the male gametes grows towards archegonia in the ovules. The pollen tube discharge their contents near the mouth of the archegonia. Subsequently, fertilisation takes place and a zygote is formed. Zygote develops into an embryo and the ovules into seeds. These seeds are not covered.

Mnemonics

Concept: Examples of Gymnosperms
Mnemonics: **G**oing to **CP**
Interpretation: **G**ingko, **C**ycas, **P**inas

Key Words

- **Isogamy:** It is the fusion of two morphologically and physiologically similar gametes.
- **Anisogamy:** It is the fusion of two gametes which are morphologically dissimilar but physiologically similar (both motile or both non-motile).
- **Oogamy:** Refers to the fusion of male and female gametes which are both morphologically and physiologically dissimilar.
- **Gametophyte:** Gametophyte is a haploid plant structure that produces gametes directly by mitosis.
- **Sporophyte:** Sporophyte is diploid (2n) plant structure that produces haploid (n) spores by meiosis.
- **Heterospory:** It is a phenomenon in which two different kinds of spores produced are produced on the same plant.

CHAPTER-4

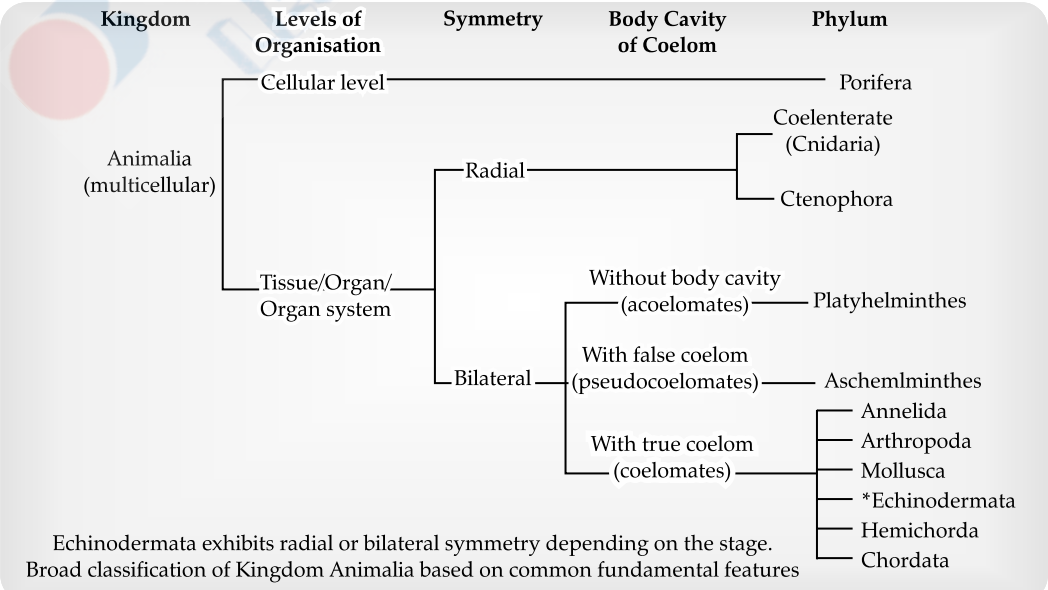
ANIMAL KINGDOM

Topic-1 Classification of Animals

Revision Notes

- **Classification of Animals**

Animals are classified on the basis of arrangement of cells, body symmetry, nature of coelom, patterns of digestive, circulatory or reproductive systems.



Echinodermata exhibits radial or bilateral symmetry depending on the stage.
Broad classification of Kingdom Animalia based on common fundamental features

Phylum Porifera

- Members of this phylum are commonly known as sponges.
- Most of them are marine and **asymmetrical** animals.
- They are primitive multicellular animals with cellular level of organisation.
- Body wall is two layered – outer dermal layer called **pinacoderm** and inner gastral layer called **choanoderm**.

Mnemonics

Concept: Phylums
Mnemonics: A CHAMP PACE
Interpretation: Aschelminthes **C**oelentterata **H**emichordata, **A**nnelida **M**ollusca **P**latyhelminthes **P**orifera, **A**rthropoda **C**tenophora, **E**chinodermata.

- Flat cells called **pinacocytes** are present in the pinacoderm and specialised flagellated cells called **collar cells or choanocytes** are present in the choanoderm.
- They possess a large cavity called spongocoel, which opens to outside through a pore called **osculum**. Choanocytes line the spongocoel.
- They have a water canal system. Water enters through minute pores called **ostia** in the spongocoel and from the spongocoel goes out through the osculum. The canal system helps in gathering of food, respiratory exchange and removal of waste.
- The body is supported by a skeleton made up of spicules or spongin fibres.
- Digestion is intracellular.
- They are hermaphrodite i.e., male and female sex organs are present on the same individual.
- They reproduce by asexual and sexual reproduction. Asexual reproduction takes place through fragmentation and sexual by formation of gametes. Fertilisation is internal.
- Development is indirect and involves a larval stage which is morphologically distinct from the adult.
- Examples: *Sycon* (Scypha), *Spongilla* (fresh water sponge) and *Euspongia* (bath sponge).

Phylum- Coelenterata (Cnidaria)

- They are aquatic, mostly marine, sessile or free-swimming animals.
- They possess radial symmetry.
- They exhibit tissue level of organisation.
- They are diploblastic.
- They possess special cells called **cnidoblasts** or **cnidocytes** on the tentacles and the body. These cells help in anchorage, defence and capturing of prey.
- They have a central gastro-vascular cavity with a single opening called **hypostome**. Digestion is extracellular and intracellular.
- Some of the coelentrates like corals possess a skeleton composed of calcium carbonate.
- Coelentrates show two basic body forms – polyp and medusa.
  - **Polyp form:** It is the sessile and cylindrical form which is observed in *Hydra* and *Adamsia*.
  - **Medusa form:** It is the umbrella-shaped and free-swimming form which is observed in *Aurelia* or jelly fish.
- Some coelentrates e.g., *Obelia* exist in both forms. These coelentrates exhibit phenomenon of alternation of generation (metagenesis). Polyp form reproduces asexually to produce medusae and medusa form reproduces sexually to produce polyps.
- Common examples of coelentrates are *Physalia* (Portuguese man-of-war), *Adamsia* (Sea anemone), *Pennatula* (Sea-pen), *Gorgonia* (Sea-fan) and *Meandrina* (Brain coral).

Phylum – Ctenophora

- Members of this phylum are commonly known as **sea walnuts** or **comb jellies**.
- They are exclusively marine and possess radial symmetry.
- They are diploblastic organisms with tissue level of organisation.
- Their body bears eight external rows of ciliated comb plates which help in locomotion.
- They exhibit the phenomenon of bioluminescence (the property of a living organism to emit light).
- Digestion is both extracellular and intracellular.
- They are hermaphrodite. They reproduce only by sexual means. Fertilisation is external and development is indirect.
- Common examples of ctenophores are *Pleurobrachia* and *Ctenoplana*.

Phylum – Platyhelminthes

- The members belonging to this phylum have dorso-ventrally flattened body. Because of this they are also called as **flatworms**.

- They possess bilateral symmetry.
- They are triploblastic and acoelomate animals with organ level of organisation.
- Most of them are endoparasites. They possess hooks and suckers to attach and absorb digested food from the host.
- Specialised cells called **flame cells** are present in them. These cells help in osmoregulation and excretion.
- They are hermaphrodite.
- Fertilisation is internal and development is through many larval stages.
- Common examples of flat worms are *Taenia* (Tapeworm) and *Fasciola* (Liver fluke).

Phylum – Aschelminthes

- As their body is circular in cross-section, they are also know as round worm.
- They are found in variety of habitats. For example, some of them are aquatic, some are terrestrial and some are parasitic in plants and animals.
- They have organ-system level of body organisation.
- They possess bilateral symmetry.
- They are triploblastic and pseudocoelomate animals.
- They possess complete digestive system with well developed muscular pharynx.
- They have an excretory tube which removes body wastes from the body cavity through the excretory pore.
- They are dioecious, i.e., males and females are distinct. Usually, females are longer than males.
- Fertilisation is internal and development may be direct or indirect.
- Some examples of aschelminthes are *Ascaris* (Round Worm), *Wuchereria* (Filarial worm) and *Ancylostoma* (Hookworm).

Phylum – Annelida

- They may be aquatic (marine and freshwater) or terrestrial; free-living, and sometimes parasitic.
- They have organ-system level of body organisation.
- They have bilateral symmetry.
- They are triploblastic and coelomate animals.
- Their body surface is distinctly marked out into segments or metameres.
- They possess longitudinal and circular muscles which help in locomotion.
- Aquatic annelids like *Nereis* possess lateral appendages called **parapodia** which help in swimming.
- They possess closed circulatory system.
- Nephridia (sing. nephridium) help in osmoregulation and excretion.
- Neural system consists of paired ganglia connected by lateral nerves to a double ventral nerve cord.
- Some of them such as *Nereis* is dioecious, while some such as earthworms and leeches are monoecious.
- They reproduce by sexual means.
- Common examples of annelids are *Nereis*, *Pheretima* (Earthworm) and *Hirudinaria* (Blood sucking leech).

Phylum Arthropoda

- This is the largest phylum of Kingdom Animalia which includes insects.
- More than two-third of all named species on earth are arthropods.
- They have organ-system level of organisation.
- They have bilateral symmetry.
- They are triploblastic, segmented and coelomate animals.
- Their body is covered by chitinous exoskeleton.
- The body is divisible into three parts – head, thorax and abdomen.
- They have jointed appendages.
- They have gills, book gills, book lungs or tracheal system as respiratory organ.
- They have open circulatory system.
- They possess sensory organs like antennae and eyes.
- They have malpighian tubules as excretory organ.
- Most of them are dioecious and oviparous.
- Fertilisation is usually internal. Development may be direct or indirect.
- Some of the arthropods such as *Apis* (Honey bee), *Bombyx* (Silkworm), *Laccifer* (Lac insect) are economically important insects while some other insects like *Anopheles*, *Culex* and *Aedes* (Mosquitoes) are vectors and some insects like *Locusta* (Locust) are pest. *Limulus* (King crab) is a living fossil.

Phylum – Mollusca

- This is the second largest phylum of Kingdom Animalia.
- Molluscs are terrestrial or aquatic (marine or freshwater) organisms.

- They have an organ-system level of organisation.
- Their body is bilaterally symmetrical.
- They are triploblastic and coelomate animals.
- They have soft and unsegmented body covered by a calcareous shell.
- Their body is differentiated into head, muscular foot and visceral hump. A soft and spongy layer of skin forms a mantle over the visceral hump. The space between the hump and the mantle is called the mantle cavity.
- The anterior region of the head bears sensory tentacles. The mouth contains a rasping organ for feeding, called radula.
- In terrestrial forms, respiration takes place through lungs and in aquatic forms, respiration takes place through feather-like gills which are present in the mantle cavity.
- Molluscs are usually dioecious and oviparous with indirect development.
- Common examples of molluscs are *Pila* (Apple snail), *Pinctada* (Pearl oyster), *Sepia* (Cuttlefish), *Loligo* (Squid), *Octopus* (Devil fish), *Aplysia* (Sea- hare), *Dentalium* (Tusk shell) and *Chaetopleura* (Chiton).

Phylum – Echinodermata

- The echinoderms are marine organisms which have an endoskeleton of calcareous ossicles.
- They have organ-system level of organisation.
- The echinoderms, in larval stage, are bilaterally symmetrical but adults are radially symmetrical.
- They are triploblastic and coelomate animals.
- The digestive system is complete. The mouth is situated on the lower (ventral) side and anus is present on the upper (dorsal) side.
- Their unique characteristic is presence of water vascular system. This sytem helps in locomotion, capture and transport of food and respiration.
- Echinoderms lack excretory system.
- They reproduce by sexual means. Sexes are separate.
- Fertilisation is usually external and development is indirect with free-swimming larva.
- Common echinoderms are *Asterias* (Star fish), *Echinus* (Sea urchin), *Antedon* (Sea lily), *Cucumaria* (Sea cucumber) and *Ophiura* (Brittle star).

Phylum – Hemichordata

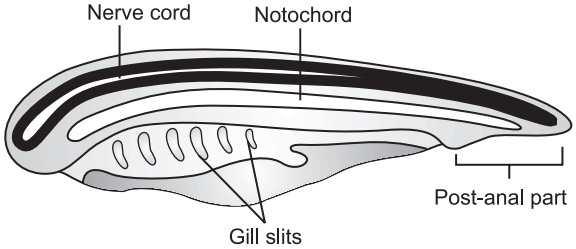
- It was earlier considered as a sub-phylum under phylum Chordata. But now it is considered as a separate phylum under non-chordata.
- This phylum incorporates worm-like marine animals with organ-system level of organisation.
- Hemichordates are bilaterally symmetrical, triploblastic and coelomate animals.
- Their body is cylindrical and differentiated into an anterior proboscis, a collar and a long trunk.
- They have open circulatory system.
- They respire through gills.
- Proboscis gland is their excretory organ.
- Sexes are separate. Fertilisation is external and development is indirect.
- Common hemichordates are *Balanoglossus* and *Saccoglossus*.

Topic-2 Chordata

Revision Notes

Phylum-Chordata

- Animals belonging to phylum Chordata are fundamentally characterised by the presence of a notochord, a dorsal hollow nerve cord and paired pharyngeal gill slits.



Chordata characteristics

- They are bilaterally symmetrical, triploblastic, coelomate with organ-system level of organisation.
- They possess a post anal tail and a closed circulatory system.

Table: Comparison of Chordates and Non-chordates.

S.No.	Chordates	Non-chordates
(i)	Notochord present.	Notochord absent.
(ii)	Central nervous system is dorsal, hollow and single.	Central nervous system is ventral, solid and double.
(iii)	Pharynx perforated by gill slits.	Gill slits are absent.
(iv)	Heart is ventral.	Heart is dorsal (if present).
(v)	A post-anal part (tail) is present.	Post-anal tail is absent.

- **Phylum Chordata is divided into three subphyla:**
  - **(i) Urochordata:** In urochordates, notochord is present only in larval tail. Their examples are *Ascidia*, *Salpa* and *Doliolum*.
  - **(ii) Cephalochordata:** In cephalochordates, notochord extends from head to tail region and is persistent throughout their life. Examples of cephalochordates is *Branchiostoma*.
  - **(iii) Vertebrata:** The members of this sub-phylum possess notochord during the embryonic period. In adults, this notochord is replaced by a cartilaginous or bony vertebral column.
    - Subphyla Urochordata and Cephalochordata are often referred to as protochordate.
    - They have a ventral muscular heart with two, three or four chambers.
    - They have kidneys for excretion and osmoregulation.
    - They have paired appendages either in the form of fins or in the form of limbs.
    - Subphylum vertebrata is divided into two Divisions: Agnatha and Gnathostomata.

Divisions : Agnatha (The jawless vertebrates).

Class – Cyclostomata

- All the members of class Cyclostomata are marine and ectoparasites on some fishes.
- They possess an elongated body containing 6-15 pairs of gill slits for respiration.
- They have a sucking and circular mouth without jaws.
- They lack scales and paired fins.
- Their cranium and vertebral column are cartilaginous.
- They have closed circulatory system.
- They are marine creatures but for spawning they migrate to freshwater. Thereafter, they die within a few days.
- Their larvae, after metamorphosis, return to the ocean.
- Some common members of class cyclostomata are *Petromyzon* (Lamprey) and *Myxine* (Hagfish).

Divisions : Gnathostomata (The jawed Vertebrates) Gnathostomata is divided into two.

Super Classes: Pisces and Tetrapod

Super Class I: Pisces (bear fins)

Class 1 – Chondrichthyes

- They are marine animals.
- Their body is streamlined and endoskeleton is cartilaginous.
- Their mouth is located on the ventral side.
- Notochord is persistent throughout life.
- Gill slits are separate and not covered by operculum.
- They contain minute placoid scales. Because of their presence, the skin is tough.
- Their teeth are modified placoid scales which are backwardly directed. Their jaws are very powerful. These animals are predaceous.
- They lack air bladder and hence to avoid sinking they have to swim constantly.
- Their heart is two-chambered (one auricle and one ventricle).
- Some of cartilaginous fishes e.g., *Torpedo* have electric organs and some of them e.g., *Trygon* possess poison sting.
- They do not have capacity to regulate their body temperature. Such type of animals are called cold-blooded animals or poikilothermous animals.
- Sexes are separate. In males, pelvic fins bear claspers.
- They show internal fertilisation and many of them are viviparous.
- Some examples of chondrichthyes are *Scoliodon* (Dog fish), *Pristis* (Saw fish) and *Carcharodon* (Great white shark) and *Trygon* (Sting ray).

Class 2 – Osteichthyes

- This class includes those marine and freshwater fishes which have bony endoskeleton.
- Their body is streamlined and mouth is terminal.
- They possess four pairs of gills which are covered by an operculum on each side.
- Skin is covered with cycloid/ctenoid scales.
- They possess air bladder which regulates buoyancy.
- They have two- chambered (one auricle and one ventricle) heart.
- They are cold-blooded animals.
- Sexes are separate.
- Fertilisation is usually external and most of them are oviparous.
- Development is direct.
- Common examples of marine bony fishes are *Exocoetus* (Flying fish), *Hippocampus* (Sea horse) while *Labeo* (Rohu), *Catla* (Katla), *Clarias* (Magur) are examples of freshwater bony fishes. Some of them such as *Betta* (Fighting fish), and *Pterophyllum* (Angel fish) are aquarium fishes.

Super class 2. Tetrapoda (bear two pairs of limbs).

Class 1. – Amphibia

- Amphibians can live in aquatic as well as terrestrial habitats.
- Their body is differentiated into head and trunk. Some amphibians also possess tail.
- Their skin is moist and lack scales.
- They have two pairs of limbs.
- The eyes have eyelids and tympanum represents the ear.
- Respiration takes place by gills, lungs and through skin.
- They possess three-chambered heart. Out of the three chambers, two are auricles and third one is ventricle.
- They are cold-blooded animals.
- Sexes are separate. They are oviparous.
- Fertilisation is external and development is direct or indirect.
- Some common amphibians are *Bufo* (Toad), *Rana* (Frog), *Hyla* (Tree frog), *Salamandra* (Salamander) and *Ichthyophis* (Limbless amphibia).

Class 2. – Reptilia

- Members of this class are mostly terrestrial animals and have creeping or crawling mode of locomotion.
- Their body is covered with dry and cornified skin, epidermal scales or scutes.
- They lack external ear openings. Tympanum represents ear.
- Most of them possess two pairs of limbs while some do not have limbs.
- Except the crocodiles, all reptiles have three-chambered heart. (Crocodiles have four-chambered heart).
- They are cold blooded animals.
- Sexes are separate.
- They are oviparous.
- Fertilisation is internal and development is direct.
- Some common reptiles are *Chelone* (Turtle), *Testudo* (Tortoise), *Chameleon* (Tree lizard), *Calotes* (Garden lizard), *Crocodilus* (Crocodile), *Alligator* (Alligator), *Hemidactylus* (Wall lizard) and poisonous snakes like *Naja* (Cobra), *Bangarus* (Krait), *Vipera* (Viper).

Class 3. – Aves

- This class includes all the birds which have ability to fly (except flightless birds like ostrich).
- They are characterised by the presence of feathers.
- They possess a beak.
- Their forelimbs are modified into wings and the hind limbs are modified for walking, swimming or clasping the tree branches.
- Their skin is dry and lacks glands but at the base of the tail, oil gland is present.
- They have fully ossified (bony) endoskeleton. The long bones are hollow with air cavities (pneumatic).
- In birds, there are additional chambers in digestive tract called the crop and gizzard.
- Heart is four – chambered.
- They are able to maintain a constant body temperature. Such type of animals are called warm-blooded or homoiothermous animals.
- They respire through lungs.

- Sexes are separate and fertilisation is internal.
- They are oviparous and development is direct.
- Common members of this class are *Corvus* (Crow), *Columba* (Pigeon), *Psittacula* (Parrot), *Struthio* (Ostrich), *Pavo* (Peacock), *Aptenodytes* (Penguin) and *Neophron* (Vulture).

Class 4. – Mammalia

- They are found in a variety of habitats like polar ice caps, deserts, mountains, forests, grasslands and dark caves. Some of them are also adapted to fly or live in water.
- They have milk producing mammary glands to nourish their young ones.
- They possess two pairs of limbs which are adapted for walking, running, climbing, burrowing, swimming or flying.
- They possess hair on the skin.
- External ears or pinnae are present.
- They possess different types of teeth in the jaw.
- The heart is four-chambered.
- They are homoiothermous.
- They respire through lungs.
- Sexes are separate and fertilisation is internal.
- They are viviparous with few exceptions and development is direct.
- Common mammals are *Macropus* (Kangaroo), *Pteropus* (Flying fox), *Camelus* (Camel), *Macaca* (Monkey), *Rattus* (Rat), *Canis* (Dog), *Felis* (Cat), *Elephas* (Elephant), *Equus* (Horse), *Delphinus* (Common dolphin), *Balaenoptera* (Blue whale), *Panthera tigris* (Tiger), *Panthera leo* (Lion). Exceptionally *Ornithorhynchus* (Platypus) is an oviparous mammal.

Salient Features of Different Phyla in the Animal Kingdom

Phylum	Level of Organisation	Symmetry	Coelom	Segmentation	Digestive System	Circulatory System	Respiratory System	Distinctive Features
Porifera	Cellular	Asymmetrical	Absent	Absent	Absent	Absent	Absent	Body with pores and canals in walls.
Coelenterate (Cnidaria)	Tissue	Radial	Absent	Absent	Incomplete	Absent	Absent	Cnidoblasts present.
Ctenophora	Tissue	Radial	Absent	Absent	Incomplete	Absent	Absent	Comb plates for locomotion.
Platyhelminthes	Organ & Organ system	Bilateral	Absent	Absent	Incomplete	Absent	Absent	Flat body, suckers.
Aschelminthes	Organ system	Bilateral	Pseudocoelomate	Absent	Complete	Absent	Absent	Often worm-shaped elongated
Annelida	Organ system	Bilateral	Coelomate	Present	Complete	Present	Present	Body segmentation like rings.
Arthropoda	Organ system	Bilateral	Coelomate	Present	Complete	Present	Present	Exoskeleton of cuticle, jointed appendages.
Mollusca	Organ system	Bilateral	Coelomate	Absent	Complete	Present	Present	External skeleton shell usually present.
Echinodermata	Organ system	Radial	Coelomate	Absent	Complete	Present	Present	Water vascular system, radial symmetry.
Hemichordata	Organ system	Bilateral	Coelomate	Absent	Complete	Present	Present	Worm-like with proboscis, collar and trunk.
Chordata	Organ system	Bilateral	Coelomate	Present	Complete	Present	Present	Notochord, dorsal hollow nerve cord, gill slits with limbs or fins.

Key Words

- **External fertilisation:** When fertilisation occurs outside the female body, it is called external fertilisation
- **Internal fertilisation:** When fertilisation occurs inside the female body, it is called internal fertilisation.
- **Direct development:** In this, the young ones resemble the adults in all respects except colour, size.
- **Indirect development:** In this, the young ones do not resemble the adults.

UNIT – II: STRUCTURAL ORGANISATION IN ANIMALS AND PLANTS

CHAPTER-5

MORPHOLOGY OF FLOWERING PLANTS

Topic-1 Morphology of Root, Stem and Leaf

Revision Notes

- **Morphology** is the branch of biological science that deals with the study of form, size, colour, structure and relative position of various parts of organisms.
- **Importance of morphology:**
  - Knowledge of morphology is essential for recognition or identification of plants.
  - It gives information about the range of variations found in a species.
- **Parts of Flowering Plants**:
  - All the flowering plants have roots, stem, leaves, flower and fruits. The underground parts of flowering plant are the root system and the portion above the ground forms the shoot system.

The Root:

  - In dicotyledons, elongation of radicle forms the primary roots which bears lateral roots of several orders called secondary roots, tertiary roots, etc. Primary roots along with lateral roots forms the **tap root system**. Examples: Mustard, Gram, etc.
  - In monocotyledons, primary root is replaced by large number of roots at its base of stem to constitute the fibrous root system. Example: Wheat, Rice, etc.
  - The roots that arise from other parts of plant beside radicle are called **adventitious roots.** Examples: Grass, Prop roots of Banyan tree, Maize, etc.
  - The main functions of root system is the absorption of water and minerals from soil, providing proper anchorage to the plant parts and storing reserve food materials.
- **Regions of Root:**
  - The apex of root is covered by a thimble like structure called **root cap**. It protects the tender apex of root while making way through soil.
  - Above the root cap is **region of meristematic activity** having small cells with dense cytoplasm.
  - The cells above the region of meristematic activity is **region of elongation** where cells undergo elongation and enlargement to increase the length of root.
  - **Region of maturation** contain root hairs that help in absorption of water and minerals.

The Stem:

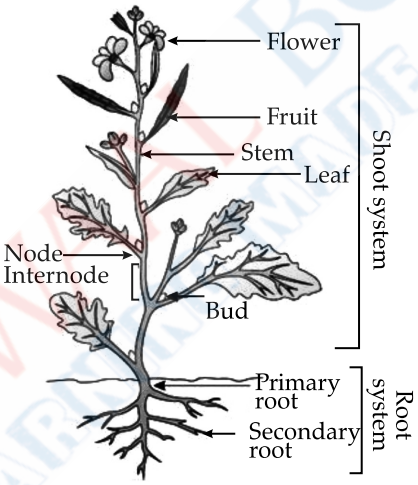
  - The ascending part of axis bears branches, leaves, flowers and fruits. It develops from plumule of the embryo.
  - Stem bears nodes and internodes. The region of stem where leaves are born are called nodes and portion between two nodes are called internodes.
  - The main function of stem is to spread branches, bear leaves, flowers and fruits. It also conducts water and minerals from root to leaves.

- Some stem perform special functions like storage of food, support, protection and vegetative propagation.

The Leaf:

- Leaf is a green, dissimilar exogenous lateral flattened outgrowth which is borne on the node of a stem or its branches. It is specialised to perform photosynthesis.
- Leaves originate from shoot apical meristem and are arranged in an acropetal order.
- A typical leaf consists of three parts- leaf base, petiole, lamina. Leaf is attached with stem by leaf base which may bear two small leaf like structure called stipules.
- Middle prominent vein is called midrib. Veins provide rigidity to the leaf blade and act as channel for the transport of water minerals and food material.
- The arrangement of vein and veinlets in the lamina is called venation.
- A leaf having a single or undivided lamina is called **simple leaf**. Here, the incisions do not touch the mid rib. Examples: Mango, Guava, etc.
- When the incision of lamina reach up to the midrib and breaks it into a number of leaflets, it is called **compound leaves**.
- The compound leaves may be of two types. In a **pinnately compound leaves**, a number of leaflets are present on common axis called **rachis**. Example- Neem.
- In **palmately compound leaves**, the leaflets are attached at a common point. Example- Silk cotton.
- The pattern of arrangement of leaves on the stem or branch is called **phyllotaxy**.
- In **alternate type of phyllotaxy,** single leaf arise at each node as in China rose.
- In **opposite types of phyllotaxy,** a pair of leaves arise from each node opposite to each other as in Guava.
- If more than two leaves arise at a node and form a whorl it is called **whorled type** of phyllotaxy as in *Alstonia*.
- Leaves are modified to perform other functions like converting to tendril for climbing as in Peas and spines for defence in Cactus.

Important Diagram



Topic-2 Parts of the Flowering Plants: Flower, Fruits and Seed; Family Solanaceae

Revision Notes

- A flower is a modified shoot wherein the shoot apical meristem changes to floral meristem.
- **Inflorescence:** The arrangement of flowers on the floral axis is termed as inflorescence. Two main types of inflorescence are **racemose** and **cymose.**
- In racemose type, the main axis continues to grow and the flowers are borne laterally in an acropetal succession. In cymose type, the main axis terminates in a flower and is limited in growth. The flowers are borne in a basipetal order.
- **The flower:**
  - Flower is the reproductive part of angiospermic plants for sexual means of reproduction. A typical flower has four whorls arranged on a swollen end of stalk or pedicel called **thalamus**. They are c**alyx, corolla, androecium** and **gynoecium**.

Mnemonics

Concept: Four whorls of Flower
Mnemonics: **C**at in **CAG**e
Interpretation: **C**alyx, **C**orolla, **A**ndroecium, **G**ynoecium

- A flower that have both androecium and gynoecium, is called **bisexual** and flower that have either androecium or gynoecium is called **unisexual**.
- When flower can be divided into two equal radial halves in any radii passing through the center, the symmetry of flower is called **actinomorphic** (radial symmetry) as in Mustard, Datura, and Chilli.
- When flower can be divided into two similar parts only in one vertical plane, it is **zygomorphic** as in Pea, Gulmohar, *Cassia*, etc.
- When floral appendages are in multiple of 3, 4 or 5, they are called **trimerous, tetramerous** and **pentamerous** respectively.
- Flower with reduced small leaf at the base of pedicel are called **bracteate** and without small leaf are called **ebracteate**.
- Based on the position of ovary with respect to other floral part on thalamus, flowers are of following types:
  1. **Hypogynous flower:** Ovary occupies the highest position i.e., ovary is superior. e.g., Mustard, brinjal and china rose.
  2. **Perigynous flowers:** Here, ovary is situated at the centre and other parts are on the rim of the thalamus. Ovary is called half-inferior. e.g., Plum, rose and peach.
  3. **Epigynous flowers:** In this, thalamus grows around the ovary fusing with its wall. Ovary is said to be inferior as in flowers of guava and cucumber, and the ray florets of sunflower.
- **Calyx** is the outermost whorls of the flower; its members are called **sepals**. They are generally green and leafy; protect the flower in bud stage. It may be **gamosepalous** (sepals united) or **polysepalous** (sepals free).
- **Corolla** consists of petals, which are brightly coloured to attract the insects for pollination. They may be **gamopetalous** or **polypetalous**.

Aestivation: The mode of arrangement of sepals or petals in floral bud with respect to the other members of same whorl is called aestivation It is of following types:

- In **valvate**, the whorls of sepals or petals touch each other as in *Calotropis*.
- In **twisted** aestivation, the whorls overlap each other as in China rose.
- In **imbricate** aestivation, margin petal overlap each other but not in particular fashion as in Gulmohar.
- In **vexillary** aestivation, the largest petal overlap the two lateral petals which in turn overlap two smallest anterior petal. e.g., Pea and Bean flowers.

The Androecium:

- Androecium represent the male reproductive part of a flower. It consists of stamens. Each stamen consists of filament and anther. Pollen grains are produced in pollen sac. Sterile stamen is called **staminode**.
- When stamens are attached with petals, it is called **epipetalous** (Brinjal). Stamen may be free (**polyandrous**) or may be united in one bundle (**monoadelphous**), two bundles (**diadelphous**), or into more than two (**polyadelphous**).

The Gynoecium:

- Female reproductive part of flower consists of one or more carpels. Each carpel is made up of stigma, style and ovary.
- When more than one carpel is present, it may be free (**apocarpous**) as in lotus and rose or fused together (**syncarpous**) as in mustard and tomato.
- After fertilisation, ovules change into seeds and ovary mature into fruits.

Placentation:

- The arrangement of ovules within the ovary is called placentation.
- The placentation are of different types namely marginal, axile, parietal, basal, central and free central.

The Fruit:

- Mature and ripened ovary developed after fertilisation is fruit. If a fruit is formed without fertilisation of ovary, it is called **parthenocarpic fruit.**
- Fruit consists of seeds and pericarp. Thick and fleshy pericarp is three layered called epicarp, mesocarp and endocarp.

- Dicotyledonous seed is made up of a seed coat and an embryo. **Embryo** is made up of embryonal axis, radicle and cotyledons.
- Seed coat has two layers: outer **testa** and inner **tegmen**. **Hilum** is scar through which seed is attached to the ovary. Small pore above the hilum is called micropyle.
- In monocotyledonous seed, outer covering of endosperm separate the embryo by a proteinaceous layer called **aleurone layer.**
- Single cotyledon is called as **scutellum** having a short axis bearing plumule and radicle.
- Plumule and radicle are closed inside sheaths called as **coleoptile** and **coleorhiza** respectively.

Solanaceae

- It is a large family, commonly called as the 'potato family'. It is widely distributed in tropics, subtropics and even temperate zones.
- **Vegetative Characters:** Plants mostly herbs, shrubs and rarely small trees
  - **Stem:** Herbaceous rarely woody, aerial; erect, cylindrical, branched, solid or hollow, hairy or glabrous, underground stem in potato (*Solanum tuberosum*).
  - **Leaves:** Alternate, simple, rarely pinnately compound, exstipulate; venation reticulate
- **Floral Characters**
  - **Inflorescence:** Solitary, axillary or cymose as in Solanum
  - **Flower:** Bisexual, actinomorphic
  - **Calyx:** Sepals five, united, persistent, valvate aestivation
  - **Corolla:** Petals five, united; valvate aestivation
  - **Androecium:** Stamens five, epipetalous
  - **Gynoecium:** Bicarpellary obligately placed, syncarpous; ovary superior, bilocular, placenta swollen with many ovules, axile.
  - **Fruits:** Berry or capsule
  - **Seeds:** Many, endospermous.
  - Many plants belonging to this family are source of food (tomato, brinjal, potato), spice (chilli); medicine (belladonna, ashwagandha); fumigatory (tobacco); ornamentals (petunia).
  - **Floral Formula:** $\oplus\ \female\!\!\male\ K_{(5)}C_{(5)}A_5G_{(2)}$
  - Many of them are source of food (potato, tomato, brinjal, etc.), spices (chilli), etc.

Key Words

- **Root cap:** It is a thimble like structure that covers the root apex.
- **Phyllotaxy:** It is the pattern of arrangement of leaves on the stem or branch.
- **Inflorescence:** The arrangement of flowers on the floral axis is known as inflorescence.
- **Unisexual flowers:** Flowers, which contain either gynoecium (stamen) or androecium (carpels), are called unisexual flowers.
- **Bisexual flowers:** Flowers, which contain both androecium (carpels) and gynoecium (stamens), are called bisexual flowers.
- **Hypogynous flowers (Superior ovary):** Flowers in which ovary occupies the highest position on the thalamus while other floral parts are situated below it.
- **Perigynous flowers (Half inferior ovary):** Flowers in which, ovary is situated at the centre and other floral parts are arranged on the rim of the thalamus
- **Epigynous flowers (Inferior ovary):** Flowers in which, the thalamus grows around the ovary fusing with its wall.
- **Aestivation:** It is the mode in which sepals or petals are arranged in a floral bud with respect to other floral members.
- **Placentation:** It refers to the arrangement of ovules within the ovary of a flower.
- **Fruit:** It is the matured or ripened ovary developed after fertilisation.

CHAPTER-6

ANATOMY OF FLOWERING PLANTS

Topic-1 Plant Tissue System

Revision Notes

- **Anatomy** is the study of internal structure of organism. In plants, anatomy includes histology, that is, organisation and structure of tissues. Anatomy helps in knowing the structural peculiarities of different group of plants and indicates the structural adaptation to diverse environments.
- The cells that have become structurally and functionally specialised and have lost the ability of cell division are called **permanent tissue**.
- **Epidermal Tissue System :**
  - It forms the outermost covering of whole plant body, which consists of epidermal cells, stomata and the epidermal appendages (trichomes and hairs).
  - Epidermis is single layered, parenchymatous with waxy thick layers of cuticle to prevent water loss.
  - Stomata is present in epidermis of leaves. It regulates the transpiration and gaseous exchange. In dicots, stomata are bean-shaped having two guard cells closing the stomatal pore. In monocots, stoma is dumb-bell shaped. Guard cells contain chloroplasts that help in opening and closing of stomata.
  - Epidermis also contains a number of hairs. Root hairs are unicellular elongation of epidermal cells. Trichomes are present on stems, which are multicellular, branched or unbranched preventing water loss due to transpiration.
- **The Ground Tissue System :**
  - All the tissue between epidermis and vascular bundle forms the ground tissues. It consists of simple permanent tissues. Parenchyma is present in pericycle, cortex, pith and medullary rays in stem and roots.
  - In leaves, the ground tissue consists of thin-walled chloroplast containing cells and is called **mesophyll**.
- **The Vascular Tissue System :**
  - The vascular system consists of complex tissues, xylem and phloem that together form vascular bundles.
  - The cambium is present between phloem and xylem. Such vascular bundles because of the presence of cambium possess the ability to form secondary xylem, and hence called **open** vascular bundles.
  - In monocots, the vascular bundles have no cambium and are called **closed**.
  - When xylem and phloem within a vascular bundle are arranged in alternate manner on different radii, the arrangement are called **radial** as in roots. When xylem and phloem are situated at the same radius of vascular bundle, it is called **conjoint** as in stem and leaves.

Topic-2 Anatomy of Root, Stem and Leaf

Revision Notes

- **Dicotyledonous Root :**
  - The outermost layer of dicot root is epidermis containing unicellular root hairs.
  - Below epidermis is the cortex which consists of many layers of thin-walled parenchymatous cells with intercellular spaces.
  - The innermost layer of cortex is called endodermis having waxy material suberin as casparian strips, which is impermeable to water.
  - Pericycle is present below endodermis. The parenchymatous cells lying between xylem and phloem are called conjunctive tissue.

- Two to four xylem and phloem patches are present. All the tissues inside the endodermis constitute the stele.

- **Monocotyledonous Roots :**
  - Anatomically in monocot roots, epidermis, cortex, endodermis, pith are similar to dicots except having more than six vascular bundles with larger pith.
- **Dicotyledonous Stem :**
  - Epidermis is the outermost layer of dicot stems having thin layer of cuticle, may contain trichomes and hairs.
  - Cortex is divided into three sub-layers, outer hypodermis (collenchymatous), middle cortical layer (parenchymatous) and inner endodermis, which is rich in starch grains so, also known as starch sheath.
  - Vascular bundles are conjoint, open, endarch with protoxylem. Pith is parenchymatous with intercellular spaces.
- **Monocotyledonous Stem :**
  - They have sclerenchymatous hypodermis, large number of scattered vascular bundles surrounded by sclerenchymatous bundle sheath. Vascular bundles are closed and conjoint. Phloem parenchyma is absent.
- **Dicotyledonous Leaf (Dorsiventral) :**
  - Vertical section through lamina shows three regions : epidermis, mesophyll and vascular system.
  - Epidermis covers both upper (adaxial) and lower (abaxial) surface. Abaxial surface have more stomata.
  - Mesophyll which bears chlorophyll to carry out photosynthesis, are made up of parenchyma. Spongy parenchyma are spherical and loosely arranged but palisade parenchyma are elongated.
  - Vascular system includes vascular bundles, which are seen in veins and midribs.
  - Vascular bundles are surrounded by thick bundle sheath cells.
- **Monocotyledonous Leaf (Isobilateral) :**
  - Monocots leaves are similar to dicots leaves anatomically except stomata are present on both surfaces of epidermis and mesophyll cells are not differentiated as spongy and palisade cells.
  - In grasses, some adaxial epidermal cell with veins are modified into large, empty, colourless cells called bulliform cells. These cells make the leaves turgid when water is absorbed and curls in case of water stress.

Key Words

- **Tissue :** Tissue is a group of cells with common origin, structure and function that work together to perform a particular function.
- **Xylem :** It is a complex permanent tissue that conducts water and mineral upward from root to the plant.
- **Phloem :** Phloem is a complex permanent tissue that conducts food synthesised in the leaves to different parts of the plant body.
- **Open vascular bundles :** Vascular bundles in which cambium is present between phloem and xylem.
- **Closed vascular bundles :** Vascular bundles which lack cambium.

CHAPTER-7

STURCTURAL ORGANISATION IN ANIMALS

Revision Notes

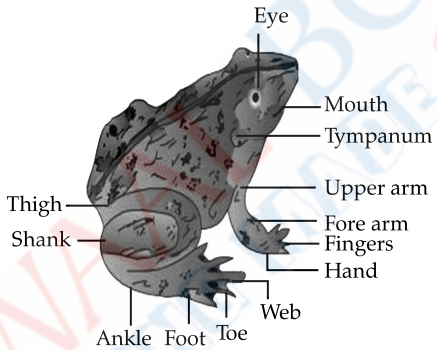
Frog (*Rana tigrina*)

- Frogs are a type of amphibious vertebrate, which belong to class Amphibia of phylum Chordata. It can live on both land and in freshwater.
- *Rana tigrina* is the most common Indian species.
- They are called cold-blooded or poikilotherms.
- **Poikilotherms:** These are organisms whose body temperature changes in response to their surroundings. As a result, they do not maintain a constant body temperature.
- They also have the ability to change the color of their skin in order to blend in with their surroundings and hide from their enemies. This ability is known as camouflage.

- During extreme hot conditions, frogs take shelter in deep burrows to protect themselves from extreme hot environment called as aestivation.
- Aestivation is defined as an organism's dormant state during the summer. This assists the organism in surviving extreme heat of summers.
- An organism's dormant state during the winter is known as hibernation or winter sleep. This assists the organism in surviving the bitter cold of winter. At this stage, the organism's metabolic and physiological activities are minimal.

Morphology:

- The skin of the frog is smooth and slippery because of the presence of mucus. This aids in keeping the skin moist at all times. The frog does not consume water. Instead, it absorbs it through the skin.
- The dorsal side of the body is olive green with dark irregular spots. The ventral side is a light yellow in colour.
- A frog's body is divided into head and the trunk. There is no neck or tail.
- The body of a frog has a pair of nostrils, bulged eyes covered by a nictitating membrane, and a membranous tympanum (ear)
- Nictitating membrane is a whitish or translucent membrane that forms an inner eyelid.
- Tympanum is a membranous structure that represents the ear on either side of the eye. It is capable of receiving sound signals.
- The forelimbs and hindlimbs aid in walking, swimming, leaping, and burrowing.
- The hind limbs are larger and more muscular than the forelimbs. They all end in five digits.
- Forelimbs are smaller and less muscular than hind limbs. They all have four digits at the end. Webbed digits on the feet aid in swimming.



- Frogs have two sexes. Male frogs are distinguished by the presence of sound-producing vocal sacs and a copulatory pad on the first forelimb digit.

Digestive System of a frog:

- It is made up of a short alimentary canal and digestive glands. The mouth opens into the buccal cavity, which leads to the oesophagus via the pharynx.
- The oesophagus is a narrow tube. It connects to the stomach. The stomach is followed by the intestine. The intestine opens into the rectum, which then opens into the outside world via the cloaca. Cloaca is a common chamber at the end of digestive tract. It is used in vertebrates (except most mammals) and certain invertebrates to release excretory and genital products.
- Liver secretes bile while the pancreas secretes pancreatic juice containing digestive enzymes.
- Stomach secretes gastric juice and HCl, which aids in the digestion of food.
- Food is captured by the bilobed tongue and digested by HCl and gastric juices in stomach from where partially digested food called chyme passes to the duodenum.
- The duodenum is the first section of the intestine. Through a common bile duct, it receives bile from the gall bladder and pancreatic juice from the pancreas. Pancreatic juice digests proteins and carbohydrates while bile emulsifies fats.
- The intestine is a part where the final digestion takes place. The numerous villi and microvilli protrude from the inner wall of intestine. They broaden the surface area available for absorption.
- Undigested solid waste enters the rectum and exits through the cloaca.

Respiration

- Respiration takes place through skin, lungs and buccal cavity. In water, they exhibit cutaneous respiration, in which the skin functions as an aquatic respiratory organ. Diffusion exchanges dissolved oxygen in water through the skin.
- On land, they exhibit pulmonary respiration. The nostrils allow air into the buccal cavity. It then travels to the lungs.

- Respiration occurs through the skin during aestivation and hibernation.

Circulatory System:

- It is well developed, with a closed type circulatory system and a lymphatic system.
- The blood vascular system consists of the heart, blood vessels, and blood itself. Lymph, lymph channels, and lymph nodes comprise the lymphatic system.
- The heart is a muscular structure located in the upper cavity of the body. It is made up of three chambers: two atria and one ventricle, which is covered by a membrane called pericardium.
- A triangular structure called sinus venosus joins the right atrium, which receives blood through the major veins called vena cava.
- The ventricle gives way to the conus arteriosus. It is a sac-like structure found on the ventral side of heart.
- The arteries (arterial system) transport blood from the heart to all parts of the body. The veins (venous system) collect blood from various parts of the body and transport it to the heart.
- A venous connection between the liver and the intestine is called hepatic portal system as well as a specialised venous connection that connects the kidney to the lower parts of the body is called renal portal system.
- Blood is made up of plasma and nucleated RBC (red blood cells) or erythrocytes, WBC (white blood cells) or leucocytes, and platelets.
- RBCs are nucleated and contain the pigment haemoglobin, which is red in color.
- Lymph is not the same as blood. It is devoid of RBCs and contain few proteins.
- During circulation, the blood transports nutrients, gases, and water to their respective sites. Blood circulation is caused by the pumping action of the muscular heart.

Excretory System:

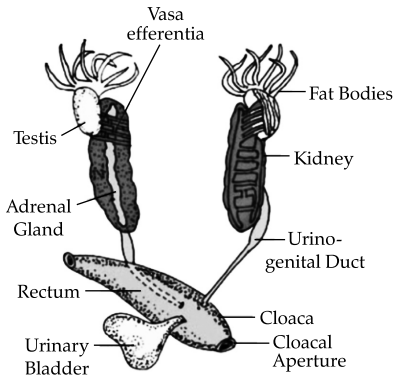
- Excretory system consists of a pair of kidneys, ureters, a cloaca, and a urinary bladder.
- Kidneys are red, bean-like structures found in the back of the body on both side of the vertebral column.
- Each kidney is composed of several structural and functional units called nephrons. There are numerous nephrons or uriniferous tubules in each kidney.
- Ureters are tubular structures that develop from the kidney. They are urogenital ducts that lead to the cloaca.
- In females, the oviduct and ureters open independently into the cloaca. The rectum connects to the cloaca as well.
- Frogs excrete nitrogenous waste as urea and thus is a ureotelic animal.

Nervous system:

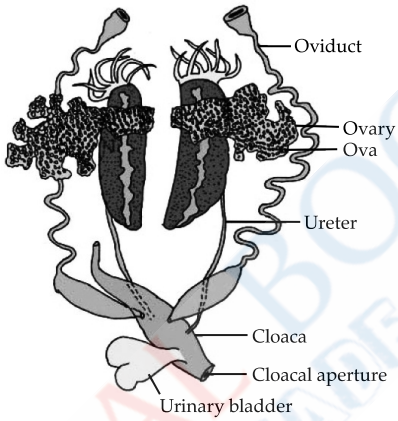
- In frogs, it is highly evolved, and it includes both the neural system and the endocrine glands.
- Pituitary, thyroid, parathyroid, thymus, pineal body, pancreatic islets, adrenal, and gonads are the most important endocrine glands in frogs.
- The nervous system is divided into three parts: the central nervous system, the peripheral nervous system, and the autonomic nervous system.
- The brain is protected by a bony structure known as the cranium or brain box.
- The brain is divided into three sections: the forebrain, the midbrain, and the hindbrain.
- The forebrain is made up of the olfactory lobes, paired cerebral hemispheres, and an unpaired diencephalon.
- The midbrain is distinguished by a pair of optic lobes.
- The cerebellum and the medulla oblongata make up the hindbrain. The medulla oblongata exits the foramen magnum and enters the spinal cord. The vertebral column protects the spinal cord.
- The sensory organs present are:
  - Organs of sense: sensory papillae
  - Organs of taste: taste buds
  - Organs of smell: nasal epithelium
  - Organs of vision: eyes
  - Hearing organs: tympanum
- Internal ears and eyes are well-organised structures.

Reproduction:

- They have well-organised reproductive systems for both males and females.
- Male reproductive organs consist of a pair of yellowish ovoid testes adhered to the upper part of kidneys by a double fold of peritoneum called mesorchium, vasa efferentia enter the kidneys on their side and open into Bidder's canal, which finally communicates with the urinogenital duct that opens into the small, median chamber cloaca.
- The female reproductive organs include a pair of ovaries with a pair of oviduct opening into the cloaca separately.
- Fertilisation is external, development involves a larval stage called tadpole, which undergoes metamorphosis to form the adult.



Male Reproductive System

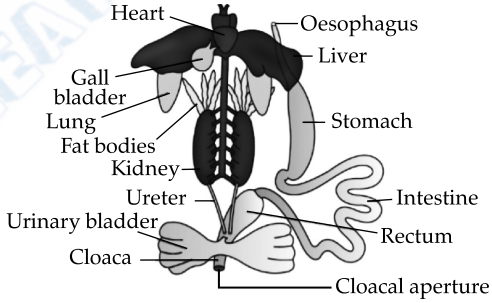


Female Reproductive System

Importance of frogs:

- Frogs are beneficial to humans because they eat insects and protect crops.
- Frogs maintain ecological balance in the ecosystem because they serve as an important link in the food chain and food web.
- Man eats the muscular legs of frogs in some countries.

Important Diagram



Alimentary canal and digestive glands

Key Words

- **Endocrine glands:** Glands that secrete their secretions directly into the blood.
- **Adipose Tissue:** It is a type of connective tissue that is specialised to store fat.
- **Blood:** Blood is a bright red coloured fluid connective tissue.

UNIT – III: CELL: STRUCTURE AND FUNCTION

CHAPTER-8

CELL: THE UNIT OF LIFE

Topic-1 Cell as Basic Unit of Life

Revision Notes

- Study of form, structure, and composition of cell is called cytology.
- Cell is the structural and functional unit of life. In unicellular organism (*Amoeba*, *Paramecium*, yeast, bacteria), single cell perform all the essential functions of life.
- In multicellular organisms, different kinds of tissues perform different function and have division of labour.

Mnemonics

Concept: Cell theory
Mnemonics: SSC
Interpretation: Schleiden and **S**chwann gave **C**ell theory

- **Matthias Schleiden** and **Theodor Schwann** (1839) proposed the cell theory.
  - All living organisms are composed of cells and products of cells.
  - All cells arise from pre-existing cells.
  - Shape and size of cells varies greatly according to their position and function.
  - Mycoplasma is the smallest cell and largest isolated cell is the ostrich egg.
  - The shape of cell may be cuboid, columnar, polygonal, thread like or irregular.

Prokaryotic Cells

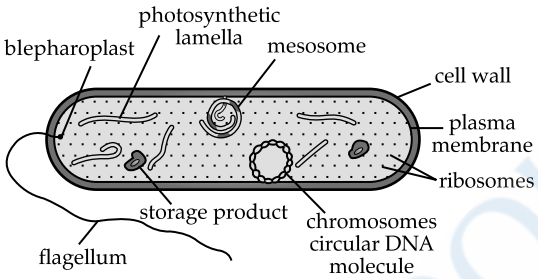
- Prokaryotic cells are represented by Bacteria, Blue green algae, Mycoplasma and PPLOS.
- They multiply rapidly and vary in size greatly.
- Bacterial cells may be bacillus (rod shaped), coccus (spherical), vibrio (comma-shaped) and spirillum (spiral).
- All prokaryotic cells have cell wall surrounding the cell membrane except in Mycoplasma.
- Genetic material is naked. Besides the genomic DNA (single chromosome) many bacteria have small circular DNA outside the genomic DNA called as plasmids.
- The plasmid DNA, in some bacteria, provides some special features like resistance to antibiotic.
- Cell organelles like Mitochondria, Golgi bodies etc., are absent in prokaryotes.
- A specialised differentiated cell membrane called mesosome is the characteristic of prokaryotes.
- In bacterial cell, a chemically complex cell envelope is present, which consist of three layers. The outermost is glycocalyx, middle one is the cell wall and innermost is the cell membrane.
- Glycocalyx may be as loose sheath in some bacteria called as slimy layer. In some other bacteria, glycocalyx may be thick and tough called capsule.
- Plasma membrane is semi-permeable having mesosome in the form of vesicles, tubules and lamellae. They help in cell wall formation, DNA replication and distribution of daughter cells.
- Motile bacterial cell contain flagella, which is composed of filament, hook and basal body. Pili and fimbriae are the other surface structure that help the bacteria in attaching with host and other substance.
- In prokaryotes, ribosomes are attached with cell membrane having two sub-units – 50S and 30S to form together 70S prokaryotic ribosomes.
- Ribosomes are site of protein synthesis. Ribosomes attach with mRNA to form a chain called polyribosomes.
- Reserved materials in prokaryotic cells are present in cytoplasm as cell inclusion bodies, which may contain phosphate, granules, glycogen granules, etc.

- Gas vacuoles are found in blue green algae and purple and green photosynthetic bacteria.

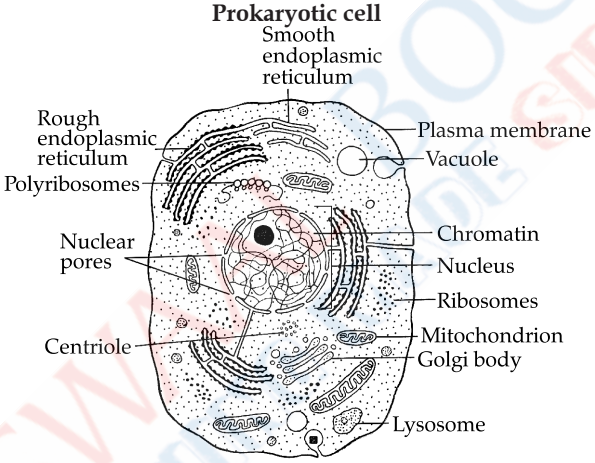
Eukaryotic Cells

- Eukaryotic cells are present in protista, plants, animals and fungi. Cytoplasm is divided into compartments due to the presence of membrane bound organelles.
- The cells contain well organised nucleus with nuclear membrane. The genetic materials are arranged in chromosomes.
- Plant cells differ in having cell wall, plastids and large central vacuole as compared to animal cells. Animal cells have centrioles, which are absent in plant cells.

Important Diagrams



Prokaryotic cell



Eukaryotic cell

Topic-2 Structure and Functions of Cell

Revision Notes

Structure of a cell:

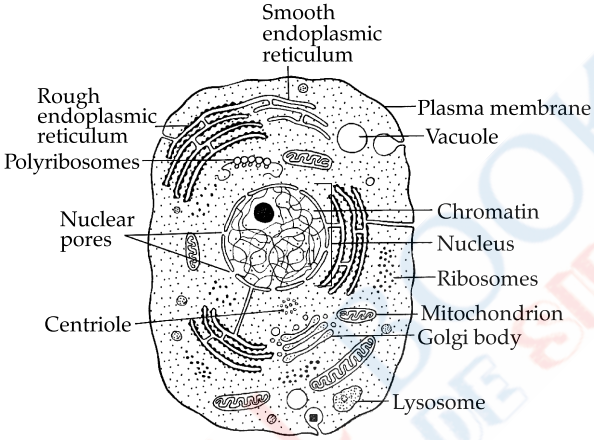
- **Cell Wall:** It is the outer, protective, supportive and semi-transparent covering of plant cells and fungi. It protects cell from mechanical damage and from the attack of pathogens and helps in cell to cell interaction. Secondary and tertiary cell wall are formed inside the primary cell wall. The middle lamella is a layer mainly of calcium pectate which holds the different neighbouring cells together. Plasmodesmata connect the cytoplasm of neighbouring cells.
- Cell membrane is composed of lipids that are arranged in bilayer. The lipids are arranged within the membrane with the polar head towards the outer side and the hydrophobic tail towards the inner part. The lipid component is mainly composed of phosphoglycerides. Later, it was found that protein is also present in cell membrane. Ratio of protein and lipids varies in different cells.
- Membrane protein may be integral or peripheral. Integral protein remains buried in membrane but peripheral protein lies on the surface.

- Singer and Nicolson (1972) proposed fluid mosaic model. According to this model, the quasi-fluid nature of lipid enables lateral movement of proteins within the bilayer of lipids.

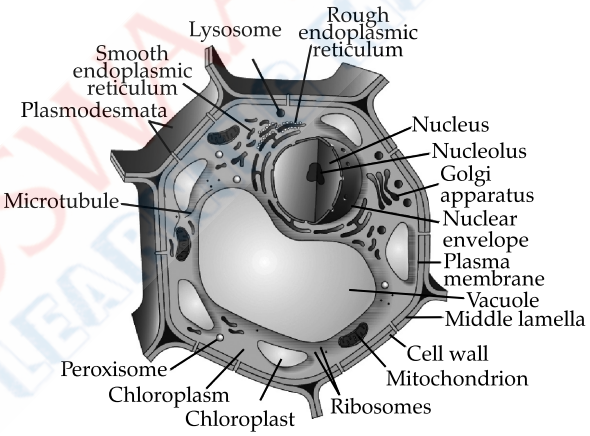
Mnemonics

Concept: Fluid Mosaic Model
Mnemonics: **S**inger **N**e gaya **F**low **M**ein
Interpretation: **S**inger and **N**icolsol gave **F**luid **M**osaic model

- The main function of plasma membrane is to transport the molecules across it. The plasma membrane is selectively permeable to some molecules present on either side of it.
- The movement of water from higher concentration to lower concentration by diffusion is called osmosis.



Eukaryotic cell



Structure of a plant cell

Cell Organelles:

- **Endoplasmic Reticulum:** Consists of vesicles, cisternae and tubular structure. RER is frequently found in cells involved in protein synthesis. SER are important for lipid synthesis and cell detoxification.
- **Golgi Apparatus (Secretory organelles of the cell):** It consists of tubules, cisternae and vesicles. Its function is packaging of different material in the vesicle and its transport outside the cell. It is important site for the formation of glycolipids and glycoproteins.
- **Lysosmes (Suicidal bags of cell):** They are formed from Golgi and E.R. They contain hydrolytic enzyme (hydrolases), active at acidic pH.
- **Vacuoles:** The vacuoles are membrane bound space in the cytoplasm. It contain water, sap and excretory products. Tonoplast covers the vacuoles in plant cell. It regulates the concentration of cell.
- **Mitochondria (Power House of cell):** Double membrane bound structure. Matrix is inside the inner membrane and number of infolding of inner membrane is called cristae. Enzymes are found in both membrane. Energy is generated in the form of ATP in the mitochondria. It has its own DNA and 70S ribosomes.

- **Plastids (Kitchen of the cell):** Based on the types of pigments, plastids can be classified into chloroplast, chromoplast and leucoplast. Chromoplast contain coloured pigments like carotene. Leucoplast are colourless with stored nutrients, amyloplast (starch storing), elaioplast (fat storing) and alueroplast (protein storing). Chloroplast are green, composed of thylakoids (which form grana and stroma) where photosynthesis takes place, contain 70S ribosome and DNA.
- **Ribosomes (Protein factories of cell):** They are composed of RNA and protein and are not surrounded by any membrane. In Prokaryotes, 70S and in eukaryotes, 80S ribosomes are found.
- **Cytoskeleton, cilia and flagella:** These are filamentous proteinaceous structures in cytoplasm. Cytoskeletons are involved in mechanical support, motility and shape maintenance while cilia and flagella are meant for attachment and movement.
- **Centrosome and centrioles:** Two centriole forms centrosome perpendicularly. They have cartwheel organisation made up of nine spaced fibres of tubulin composed of central hub and peripheral spokes. These are important in cell division.
- **Nucleus (Brain of the cell):** It consists of nuclear membrane and nucleoplasm. Nuclear membrane is bilayered and is selectively permeable. In outer membrane R.E.R. is present. Movement of RNA and protein takes place between nucleus and cytoplasm. Nucleoplasm contain nucleolus and chromatin. Nucleolus is the site for RNA synthesis. Chromatin contains DNA, RNA, histone and non-histone proteins.
- Based on the position of the centromere, the chromosomes are classified into four types: acrocentric, telocentric, sub-metacentric and metacentric.
- Many membrane bound minute vesicles called microbodies that contain various enzymes, are present in both plant and animal cells.

Key Words

- **Cell:** Cell is the biological, functional and structural unit of life.
- **Totipotency:** It is the ability of living cells to form the whole organism, unless and until they have become extremely specialised.
- **Undifferentiated cells:** These are unspecialised cells that have the ability to divide.
- **Differentiated cells:** The cells that have become specialised to perform specific functions are called differentiated cells.
- **Dedifferentiated cells:** The cells which revert to undifferentiated state to take over the function of division are known as dedifferentiated cells.
- **Prokaryotes:** Organisms whose cells do not possess a well defined nucleus is known as prokaryotes.
- **Eukaryotes:** Organisms whose cells have a nucleus with a well-defined nuclear membrane is known as eukaryotes.
- **Mesosome:** Mesosome is specialised membranous structures defined by the invagination of the cell membrane in bacteria.
- **Polyribosome:** Several ribosomes may attach to a single mRNA and form a chain called polyribosomes or polysome.
- **Diffusion:** The process of movement of substance from the region of higher water concentration to the region of lower concentration, so as to spread the substance uniformly in the given space is known as diffusion.
- **Osmosis:** It is defined as the diffusion of water from region of higher concentration to region of lower concentration across the semi-permeable membrane.
- **Hypotonic Solution:** Hypotonic is the solution which has lower osmotic concentration than the cell.
- **Hypertonic Solution:** Hypertonic is the solution that has higher osmotic concentration than the cell.
- **Isotonic Solution:** It is the solution that has same osmotic concentration as inside the cell.
- **Plasmolysis:** It is the phenomenon of the loss of water from a plant cell by osmosis when kept in a hypertonic solution.
- **Active transport:** It is the process of transport of molecules across the plasma membrane against the concentration gradient.
- **Endomembrane system:** The endomembrane system is the grouping of some membrane organelles as their functions are coordinated. It includes endoplasmic reticulum (ER), golgi complex, lysosomes and vacuoles.

CHAPTER-9

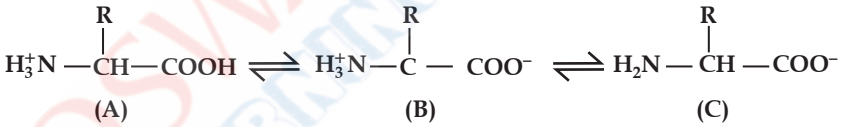
BIOMOLECULES

Topic-1 Structure and Function of Biomolecules

Revision Notes

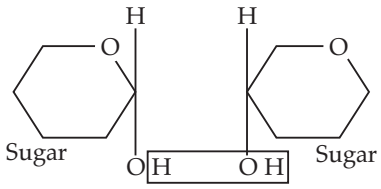
- Chemicals or molecules present in the living organism are known as **biomolecules**. Biomolecules are divided into two types- inorganic and organic.
- Inorganic biomolecules includes minerals, gases and water and organic biomolecules includes carbohydrates, fats, proteins, nucleic acids, vitamins, etc.
- Different biomolecules can be classified as aldehyde, ketones and aromatic compounds as chemical form and amino acids, nucleotides and fatty acids as biochemical forms.
- Except lipids, macromolecules are formed by polymerisation of sub-units called monomers.
- Proteins are polymers of amino acids. Amino acids are linked by peptide bond formed by dehydration between COOH group of one amino acids and NH_3 group of next with the removal of H_2O.

- A particular property of amino acids is the ionizable nature of $–NH_2$, and –COOH groups.
  Hence, in solutions of different pHs the structure of amino acids changes.



B is a zwitter ionic form

- **Lipids** could be simply fatty acids. A fatty acid has a carboxyl group attached to an R group. R group could be $–CH_3$ or $–C_2H_5$ or higher number of $–CH_2$ groups. *For example,* Palmitic acid has 16 carbon. Another simple lipid is glycerol which is a trihydroxy propane. Fatty acids could be saturated or unsaturated.
- In **nucleic acids**, the phosphate molecules links 3′ C of sugar of one nucleoside to the 5′ C of sugar of next nucleosides releasing two water molecules to form 3′-5′ phosphodiester bond.
- In **polysaccharides**, the mono-saccharides are linked by glycosidic bonds formed by dehydration between two carbon atoms of two adjacent monosaccharides.



Glycosidic bond

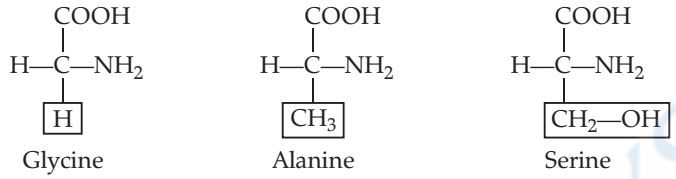
Carbohydrates (Polysaccharides)

- Polysaccharides are long chain of sugar containing different monosaccharaides as a building block.
- Starch is present in plants as store house of energy in plants. It forms helical secondary structure to hold the 12 molecules.
- Cellulose molecules contain glucose molecules joined together by 1-4 β linkage. It is the most abundant organic molecules on earth.

- Glycogen is called animal starch as it is the reserve food materials for animals, bacteria and fungi. Glucose molecules are arranged in highly branched bush like chain having two types of linkage α, –1, 4 in straight chain and α, 1, 6 linkage in branching.

Protein:

- Proteins are polypeptide chains made up of amino acids. There are 22 types of amino acids joined together by peptide bond between amino and carboxylic group.
- **There are two kinds of amino acids:**
  - **Essential amino acids** are obtained by living organism along with food.
  - **Non-essential amino acids** can be prepared by our body from raw materials.



Glycine Alanine Serine

Amino acids

- **The main functions of protein in living cell are:**
  - Transport of nutrient across the membrane.
  - Fight infectious organisms.
  - Produce enzyme and proteins.

Mnemonics

Concept: Secondary Structures of proteins
Mnemonic: Please **S**ee **T**his **Q**uestion
Interpretation: Primary structure, **S**econdary structure, **T**ertiary structure, **Q**uaternary structure

- **Collagen** is the most abundant protein in animal world.
- **Primary structure of protein** is the linear sequence of amino acids in a polypeptide chain. The first amino acid of sequence is called N-terminal amino acids and last amino acid of peptide chain is called C-terminal amino acids.
- **Secondary structure proteins** forms helix. There are three types of secondary structure: α helix, β pleated and collagen helix.
  - In α **helix**, the polypeptide chain is coiled spirally in right handed manner.
  - In β **pleated** secondary proteins, two of more polypeptide chains are interconnected by hydrogen bonds.
  - In **collagen** there are three strands or polypeptides coiled around one another by hydrogen bonds.
- In **Tertiary structure** long protein chain is folded upon itself like a hollow woollen ball to give three dimensional view of protein.
- In **Quaternary structure**, each polypeptide develops its own tertiary structure and function as subunit of protein. Example: Haemoglobin. In adult human haemoglobin, 4 sub-units are involved. The two subunits are of α type and two subunits of β types.

Nucleic Acid:

- Nucleic acids are polynucleotides. A nucleic acid has three chemically distinct components: heterocyclic compound (nitrogenous base), polysaccharides (ribose/ deoxy-ribose sugar) and phosphate or phosphoric acid.
- The sugar found in nucleic acid is either ribose or deoxyribose. Nucleic acid containing deoxyribose sugar is called DNA (Deoxyribonucleic acid) and those containing ribose sugars are called RNA (Ribonucleic acid).

Topic-2 Enzymes: Types and Properties, Enzyme Action

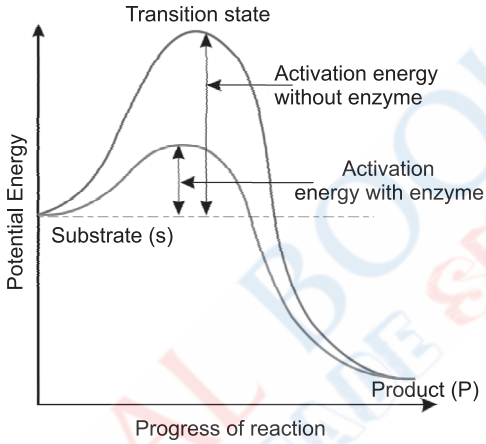
Revision Notes

Enzymes

- Enzymes are proteinaceous substances which are capable of catalyzing chemical reactions of biological origin without themselves undergoing any change, commonly called as biocatalysts.
- The nucleic acids that behave like enzymes are called **ribozymes**.
- The tertiary structure of protein has pockets or crevices into which substrate fit to catalyze the biochemical reactions.

- The major difference between inorganic and organic catalyst is that inorganic catalyst works effectively at high temperature and pressure but enzyme get damaged at high temperature. Thermal stability is an important quality of enzymes isolated from thermophilic organisms as these enzymes retain their catalytic power at high temperature is (upto 30°-90°C).
- The external energy required to start a chemical reaction is called **activation energy**.
  - **(i)** The substrate binds to the active site of the enzyme.
  - **(ii)** This binding of the substrate induces the enzymes to alter its shape and fit more closely around the substrate.
  - **(iii)** The active site of the enzyme, now is in close proximity of the substrate breaks the chemical bonds of the substrate and an enzyme-product complex is formed.
  - **(iv)** The enzyme releases the products of the reaction and the free enzyme is ready to take up another molecule of the substrate.

Important Diagram



Activation energy requirement of non-catalysed and enzyme catalysed chemical reaction

Key Words

- **Biomicromolecules:** They are small sized simple chemicals that have low molecular weight (less than 1000 Da), higher solubility and simple conformation.
- **Biomacromolecules:** They are large sized complex chemicals that have high molecular weight (greater than 1000 Da, except lipids), low solubility and complex conformation.
- **Amino acids:** Amino acids are organic compounds that are the building blocks of proteins.
- **Isoelectric point:** It is defined as the point at which a molecule exists as zwitter ion with no net charge.
- **Essential amino acids:** Amino acids which cannot be synthesised by the body and therefore, need to be supplied through the diet is called essential amino acids.
- **Non-essential amino acids:** The amino acids that can be synthesised in our body to meet the biological needs are called as non-essential amino acids.
- **Lipids:** Lipids are esters of fatty acids with alcohol.
- **Phospholipids (Phosphatides):** They are esters of fatty acids with glycerol containing an esterified phosphoric acid and a nitrogen base.
- **Primary structure of protein:** It is the linear sequence of amino acids in a polypeptide chain.
- **Living state:** It is a non-equilibrium steady state to be able to perform work.
- **Enzymes:** They are complex macromolecules with high molecular weight.

CHAPTER-10

CELL CYCLE AND CELL DIVISION

Topic-1 Cell Cycle and Mitosis

Revision Notes

- The sequence of events by which a cell duplicates its genome, synthesises the other constituents of cells and eventually divides into two daughter cells is called **cell cycle**.
- DNA synthesis occurs in one specific stage of cell division but distribution of chromosome in cells occurs in complex series of events during cell division.

Phases of Cell cycle

- Human cell divides once in approximately 24 hours, which may vary in different organisms. In yeasts it takes about 90 minutes to complete the cell division process.

  Cell cycle is divided into two basic phases.

  Interphase: It is the phase between two successive M phases.

  Interphase lasts for 95% of a cell cycle. This phase is called as resting phase but during this period the cells prepare itself for nuclear division by cell growth.
- G_1 phase represents the interval between mitosis and initiation of DNA replication.
- Cell is continuously active and grows in size.
- During synthesis phase, replication or synthesis of DNA takes place and amount of DNA gets double per cell.
- During G_2 phase, protein is synthesised which is used for mitosis.
- In adult animals, some cells do not divide or may divide occasionally. The cells that do not divide further and exits the G_1 phase to enter an inactive stage is called **Quiescent Stage** (G_0) of cell cycle.
- In animals, mitotic division is present in only somatic diploid cells but in plants it is seen in both haploid and diploid cells.
- Mitotic cell division is also known as **equational division** because the numbers of chromosome remain same in parental and progeny cells.

  M Phase: When the actual cell division or mitosis occurs, it starts with karyokinesis (nuclear division) or separation of daughter of chromosome and end with cytokinesis or division of cell matrix (cytoplasm division).
- **Prophase** is the first phase of mitosis followed by G_2 phase. It involves following events:
  - Initiation of condensation of chromosomal materials.
  - Movement of centrioles towards opposite poles of the cell.
  - At the end of prophase, endoplasmic reticulum, nuclear membrane, golgi complex disappears.
- **Metaphase** starts with complete disappearance of nuclear membrane. It is the most suitable stage for the study of morphology of chromosomes. It involves:
  - Condensation of chromosomal materials into compact and distinct chromosomes made up of two sister chromatids attached with spindle fibres. Small disc-shaped structures at the surface of centromeres known as kinetochores serve as the sites of attachment of spindle fibres.
  - Chromosomes arrange at centre of cell called metaphase plate.
- **Anaphase** involves the
  - Splitting of each chromosome at centromere into two sister chromatids.
  - Two chromatids start moving towards opposite poles.
- **Telophase** is the last stage of mitosis. It involves following events:
  - Chromosomes reach at opposite poles and loose its identity as discrete unit.
  - Nuclear membrane reassembles around the chromosome clusters.
  - Nucleolus, Golgi complex and ER reappear.

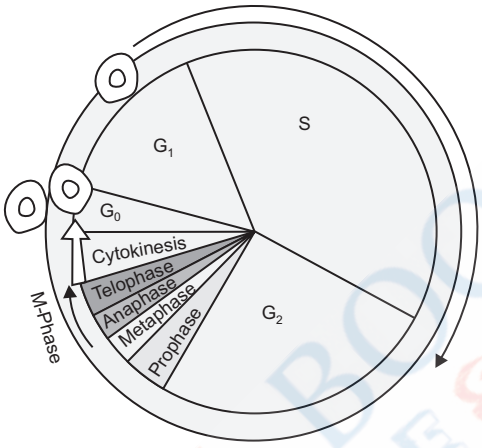
Cytokinesis is the division of cytoplasm of a cell after **karyokinesis** (division of chromosome) into two daughter cells. In animal cells, appearance of furrows in plasma membrane gradually deepens and joins to divide cytoplasm into two parts.

- In plants, cell wall formation starts at the centre and grows outwards to meet lateral walls. The formation of cell wall begins with formation of cell plate.

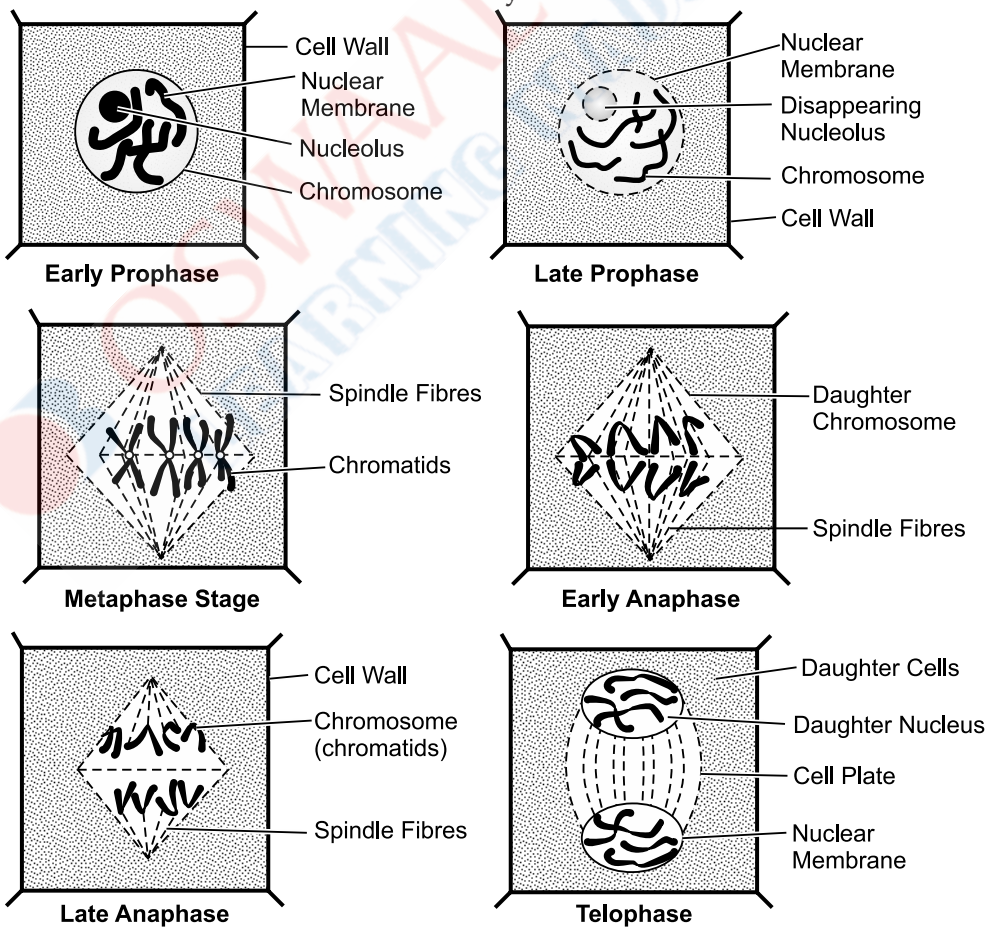
Significance of Mitosis

- Mitosis produces diploid daughter cells with identical genetic complement.
- It helps in repair of cells specially in lining of guts and blood cells.
- Meristematic division in apical and lateral cambium results in continuous growth of plants.

Important Diagrams



Cell Cycle



Phases of mitotic division

Topic-2 Meiosis and its Significance

Revision Notes

- **Meiosis:** It is a type of cell division that reduce the number of chromosome to half and results in the production of haploid daughter cells. It ensure the production of haploid phase in the life cycle of sexually reproducing organisms. It involves following events.
  - Two sequential cycles of nuclear and cell division called meiosis I and meiosis II but single cycle of DNA replication.
  - It involves pairing of homologous chromosome and their recombination.
  - Four haploid cells are formed at the end of meiosis II.
  - Prophase I of Meiosis I is typically longer and involves five phases based on chromosomal behaviour, i.e., Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.
- During **Leptotene,** the chromosome becomes distinct and visible under microscope. Compaction of chromosome continues throughout the leptotene phase.
- During **Zygotene** stage, chromosomes start pairing together **(synapsis).** The paired chromosomes are called **homologous chromosome**. Synaptonemal complex formed by a pair of homologous chromosome is called bivalent or a tetrad.
- During **Pachytene** stage, crossing over between non-sister chromatids of homologous chromosome occurs for exchange of genetic material. The crossing over is enzyme – mediated process which involves the enzyme recombinase.
- **Diplotene** is recognised by dissolution of synaptonemal complex and tendency of separation of bivalent except at the site of crossing over. This forms an X like structure called **chiasmata**.
- **Diakinesis** is marked by terminalisation of chiasmata. The nuclear membrane breaks and nucleolus disappear.
- **In metaphase I,** the bivalent chromosome align at equatorial plate and microtubules from the opposite poles of the spindle attach to the pair of homologous chromosomes.
- **In anaphase I,** homologous chromosome separate but sister chromatids remain attached at centromere.
- During **Telophase I**, nuclear membrane and nucleolus reappears and cytokinesis follows. This is called as dyad of the cells.
- The stage between two meiotic divisions is called **interkinesis** and it is short lived that follows Prophase II.

Mnemonics

Concept: Stages of Prophase I
Mnemonics: **L**imited **Z**oology **P**adao **D**idi
Interpretation: **L**eptotene, **Z**ygotene, **P**achytene, **D**iplotene, **D**iakinesis

Meiosis II

- It is initiated immediately after cytokinesis before chromosome gets elongated.
- In prophase II, nuclear membrane disappears and chromosome becomes compact.
- At metaphase II stage, the chromosomes align at equator and microtubules attach with kinetochores of sister chromatids.
- Anaphase II start with splitting of centromere of each chromosome to move towards opposite poles. Meiosis ends with Telophase II in which two groups of chromosomes get enclosed by nuclear membrane followed by cytokinesis to form tetrad of cells (four daughter cells).

Significance of meiosis:

- Meiosis forms gametes that are essential for sexual reproduction.
- Crossing over introduces new recombination of traits.
- Maintains the chromosome number of sexually reproducing organism.

Important Diagrams

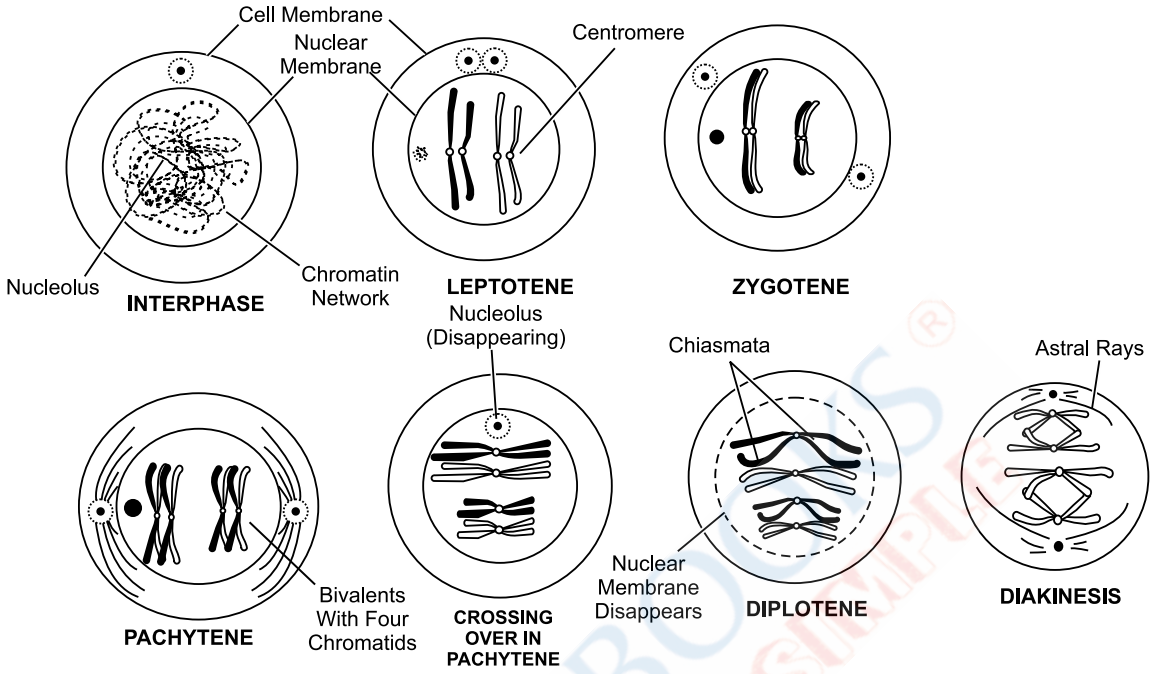
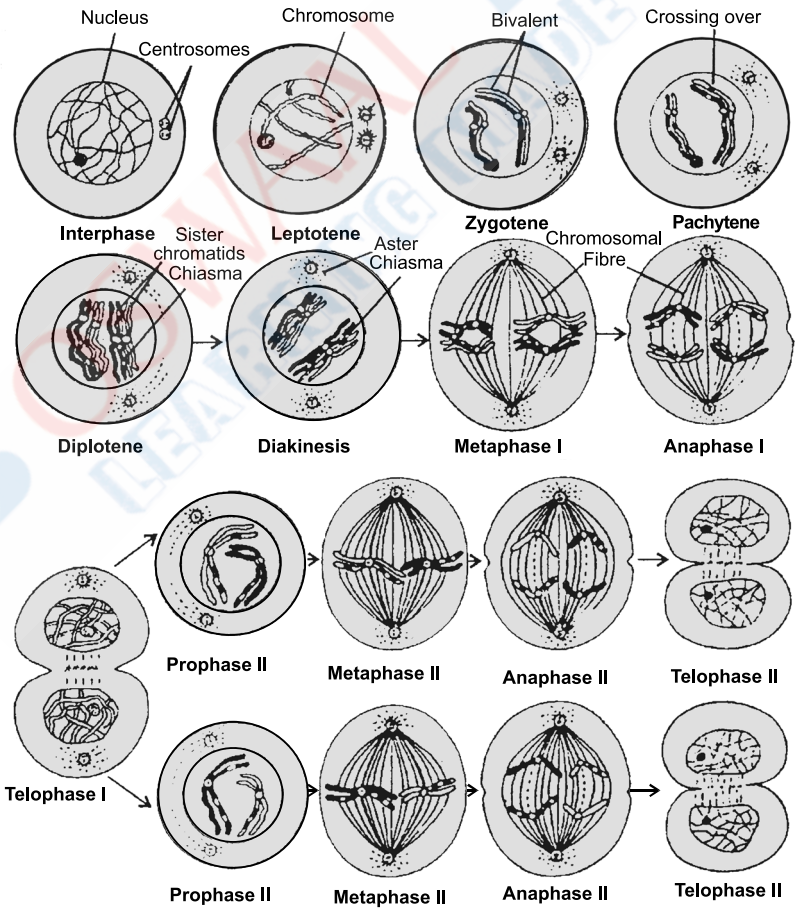


Fig.: Prophase I of meiosis I



Stages in meiosis

Key Words

- **Cell cycle:** The sequence of events by which a cell duplicates its genome, synthesises other cell constituents, and eventually divides into two daughter cells is known as cell cycle.
- **Interphase:** The interval between two successive cell divisions is termed as Interphase.
- **S phase (Synthetic phase):** It is the stage during which DNA synthesis occurs.
- **G_0 or quiescent phase:** It is the stage wherein cells remain metabolically active, but do not proliferate unless called to do so.
- **Mitosis:** Mitosis is the process of cell division wherein the chromosomes replicate and get equally distributed into two daughter cells.
- **Cytokinesis:** It is the process in which the cell actually divides into two.
- **Synapsis:** The process of attachment of the homologous chromosomes to form a complex structure called synaptonemal complex is known as synapsis.
- **Crossing over:** Crossing over is the exchange of genetic material between two homologous chromosomes with the help of enzyme recombinase.
- **Chiasma:** The X-shaped, point of interchange and re-joining is known as chiasma.

UNIT – IV: PLANT PHYSIOLOGY

CHAPTER-11

PHOTOSYNTHESIS IN HIGHER PLANTS

Topic-1 Photosynthesis and pigments

Revision Notes

- Photosynthesis is an enzyme regulated anabolic process of manufacturing organic compounds inside the chlorophyll containing cells from carbon dioxide and water with the help of sunlight as source of energy.

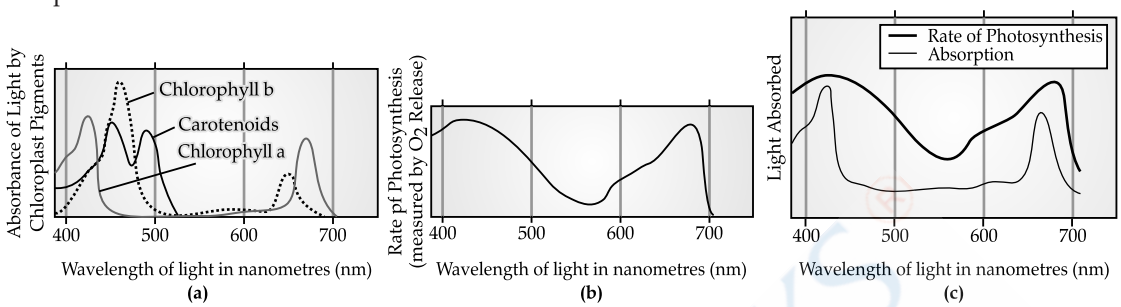
$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

- Photosynthesis is the basis of life on earth because it is the primary source of all food on earth and it is responsible for release of O_2 in the atmosphere.
- Chlorophyll, light and CO_2 is required for photosynthesis. It occurs only in green part of leaves in presence of light.

Photosynthesis

- Chloroplasts are green plastids which function as the site of photosynthesis in eukaryotic photoautotrophs. Inside the leaves, chloroplast is generally present in mesophyll cells along their walls.
- Within the chloroplast there is a membranous system consisting of grana, the stroma lamellae and the fluid stroma.
- The membrane system is responsible for synthesis of ATP and NADPH. In stroma enzymatic reactions incorporate CO_2 in plants leading to synthesis of sugar.
- The reaction in which light energy is absorbed by grana to synthesis ATP and NADPH is called light reaction. The later part of photosynthesis in which CO_2 is reduced to sugar, in which light is not necessary is called dark reaction.

- Maximum absorption by chlorophyll 'a' occurs in blue and red regions having higher rate of photosynthesis. So, chlorophyll 'a' is the chief pigment.
- Other thylakoid pigments like chlorophyll 'b' (yellow green), xanthophyll (yellow) and carotenoids (yellow to yellow-orange) are called accessory pigments that absorb light and transfer energy to chlorophyll 'a' and protect them from photooxidation.



TOPIC-2 Photosynthetic pathways and Factors Affecting Photosynthesis

Revision Notes

Light Reaction

- Light reaction (photochemical phase) includes :
  (a) Light absorption (b) Water splitting (c) Oxygen release (d) Formation of high energy chemical intermediates (ATP and NADPH).
- The pigments are organised into two discrete LHC (light harvesting complex) within Photosystem I and Photosystem II.
- LHC are made up of hundreds of pigments molecules containing all pigments (except single chlorophyll a molecules) also called antennae.
- The pigments in photosystem I and photosystem II absorbs the lights of different wavelength.
- Single chlorophyll molecules make the reaction centre. In PS I, reaction centre has absorption peak at 700nm, hence called P700 and in PS II, reaction centre has absorption peak at 680 nm, so called P680.

The Electron Transport System

- Reaction centre of photosystem II absorbs light of 680 nm in red region and cause electron to become excited.
- These electrons are picked by an electron acceptor which passes the electron to electron transport system consisting of cytochromes.
- This movement of electrons is down hill in terms of redox potential scale.
- Electrons are passed through electron transport chain and passed on to the pigment of PS I. Electron in the PSI also get excited due to light of wavelength 700nm and is transferred to another acceptor molecule that has a higher redox potential.
- When electron passes in downhill direction, energy is released that reduce the ADP to ATP and $NADP^+$ to NADPH. The whole scheme of transfer of electron is called Z-scheme due to its shape.
- Photolysis of water release electrons that provide electron to PS II. Oxygen is released during photosynthesis due to this.

$$2H_2O \longrightarrow 4H^+ + O_2 + 4e^-$$

Cyclic and Non-cylic photo-phosphorylation

- The process of synthesis of ATP from ADP and inorganic phosphate in the presence of light is known as photophosphorylation.
- When the two photosystems work in a series first PS II and then PS I, a process called non-cyclic photophosphorylation occurs. The two photosystems are connected through an electron transport chain.
- When only PS I is functional, the electron is circulated within the photosystem and the phosphorylation occurs due to cyclic flow of electrons.
- Cyclic photophosphorylation also occurs when only light of wavelength beyond 680 nm are available for excitation.

Chemiosmotic Hypothesis of ATP Formation

- This hypothesis was proposed by Mitchell in 1961. ATP synthesis is linked to development of proton gradient across the membrane of thylakoids and mitochondria.
- The process involved in the development of proton gradient across the membrane are :
  - **(i)** Splitting of water molecules occurs inside the thylakoid to produce hydrogen ion or proton.
  - **(ii)** As electron passes through the photosystem, protons are transported across the membrane because primary acceptor of electron is located towards the outer side of the membrane.
  - **(iii)** The NADP reductase enzyme is located on the stroma side of membrane. Electrons come out from the acceptor of electrons of PSI. Protons are necessary for reduction of $NADP^+$ to NADPH + H^+. These protons are also removed from the stroma. This creates proton gradient across the thylakoids membrane along with pH in the lumen.
  - **(iv)** Gradient is broken down due to movement of protons across the membrane to the stroma through trans-membrane channel of F_0 of ATPase. One part of this enzyme is embedded in membrane to form trans-membrane channel. The other portion is called F_1 that protrudes on the outer surface of thylakoid membrane which makes the energy packed ATP.
  - **(v)** ATP and NADPH produced due to movement of electron is used immediately to fix CO_2 to form sugar.
- The product of light reaction is used to drive the process leading to synthesis of sugar and is called biosynthetic phase of photosynthesis.

Calvin Cycle/C_3 cycle/Reductive Pentose Sugar Phosphate Pathway

- Melvin Calvin, Benson and their colleagues used radioactive ^{14}C and *Chlorella* and *Scenedesmus* algae to discover that first CO_2 fixation product is 3-carbon organic compound (3-phosphoglyceric acid) or PGA. Later on a new compound was discovered which contain 4- carbon called Oxaloacetic Acid (OAA). On the basis of number of carbon atoms in first stable product they are named as C_3 and C_4 pathway. C_3 cycle involves 3 steps :
  - Carboxylation is the fixation of CO_2 into 3-phosphoglyceric acid(3-PGA). Carboxylation of RuBP occurs in presence of enzyme RuBP carboxylase (RuBisCO) which results in the formation of two molecules of 3-PGA.
  - Reduction is series of reaction that leads to formation of glucose. Two molecules of ATP and two molecules of NADPH are required for reduction of one molecules of CO_2. Six turn of this cycle are required for removal of one molecule of Glucose molecule from pathway.
  - Regeneration is the generation of RuBP molecules for the continuation of cycle. This process require one molecules of ATP.
  - For every molecules of CO_2 entering the Calvin Cycle, 3 molecules of ATP and 2 molecules of NADPH is required. To make one molecules of glucose, 6 turns of cycle is completed.

In	Out
Six CO_2	One glucose
18 ATP	18 ADP
12 NADPH	12 NADP

C_4 pathway/Hatch Slack Pathway

- This pathway was worked out by Hatch and Slack (1965, 1967), mainly operational in plants growing in dry tropical region like Maize, Sugarcane, Sorghum, etc.
- In this pathway, first stable product is a 4-carbon compound, Oxaloacetic acid (OAA) so called as C_4 pathway. C_4 plants have Kranz Anatomy (vascular bundles are surrounded by bundle sheath cells arranged in wreath like manner), characterised by large number of chloroplast, thick wall, impervious to gases and absence of intercellular spaces.
- The primary CO_2 acceptor is a 3-carbon molecule (Phosphoenol pyruvate) present in mesophyll cells and enzyme involved is PEP carboxylase.
- OAA formed in mesophyll cell forms 4-carbon compound like malic acid or aspartic acid which is transported to bundle sheath cells.
- In bundle sheath cell, it is broken into CO_2 and a 3- carbon molecule. The 3-carbon molecule is returned back to mesophyll cells to form PEP.
- The CO_2 molecule released in bundle sheath cells enters the Calvin cycle, where enzyme RuBisCO is present that forms sugar.

Photorespiration

- It is the light dependent process of oxygenation of RuBP and release of carbon dioxide by photosynthetic organs of plants.
- Photorespiration decrease the rate of photosynthesis when oxygen concentration is increased from 2-3% to 21%.
- Presence of light and higher concentration of oxygen results the binding of RubisCO enzyme with O_2 to form phosphoglyceric acid and phosphoglycolate.

  RuBisCO + O_2 $\longrightarrow$ PGA + phosphoglycolate

This pathway involves Chloroplast, Peroxisome and Mitochondria. Photorespiration does not occurs in C_4 plants.

Factors affecting photosynthesis :

(a) Light : As light intensity increases, the rate of photosynthesis also increases until light reaches saturation point.

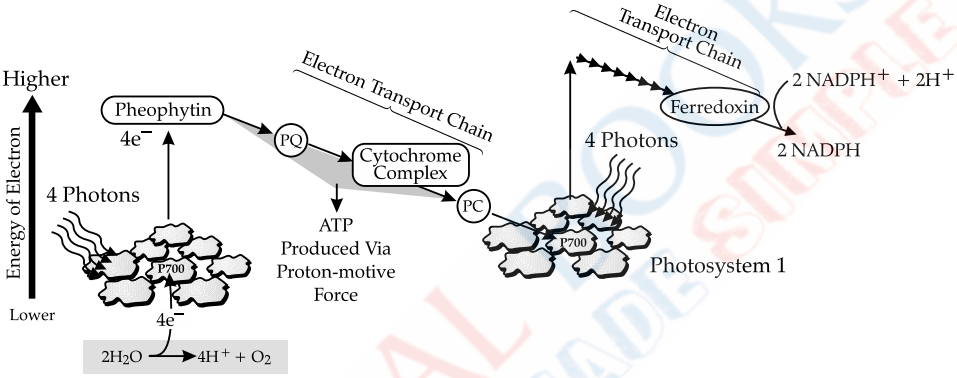
(b) Carbon dioxide concentration : With increase in concentration of CO_2, rate of photosynthesis increase till the compensation point.

(c) Temperature : It does not influence the rate of photosynthesis directly but at higher temperature, enzyme activity is inhibited due to denaturation to affect the dark reaction.

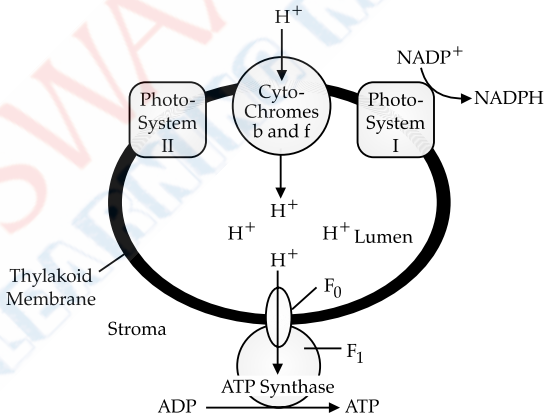
(d) Water : Rate of photosynthesis do not increase proportionally as after saturation no more water is required during photosynthesis.

Principle of law of limiting factors states that if a chemical process is affected by more than one factor, then its rate could be determined by the factor which is nearest to its minimal value which directly affects the process if its quality is changed.

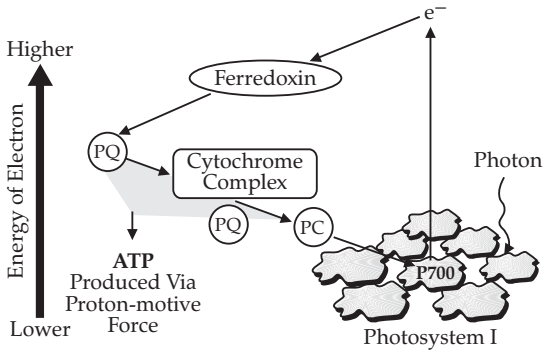
Important Diagram



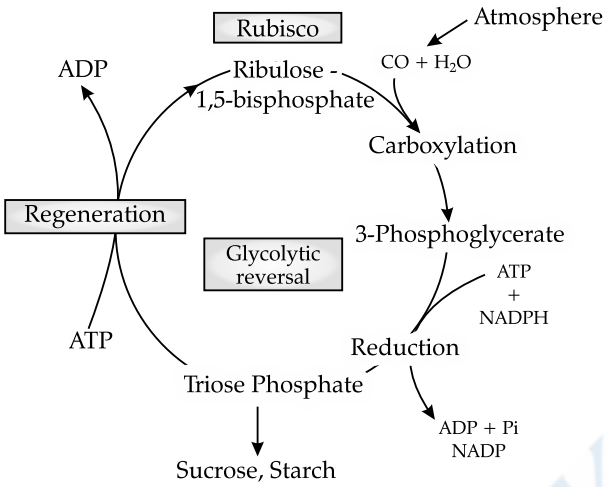
Non-cyclic photophosphorylation



ATP synthesis through chemiosmosis



Cyclic photophosphorylation



The Calvin cycle

Key Words

- **Photosynthesis :** It is a physio-chemical process that involves production of organic compounds from inorganic molecules using light energy trapped by chlorophyll.
- **Pigments :** The pigments are chemicals which absorb light energy and convert it to chemical energy.
- **Absorption spectrum :** An absorption spectrum is the graph plotted against the fraction of light absorbed by the pigment.
- **Photolysis of water :** It is the process of splitting of water with release of oxygen and hydrogen.
- **Action spectrum :** Curve showing rate of photosynthesis at different wavelengths of light is called action spectrum.
- **Photophosphorylation :** It is the process of formation of high-energy chemicals (ATP and NADPH) in chloroplast in the presence of sunlight.
- **Photorespiration :** It is a process in which there is no formation of ATP or NADPH, but there is utilisation of ATP with release of CO_2.

CHAPTER-12

RESPIRATION IN PLANTS

Topic-1 Cellular Respiration and TCA Cycle

Revision Notes

- Respiration is an energy releasing enzymatically controlled catabolic process which involves a step-wise oxidative breakdown of food substance inside living cells.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

- Living organism require energy for all activities like absorption, movement, reproduction or even breathing
- Energy is obtained from oxidation of food during respiration.
- **Cellular respiration** is the mechanism of breaking down of food materials within the cell to release energy for synthesis of ATP.
- Breaking down of complex molecules takes place to produce energy in cytoplasm and in the mitochondria.
- Breaking down of C-C bond of complex compounds through oxidation within the cells leading to release of considerable amount of energy is called respiration. The compounds that get oxidised is called respiratory substrates.

- Energy released during oxidation is not used directly but utilised in synthesis of ATP, which is broken down when energy is required. Therefore, ATP is called energy currency of cells.
- The process of respiration requires oxygen. In plants, oxygen is taken in by stomata, lenticels and root hairs.
- Plants can get along without respiratory organs because:
  - Each plant part takes care of its own gas-exchange needs.
  - Plants do not present great demands for gas exchange.
  - Distance that gases must diffuse in large plant is not large.
  - During photosynthesis O_2 is released in leaves and diffused to other part of leaves.
  - Most cells of a plant have at least a part of their surface in contact with air.
  - There is loose packing of parenchyma cells in network of air spaces.
- During the process of respiration, oxygen is utilised and carbon dioxide and water is released along with energy molecules in form of ATP.
- **Aerobic Respiration** is an enzymatically controlled release of energy in a stepwise catabolic process of complete oxidation of organic food into carbon dioxide and water with oxygen acting as terminal oxidant.
- **Glycolysis**
  - The scheme of glycolysis is given by Gustav Embden, Otto Meyerhof, and J. Parnas. It is also called as **EMP pathway**.
  - Glycolysis is the partial oxidation of glucose or similar hexose sugar into two molecules of pyruvic acid through a series of enzyme mediated reaction releasing some ATP and NADH. It occurs in cytoplasm.
  - In plants, glucose is derived from sucrose or from storage carbohydrates. Sucrose is converted into glucose and fructose by enzyme invertase.
  - Glycolysis starts with phosphorylation of glucose in presence of enzyme hexokinase to form Glucose-6-phosphate. One molecules of ATP is used in this process.
  - In next step, Glucose-6-phosphate is converted into fructose-6-phosphate, catalyzed by enzyme phosphohexose isomerase.
  - Fructose-6-phosphate uses another molecules of ATP to form Fructose-1-6 bisphosphate in presence of enzyme phosphofructokinase.
  - In glycolysis, two molecules of ATP are consumed during double phosphorylation of glucose to fructose 1,6 bisphosphate. Two molecules of NADPH are formed at the time of oxidation of glyceraldehyde 3-phosphate to 1,3 biphosphoglycerate. Each NADH is equivalent to 3ATP, so that net gain in glycolysis is 8 ATP.
  - 3-phosphoglycerate produces phosphoenol pyruvate and further. Phosphoenol pyruvate is converted into pyruvic acid.
  - Pyruvic acid is the key product of glycolysis, further breakdown of pyruvic acid depends upon the need of the cell.
  - In animal cells, like muscles during exercise, when oxygen is insufficient for aerobic respiration, pyruvic acid is reduced to Lactic acid by enzyme lactate dehydrogenase due to reduction by $NADH_2$.
  - In fermentation by yeast, pyruvic acid is converted to ethanol and CO_2. The enzyme involved is pyruvic acid decarboxylase and alcohol dehydrogenase.
  - In both lactic acid fermentation and alcohol fermentation very less amount of energy is released.
  - Final product of glycolysis, pyruvate is transported from the cytoplasm into mitochondria for further breakdown.
  - Oxidation of Pyruvate to Acetyl-CoA is done to produce CO_2 and NADH. The reaction catalyzed by pyruvic dehydrogenase requires the participation of several coenzymes including NAD^+.

$$\text{Pyruvic acid} + \text{CoA} + \text{NAD}^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{\text{Mg}^{2+}} \text{Acetyl CoA} + \text{CO}_2 + \text{NADH} + \text{H}^+$$

  - The Acetyl CoA enters a cyclic pathway called TCA cycle or Kreb's cycle.
- **Tricarboxylic Acid Cycle/Kreb's Cycle:**
  - TCA cycle was discovered by Hans Krebs in 1940. This cycle is called TCA cycle because initial product is citric acid.
  - Acetyl CoA combine with OAA (Oxaloacetic acid) and water to yield citric acid in presence of enzyme citrate synthase to release CoA.
  - A molecule of glucose produces two molecules of NADH, 2ATP and two pyruvate while undergoing glycolysis. The two molecules of pyruvate are completely degraded in Krebs cycle to form two molecules of ATP, 8NADH and $2FADH_2$.

$$\text{Pyruvic acid} + 4\text{NAD}^+ + \text{FAD}^+ + 2\text{H}_2\text{O} + \text{ADP} + \text{Pi} \xrightarrow{\text{Mitochondrial Matrix}} 3\text{CO}_2 + 4\text{NADH} + 4\text{H}^+ + \text{FADH}_2 + \underset{\text{ATP}}{}$$

- Terminal Oxidation is the name of oxidation found in aerobic respiration that occurs towards end of catabolic process and involves the passage of both electrons and protons of reduced coenzyme to oxygen to produce water.

Topic-2 ETS, Amphibolic Pathways; Respiratory Quotient

Revision Notes

- **Electron Transport Chain**
  - The metabolic pathway through which the electron passes from one carrier to another inside the inner mitochondrial membrane is called ETC or mitochondrial respiratory chain.
  - Electrons from NADH produced during citric acid cycle are oxidised by NADH dehydrogenase and electrons are transferred to ubiquinone located within the inner membrane. Ubiquinone also receives electrons from $FADH_2$. The reduced ubiquinone (ubiquinol) is oxidised with transfer of electrons to cytochrome c via cytochrome bc_1 complex.
  - When the electrons pass from one carrier to another via electron transport chain, they produce ATP from ADP and inorganic phosphate. The number of ATP molecules synthesised depends upon electron donor.
  - Oxidation of one molecule of NADH give rise to 3 molecules of ATP, while oxidation of one molecule of $FADH_2$ produce two molecules of ATP.
  - The energy released during ETC is used to synthesise ATP with the help of ATP synthetase, which consists of two major F_1 and F_0.
  - F_1 is a peripheral membrane protein complex having site for synthesis of ATP from ADP and inorganic phosphate. F_0 is integral membrane protein that form channel for protein.
  - For each ATP produced $2H^+$ passes through F_0 from the intermediate space to the matrix down the electrochemical proton gradient.
- **Respiratory Quotient** is the ratio of the volume of carbon dioxide produced to the volume of oxygen consumed in respiration over a period of time. RQ is equal to one for carbohydrate and less than one for protein and peptones.
  - Respiratory Quotient depends upon the type of respiratory substrate during respiration.
  - Compensation point is that value or point in light intensity and atmospheric CO_2 concentration when the rate of photosynthesis is just equal to the rate of respiration i.e., no net gaseous exchange.
- **Amphibolic Pathway**
  - Glucose is the favoured substrate for respiration. All carbohydrates are usually converted into glucose before used for respiration.
  - Fats need to be broken down into glycerol and fatty acid, which is further converted into Acetyl CoA and before entering the respiratory pathway.
  - Proteins are broken into amino acids which further enter into Kreb's cycle.
  - Breaking down process within living organism is called catabolism and synthesis process is called anabolism process. So, respiration is a Amphibolic pathway.

Key Words

- **Glycolysis:** It is the process of breakdown of glucose molecule to pyruvic acid.
- **Fermentation:** It is the process of incomplete oxidation of pyruvic acid, under anaerobic respiration to form lactic acid or ethyl alcohol.
- **Electron transport system:** The metabolic pathway, through which the electron passes from one carrier to another, is called electron transport system.
- **Oxidative phosphorylation:** Phosphorylation that takes place in presence of oxygen is called oxidative phosphorylation.
- **Respiratory quotient:** Respiratory quotient or respiratory ratio is the ratio of the volume of CO_2 evolved to the volume of O_2 consumed during respiration.

CHAPTER-13

PLANT GROWTH AND DEVELOPMENT

Topic-1 Seed Germination and growth in plants

Revision Notes

- Root, stem, leaves, flower, fruits and seeds arise in orderly manner in plants.
- Plants complete their vegetative phase to move into reproductive phase in which flowers and fruits are formed for continuation of life cycle of plant.
- Development is the sum of two processes: **growth** and **differentiation.** Intrinsic and extrinsic factors control the process of growth and development in plants.
- **Growth** is a permanent or irreversible increase in dry weight, size, mass or volume of cell, organ or organism. It is internal or intrinsic in living beings.
- In plant, growth is accomplished by cell division, increase in cell number and cell enlargement. So, growth is a quantitative phenomenon which can be measured in relation to time.
- **Plant growth is generally indeterminate** due to capacity of unlimited growth throughout the life. Meristem tissues is present at certain locality of plant body.
- The plant growth in which new cells are always being added to plant body due to meristem is called open form of growth.
- Root apical meristem and shoot apical meristem are responsible for primary **growth** and **elongation** of plant body along the axis.
- **Intercalary meristem** located at nodes produce buds and new branches in plants.
- Secondary growth in plants is the function of lateral meristem i.e., vascular cambium and cork cambium.

Phases of plant growth

- **Meristematic phase** is also called as the phase of cell formation or cell division. It occurs at root apex, shoot apex and other region having meristematic tissue. The cells in this region are rich in protoplasm and possess large conspicuous nuclei. Their cell walls is thin and cellulosic with abundant plasmodesmatal connection.
- **Phase of Elongation:** Newly formed cells produced in the meristematic phase undergo enlargement. Increased vacuolation and new cell wall deposition are the other characteristics of the cells in this phase.
- Cell enlargement occurs in all direction with maximum elongation in conducting tissues and fibres.
- **Phase of maturation:** The enlarged cells develops into special or particular type of cells by undergoing structural and physiological differentiation.
- **Growth Rate:** Increase in growth per unit time is called growth rate. Growth rate may be arithmetic or geometrical.
- Quantitative comparison between the growth of living system can be made by:
  - **I.** Measurement and comparison of total growth per unit time is called the absolute rate.
  - **II.** The growth of given system per unit time expressed on a common basis is called relative growth rate.

Condition for growth

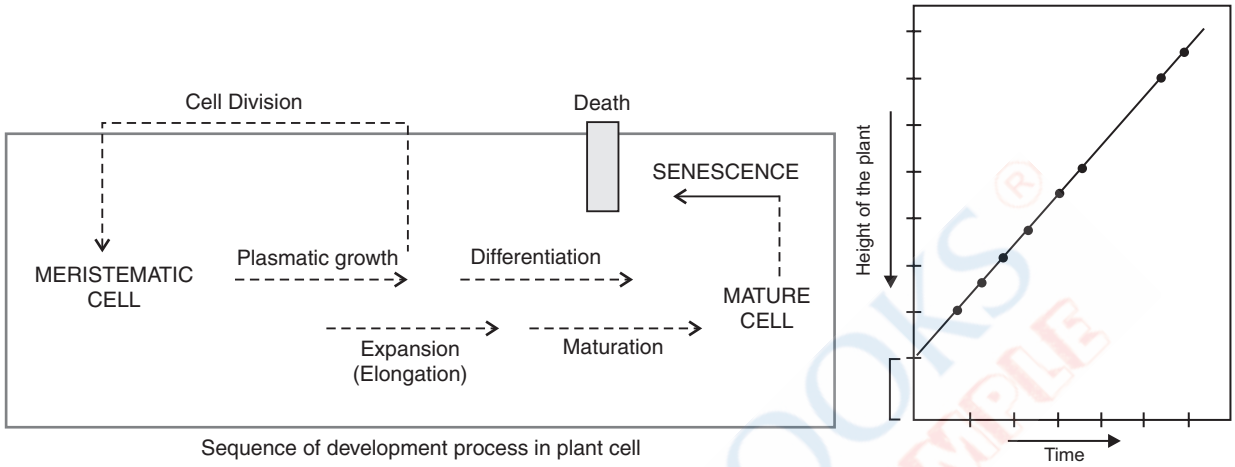
- Necessary condition for growth includes water, oxygen and essential elements. Water is required for cell enlargement and maintaining turgidity. Water also provide medium for enzymatic conditions.
- Optimal temperature and other environmental conditions are also essential for growth of the plant.
- Cells produced by apical meristem and cambium differentiate to become specialised to perform specific function. This act of maturation is called **differentiation**.
- The living differentiated cells that have lost ability of division can regain the capacity of division. This phenomenon is called **dedifferentiation.** For example interfascicular cambium and cork cambium.
- Dedifferentiated cells mature and lose the capacity of cell division again to perform specific functions. This process is called **redifferentiation**.

Development

- It is the sequence of events that occur in the life history of cell, organ or organism which includes seed germination, growth, differentiation, maturation, flowering, seed formation and senescence.

- Different structures develop in different phases of growth as well as in response to environment. The ability to change under the influence of internal or external stimuli is called **plasticity**. Heterophylly is the example of plasticity as in lark spur and butter cup.
- Development in plants is under the control of intrinsic and extrinsic factors.

Important Diagram



Sequence of development process in plant cell

Topic-2 Growth Regulators–Auxins, Gibberellin, Cytokinin

Revision Notes

Plant Growth Regulators

- Simple molecules of diverse chemical composition which may be indole compounds, adenine derivatives; derivatives of carotenoids; terpenes or gases.
- PGRs are broadly divided into two groups on the basis of their functions. One group of PGRs are involved in growth promoting activities such as cell division, cell enlargement, pattern formation, flowering, fruiting and seed formation. These are called plant growth promoters, e.g., auxins, gibberellins and cytokinins, ABA, Ethylene.
- The PGR's of the other group act as plant growth inhibitors. Plant growth inhibitors are involved in various growth inhibiting activities such as dormancy and abscission. They also play an important role in plant responses to wounds and stresses of biotic and abiotic origin, e.g., abscisic acid. Ethylene, could fit either of the group, but it is largely a plant inhibitor.
- Auxin was isolated by **F.W. Went** from tips of coleoptiles of oat seedlings.
- The 'bakane disease' of rice seedlings is caused by fungal pathogen *Gibberella fujikuroi*. E. Kurosawa found that this disease is caused due to presence of Gibberellin.
- **Skoog and Miller** identified and crystallised the cytokinesis promoting active substance called kinetin.
- Three independent researches reported the purification and chemical characterisation of three different kinds of inhibitors: Inhibitor B, Abscission II and Dormin. Later, it was found that all the three were chemically identical and named abscissic acid (ABA). Cousins in 1960, confirmed the release of a volatile substance from ripened oranges that hastened the ripening of unripened bananas. Later it was identified as ethylene.

  Auxin was first isolated from human urine. It is commonly indole-3-acetic acid (IAA). It is generally produced at stem and root apex and migrate to its site of action.
- Auxins like IAA and IBA (indole butyric acid) have been isolated from plants. NAA (naphthalene acetic acid) and 2,4-D (2,4-dichlorophenoxyacetic) are synthetic auxins,

  Functions
  - Cell enlargement
  - Apical dominance
  - Cell division and controls xylem differentiation

- Inhibition of abscission
- Induce Parthenocarpy

Gibberellins: These are promotery PGR found in more than 100 forms named as GA_1, GA_2, GA_3…. GA_{100}. The most common one is GA_3 (Gibberellic acid).

Functions:

- Cell elongation
- Breaking of dormancy
- Early maturity
- Seed germination
- Promotes bolting (internode elongation) in plants.

Cytokinins: This plant growth hormone is basic in nature. Most common forms includes kinetin, zeatin etc. They are mainly synthesised in root apices, developing shoot-buds, with rosette habit young fruits, etc.

Functions:

- Cell division and cell differentiation.
- Essential for tissue culture.
- Overcome apical dominance.
- Promote nutrient mobilisation there by delaying leaf senescence.

Ethylene : It is a gaseous hormone which stimulates transverse or isodiametric growth but retards the longitudinal one. It is one of the most widely used PGR in agriculture.

Functions:

- Inhibition of longitudinal growth
- Fruit ripening (The increase in the rate of respiration during ripening is known as respiratory climatic)
- Promotes senescence and abscission
- Promote apical dominance
- Breaks seed and bud dormancy

Mnemonics

Concept: Plant Growth Hormones
Mnemonics: **A**ll **C**ompanions **A**re **G**oing to **E**urope
Interpretation: **A**uxins, **C**ytokinins, **A**bscisic acid, **G**ibberellins, **E**thylene

Abscisic Acid – It is also called stress hormone or dormin. It is mainly produced in chloroplast of leaves.

Functions:

- Bud dormancy
- Leaf senescence
- Induce Parthenocarpy
- Seed development and maturation

Key Words

- **Growth rate:** Growth rate can be defined as the increase in growth per unit time.
- **Development:** It refers to the various changes occurring in an organism during its life cycle- from the germination of seeds to senescence.
- **Plant growth regulators:** They are the chemical molecules produced by plants affecting the physiological attributes of a plant.
- **Apical dominance:** It is the phenomenon whereby the growing apical bud inhibits the growth of lateral bud.

UNIT – V: HUMAN PHYSIOLOGY

CHAPTER-14

BREATHING AND EXCHANGE OF GASES

Topic-1 Mechanism of Breathing and respiratory organs

Revision Notes

- The process of exchange of O_2 from the atmosphere with CO_2 produced by the cell is called breathing. It occurs in two stages: Inspiration and Expiration. During inspiration, air enters the lungs from atmosphere and during expiration air leaves the lungs.
- **Respiratory Organs:** Mechanism of breathing varies in different organisms according to their body structure and habitat.

Respiratory Organs	Organisms
Entire body surface	Sponges, Coelenterate, flat-worms
Skin	Earthworm
Tracheal system	Insects
Gills	Pisces, aquatic arthropods and molluscs
Lungs	Amphibians, mammals

Human Respiratory System

- Human respiratory system consists of a pair of nostrils, pharynx, larynx, bronchi and bronchioles that finally terminates into alveoli.
- Nasal chamber open into pharynx that leads to larynx. Larynx contains voice box (sound box) that help in sound production.
- The trachea, primary, secondary and tertiary bronchi and initial bronchioles are supported by incomplete cartilaginous rings to prevent collapsing in absence of air.
- Each bronchiole terminates into a irregular walled, vascularised bag like structure called alveoli.
- The branching network of bronchi, bronchioles and alveoli collectively forms the lungs.
- Two lungs are covered with double layered pleura having pleural fluid between them to reduce the friction on the lung surface.
- Alveoli is the site of actual diffusion of O_2 and CO_2 between blood and atmospheric air.

Steps of Respiration

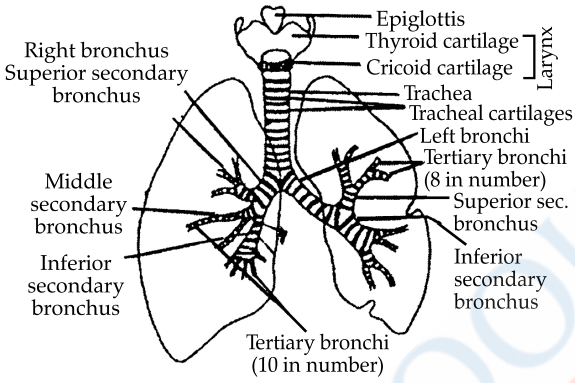
- Breathing in which oxygen rich atmospheric air is diffused in and CO_2 rich alveolar air is diffused out.
- Diffusion of gases across alveolar membrane.
- Transport of gases by blood.
- Diffusion of O_2 and CO_2 between blood and tissues.
- Utilisation of O_2 by cells to obtain energy and release of CO_2 (cellular respiration).

Mechanism of Breathing

- Breathing involves inspiration and expiration. During inspiration, atmospheric air is drawn in and during expiration, alveolar air is released out.
- Movement of air in and out takes place due to difference in pressure gradient. Inspiration occurs when pressure inside the lung is less and expiration occurs when pressure is more in lungs than outside.
- The diaphragm and external and internal intercostal muscles between the ribs help in developing pressure gradient due to change in volume.

- The contraction of intercostal muscles lifts the ribs and sternum causing an increase in volume of thoracic cavity that results in the decrease in pressure than the atmospheric pressure to cause inspiration.
- Relaxation of the diaphragm and intercostal muscles reduce the thoracic volume and increase the pressure to cause expiration.
- The volume of air involved in breathing movements is estimated by using spirometer for clinical assessment of pulmonary functions.

Important Diagram



Topic-2 Exchange of Gases, Respiratory Volume, Respiratory Disorders

Revision Notes

Respiratory Volume and Capacities

- **Tidal Volume (TV):** Volume of air inspired or expired during a normal respiration. It is about 500 mL in healthy man.
- **Inspiratory Reserve Volume (IRV):** Additional volume of air a person can inspire by forceful inspiration. It is about 2500 mL to 3000 mL.
- **Expiratory Reserve Volume (ERV):** Additional volume of air a person can expire by forceful expiration. It is about 1000 mL to 1100 mL.
- **Residual Volume (RV):** Volume of air that remains in lungs even after a forcible expiration. It is about 1100 mL to 1200 mL.
- **Inspiratory Capacity (IC):** Total volume of air a person can inspire after a normal expiration. TV + IRV
- **Expiratory Capacity (EC):** Total volume of air a person can expire after a normal inspiration TV + ERV
- **Functional Residual Capacity (FRC):** Volume of air that will remain in the lungs after a normal expiration ERV + RV
- **Vital Capacity (VC):** Maximum volume of air a person can breathe in after a forceful expiration.
- **Total Lung Capacity (TLC):** Total volume of air accommodated in the lungs at the end of forced inspiration. RV+ ERV+ TV+ IRV or Vital capacity + Residual Volume.

Exchange of Gases

- **Exchange of gases takes place at two sites:**
  - Alveoli to blood
  - Between blood and tissues.
- Exchanges of gases occur by simple diffusion due to pressure/ concentration gradient, solubility of the gases and thickness of membrane.
- Pressure contributed by individual gas in a mixture of gas is called partial pressure represented by pCO_2 and pO_2.
- Partial pressure of oxygen and carbon dioxide at different part involved in diffusion varies from one part to another and moves from higher partial pressure to lower partial pressure.
- Solubility of CO_2 is 20-25 times more than solubility of O_2, so CO_2 diffuse much faster through membrane.
- Diffusion membrane is three layered thick, that is the alveolar squamous epithelium, the endothelium of alveolar capillaries and the basement substance between them.

Transport of Gases

- Blood is the medium of transport of CO_2 and O_2. Most of oxygen (97%) is transported through RBC and remaining 3% by blood plasma.
- 20-25% of CO_2 is transported by RBC and rest 70% as bicarbonate and rest of 7% by blood plasma.

Transport of Oxygen

- Haemoglobin in RBC combines with O_2 to form oxyhaemoglobin. Each haemoglobin combine with four oxygen molecules.
- Binding of O_2 is related with partial pressure of O_2 and CO_2, hydrogen ion concentration and temperature.
- When percentage saturation of haemoglobin with O_2 is plotted against the partial pressure of oxygen forms sigmoid curve (oxygen dissociation curve).
- In the alveoli, pO_2 is more and pCO_2 is less. Less H^+ ions concentration and lower temperature favour the binding of O_2 with haemoglobin. whereas, opposite condition in tissues favour the dissociation of oxyhaemoglobin. This clearly indicates that O_2 gets bound to haemoglobin in the lung surface and gets dissociated at the tissue.
- Carbon dioxide is transported by haemoglobin as carbamino-haemoglobin. In tissues, pCO_2 is high and pO_2 is less. This favour the binding of carbon dioxide with haemoglobin. Opposite condition help in dissociation of carbamino- haemoglobin in alveoli.
- Enzyme carbonic anhydrase help in formation of carbonate ions to transport carbon dioxide.

$$CO_2 + H_2O \xrightleftharpoons{\text{Carbonic anhydrase}} H_2CO_3 \xrightleftharpoons{\text{Carbonic anhydrase}} HCO_3^- + H^+$$

Regulation of Respiration:

- Human beings have ability to maintain and moderate the rate of respiration to fulfil the demand of body tissues by neural system.
- Respiratory rhythm centre is located in medulla region of hind brain. Pneumotaxic centre in pons moderate the function of respiratory rhythm centre.
- Chemosensitive area is highly sensitive to CO_2 and H^+ ions that ultimately control the respiratory rate. Oxygen do not play major role in controlling rate of respiration.

Functions of Respiration:

- Energy production
- Maintenance of acid-base balance.
- Maintenance of temperature
- Return of blood and lymph.

- Mountain Sickness is the condition characterised by the ill effect of hypoxia (shortage of oxygen) in the tissues at high altitude commonly to person going to high altitude for the first time.

Symptoms:

- Loss of appetite, nausea, and vomiting occurs due to expansion of gases in digestive system.
- Breathlessness occurs because of pulmonary oedema.
- Headache, depression, disorientation, lack of sleep, weakness and fatigue.

Disorder of Respiratory System

- **Asthma:** It is due to allergic reaction to foreign particles that affect the respiratory tract. The symptoms include coughing, wheezing and difficulty in breathing. This is due to excess of mucus in wall of respiratory tract.
- **Emphysema:** It is the inflation or abnormal distension of the bronchioles or alveolar sacs of lungs. This occurs due to destroying of septa between alveoli because of smoking and inhalation of other smokes. The exhalation becomes difficult and lung remains inflated.
- **Occupational Respiratory Disorders:** Occurs due to occupation of individual. This is caused by inhalation of gas, fumes or dust present in surrounding of work place. This includes Silicosis, Asbestosis due to exposure of silica and asbestos. The symptom includes proliferation of fibrous connective tissue of upper part of lung causing inflammation.
- **Pneumonia:** It is acute infection or inflammation of the alveoli of the lungs due to bacterium *Streptococcus pneumoniae.* Alveoli become acutely inflamed and most of air space of the alveoli is filled with fluid and dead white blood corpuscles limiting gaseous exchange.

Mnemonics

Concept: Respiratory System

Mnemonics: **A**dam and **E**ve are **O**ver **P**owered

Interpretation: **A**sthma, **E**mphysema **O**ccupation respiratory disorders, **P**neumonia

Key Words

- **Respiration:** Process of exchange of O_2 with CO_2 along with its transport.
- **Breathing:** Process of moving of air in and out of the lungs.
- **Tidal Volume:** Amount of air inspired or expired during normal respiration.
- **Vital Capacity:** Maximum volume of air, which can be breathed in after a forced expiration.
- **Residual Volume:** Volume of air remaining in the lungs after forced expiration.
- **Alveoli:** Primary sites of gas exchange in respiratory system.
- **Pulmonary respiration:** Respiration by lungs.

CHAPTER-15

BODY FLUIDS AND CIRCULATION

Topic-1 Blood Lymph and Human Heart

Revision Notes

- Body fluids are the medium of transport of nutrients, oxygen and other important substance in the body.
- Blood is the most commonly used body fluid in most of the higher organisms. Lymph also transports certain substances like protein and fats.
- Blood is a mobile connective tissue composed of a fluid matrix plasma and the cells, the blood corpuscles. It forms about 30-35% of the extracellular fluid. It is slightly alkaline fluid having pH 7.4.
- Plasma is straw coloured viscous fluid that constitutes 55% of blood volume. It consists of 90-92% water, 6-8% protein (fibrinogens, albumins and globulins), glucose, amino acids and small amount of minerals like Na^+, Mg^{++}, Ca^{++}, HCO_3^-. Cl^-, etc.
- Erythrocytes, leucocytes and platelets are collectively called formed elements.
- Erythrocytes are most abundant cells in human body. Total blood count of RBCs is 4-5.5 million per mm^3 of blood which is slightly less in females due to menstruation. It is formed in the red bone marrow. They have life span of 120 days.
- Nucleus is absent in mammalian RBCs which are biconcave in shape.
- Every 100 ml of blood contain 12-16 gm of haemoglobin.
- RBCs are destroyed in spleen (graveyard of RBCs).

Mnemonics

Concept: Types of WBCs
Mnemonic: **N**ine **L**ittle **M**onkey **E**ating **B**ananas
Interpretation: **N**eutrophils **L**ymphocytes **M**onocytes **E**osinophils **B**asophils.

- Leucocytes or WBCs are colourless due to absence of haemoglobin. 6000-8000 per mm^3 of blood of WBCs are present.
- Neutrophils are most abundant and basophils are least abundant WBCs. Monocytes and neutrophils are phagocytic cells which destroy foreign organisms.
- Basophils secrete histamine, serotonin and heparin that are involved in inflammatory reactions.
- Eosinophils resist infection and allergic reactions. B and T lymphocytes are responsible for immune response of the body.
- Thrombocytes or platelets are cell fragments produced from megakaryocytes in bone marrow. Blood normally

contains 150000-350000 platelets per mm^3 of blood. Platelets are involved in clotting or coagulation of blood in case of injuries.

- **Blood Groups:** Blood of human beings differ in certain aspects although it appears same in all individuals. Two main types of grouping are ABO and Rh.
- ABO grouping is based on presence or absence of two surface antigens on RBC, antigen A and antigen B. The plasma of an individual also contains two antibodies produced in response of antigens.

Blood Group	Antigens on RBCs	Antibodies in Plasma	Donor's Group
A	A	anti-B	A, O
B	B	anti-A	B, O
AB	A, B	nil	AB, A, B, O
O	nil	anti-A, B	O

  - During blood transfusion, blood of donor has to be matched with blood of recipients to avoid clumping of RBCs.
  - Group 'O' blood can be donated to any individual with any blood group, so it is called universal donor.
  - Person with 'AB' blood group can receive blood from any person of any group, so it is called universal recipient.
- **Rh grouping:** Rh antigen (similar to antigen present in Rhesus monkey) are observed on surface of RBCs of majority of individuals (about 80%). Such people are called Rh positive (Rh^+). The person in which this antigen is absent are called Rh negative (Rh^-).
- **Erythroblastosis foetalis:** If father blood is Rh^+ and mother blood is Rh^-, the foetus blood will be Rh^+. During the delivery of first child there is a possibility of exposure of mother blood with foetus blood to develop antibodies in mother blood. In subsequent pregnancy, the mother blood can leak into foetus blood that destroys the foetal RBC. This case is called erythroblastosis foetalis.

Coagulation of blood (Blood Clotting)

- When an injury is caused to a blood vessel bleeding starts which is stopped by a process called blood clotting. An injury or trauma stimulates the platelets in the blood to release certain factors that activate the mechanism of coagulation. Calcium play important role in blood clotting.

Lymph

- During flow of blood through capillaries, some water soluble molecules move out in the space between cells of tissues. This fluid released out is called interstitial fluid or tissue fluid. It is similar to the blood but has fewer blood proteins, less calcium and phosphorus and high glucose concentration.
- Lymph is a colourless fluid containing specialised lymphocytes that provide immune response to body.
- Main function of lymph is to provide immunity, carry proteins and fats molecules and transport oxygen, food materials, hormones etc.

Blood vessels

- Blood moves around the body in special tubes called blood vessels. They are located throughout the human body.
- There are three types of blood vessels: arteries, veins and capillaries.
- A blood vessel is made up of three layers:
  - Tunica interna (Inner most layer).
  - Tunica media (Middle layer).
  - Tunica externa or Tunica adventitia (outermost layer)
- **Human Circulatory System:** Consists of 4-chambered muscular heart, closed, branching blood vessels and circulatory fluid blood. Annelids and chordates have a closed circulatory system in which the blood pumped by the heart is always circulated through a closed network of blood vessels.
- Heart is the mesodermally derived muscular organ, present in thoracic cavity between the two lungs protected by double membrane of pericardium.
- The upper two chamber is called atria and lower two chambers are called ventricles. Inter-atrial septum separate the right and left atrium. Thick walled inter-ventricle septum separate the ventricles.
- The opening between right atrium and right ventricle is guarded by a three muscular flaps or cusps called tricuspid valve. Bicuspid or mitral valve guards the left atrium and ventricle.
- The opening of right and left ventricle to pulmonary artery and aorta respectively is controlled by semilunar valve.

- The nodal tissue present on upper right corner of right atrium is called SAN (sino-atrial node) and those on lower left corner of right atrium is called AVN (atrio-ventricular node).
- The Purkinje fibres along with right and left bundles form the bundle of His. The nodal musculature has the ability to generate action potential without any external stimuli.
- SAN generate maximum number of action potential i.e., 70-75 min^{-1} and is responsible for rhythmic contraction of heart. Therefore it is called pacemaker. Our heart normally beats 70-75 times in a minute (average 72 beats min^{-1})

Important Diagram

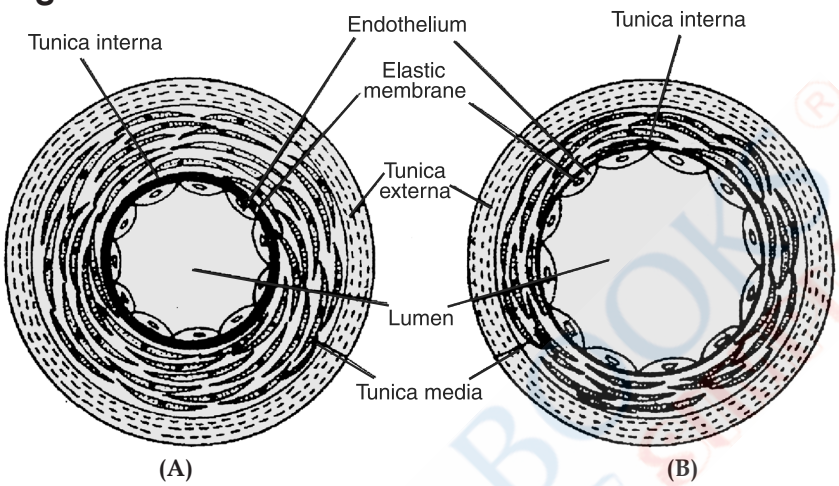


Fig. T.S. of (A) Artery and (B) Vein

Topic-2 Blood Circulation and Disorders of Circulatory System

Revision Notes

Cardiac Cycle

- To begin with, all four chambers are in relaxed state called joint diastole. The blood from pulmonary vein and vena cava flows to left and right ventricle through bicuspid and tricuspid valve. Semilunar valves are closed at this stage.
- SA node generates action potential that contracts the both atria (atrial systole). The action potential is passed to AV node and bundle of HIS transmit it to ventricular musculature to cause ventricular systole. At the same time atria undergoes relaxation (diastole) to close the bicuspid and tricuspid valve.
- Semilunar valves open into circulatory system that relax the ventricle and close the valves to prevent back flow of blood.
- As the pressure inside ventricle decreases the bicuspid and tricuspid valve open to repeat the process of cardiac cycle.
- During each cardiac cycle two sounds are produced. The first sound (lub) is due to closure of bicuspid and tricuspid valve and second heart sound (dub) is due to closure of semilunar valve.
- Cardiac output is defined as the volume of blood pumped out by each ventricle per minute.
- In a normal healthy person cardiac output is 5000 ml or 5 L on an average.
- ECG (Electrocardiograph) is a graphical representation of electrical activity of heart during cardiac cycle. The electrocardiograph machine is used to obtain electrocardiogram. The patient is connected to three electrical leads to wrists and left ankle.
- The P-wave represents the electrical excitation of atria (depolarisation) which leads to contraction of atria.
- The QRS-wave represents the depolarisation of ventricles, which initiates the ventricular contraction.
- The T-wave represents the return of ventricle from excited to normal state (repolarisation).
- The end of T-wave marks the end of systole. Counting the number of QRS complex in given period of time determine the heartbeat rate.

Double Circulation

- Flow of same blood twice through the heart once in oxygenated form and other in deoxygenated form is called double circulation. It includes systematic and pulmonary circulation.
- Systemic circulation includes flow of oxygenated blood from the left ventricle to all parts of body and deoxygenated blood from various body parts enters into the right atrium. All systemic circulation starts form aorta and ends at superior vena cava, inferior vena cava or coronary sinus to right atrium.
- The systemic system provides oxygen, nutrients and other substance to the tissues of different body parts and take CO_2 and other harmful substance from the body parts.
- The flow of deoxygenated blood from the right ventricle to the lungs and the return of oxygenated blood from the lung to the left atrium is called pulmonary circulation.
- Two pulmonary veins from each lung transport the oxygenated blood to the left atrium.
- Double circulation reduces the chances of mixing of oxygenated and deoxygenated blood.

Regulation of Cardiac Activity

- Normal activities of heart are regulated by nodal tissue (SA and AV node), so the heart is myogenic. A special neural centre in medulla oblongata moderates the cardiac function by ANS. Sympathetic nerve increase the rate of heart beat and parasympathetic nerve of ANS decreases the rate of heart beat. Adrenal medullary hormone also increases the cardiac output.

Disorder of Circulatory System

(a) **Hypertension (high blood pressure):** Blood pressure higher than (120/80). 120 mm Hg is the systolic that is pumping pressure and 80 mm Hg is the diastole, resting pressure. High blood pressure leads to heart disease and affect vital organs like brain and kidney.

(b) **Coronary Artery Disease (CAD):** Commonly known as atherosclerosis that affects the blood vessels that supply blood to heart muscles due to deposition of fat, calcium, cholesterol that makes the arteries lumen narrower.

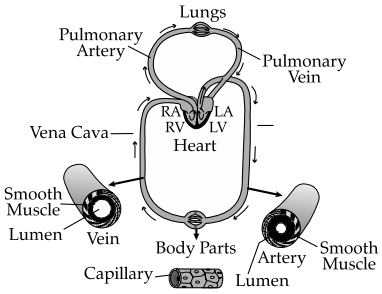
(c) **Angina also called angina pectoris:** Acute chest pain due to less supply of oxygen to heart muscles. It may occur in elderly male and female. It occurs due to restricted blood flow.

(d) **Heart failure:** In this, heart does not pump enough blood to meet the requirement of body. It is also known as congestive heart failure because congestion of lung is one of its symptoms. Heart failure is different from heart attack (heart muscle is damaged by inadequate blood supply) and cardiac arrest (when heart stops beating)

Mnemonics

Concept: Disorders of circulatory system.
Mnemonic: **H**igh **C**ourt orders **A**a gaye **H**ai
Interpretation: **H**ypertension, **C**oronary
astery disease, **A**ngina pectoris, **H**eart **F**ailure.a

Important Diagram



Key Words

- **Blood:** Red colour fluid connective tissue, composed of a fluid, plasma and the cells, the blood corpuscles.
- **Lymph node:** Small, oval or bean shaped structures located along the length of lymphatic vessels.
- **Plasma:** Pale, straw coloured fluid, occupying about one half of total blood volume.
- **Cardiac cycle:** Sequence of events that occur during single heart beat is called cardiac cycle.

- **Systemic circulation:** Circulation of blood between heart and body is called systemic circulation.
- **Cardiac output:** Amount of blood pumped by heart per minute is called cardiac output.
- **Pulse rate:** Number of times the heart beats in a minute is known as pulse rate.

CHAPTER-16

EXCRETORY PRODUCTS AND THEIR ELIMINATION

Topic-1 Modes of Excretion, Human Excretory System and Urine Formation

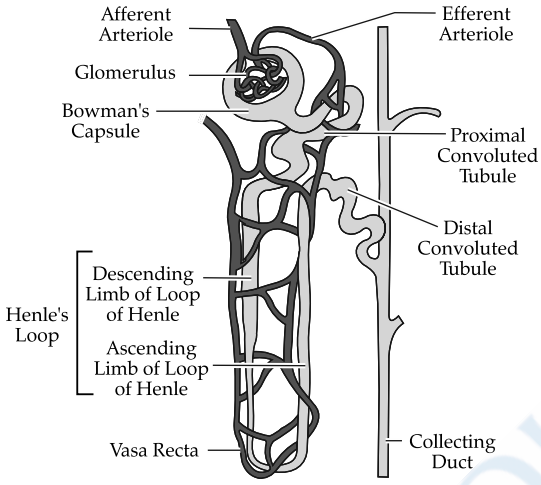
Revision Notes

- **Modes of Excretion:**
  - Elimination of metabolic waste products from the animal body to regulate the composition of body fluids and tissues is called excretion. These waste products includes ammonia, uric acid, urea, carbon dioxide and ions like Na^+, K^+, Cl^- and phosphates and sulphate.
  - Ammonia is the most toxic and **uric acid** is the least toxic. The process of removing ammonia is called **ammonotelism** and organisms that excrete ammonia are called **ammonotelic** (bony fishes, aquatic amphibians and insects).
  - The organisms that release urea as nitrogenous wastes are called **ureotelic** (mammals, terrestrial amphibians).
  - The organism that excretes uric acid are called **urecotelic** (reptiles, birds and land snails).
  - Protonephridia or flame cells are the excretory structures in Platyhelminthes (e.g., *Planaria*), some annelids and the cephalochordata (e.g., *Amphioxus*).
  - Nephridia are the excretory structures of earth worms and other annelids.
  - Malpighian tubules are the excretory structures of most of the insects for example-Cockroaches.
  - Antennal glands or green glands perform the excretory function in crustaceans like prawns.
- **Human Excretory System**

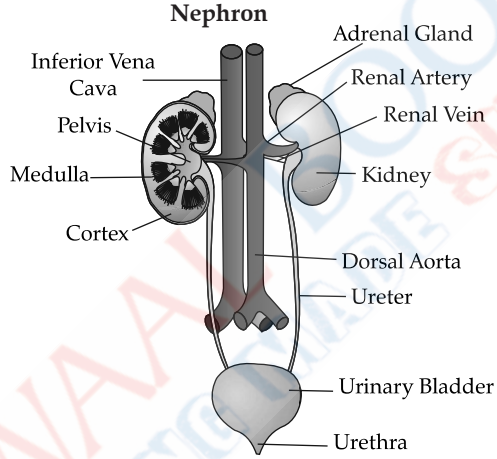
  Human excretory system consists of
  - A pair of kidneys
  - A pair of ureters
  - A urinary bladder
  - A urethra
- **Kidneys** are reddish brown bean shaped structure situated between last thoracic and lumbar vertebra.
- Each has a notch on its inner side called hilum through which ureter, blood vessels and nerves enter.
- Inside the hilum is a broad funnel shaped space called renal pelvis with projection called calyces.
- Inside the kidney are two zone- outer cortex and inner medulla. Medulla is divided into medullary pyramids projecting into calyx.
- Cortex extends between medullary pyramids as renal column called **Columns of Bertini**.
- The functional unit of kidney is nephron. Each kidney contains about one million nephrons.
- Each nephron had two parts- the **glomerulus** and the **renal tubules**. Glomerulus is the tuft of capillaries formed by **afferent arteriole**. Blood from glomerulus is carried away by **efferent arteriole**.
- Renal tubules starts with **Bowman's capsule** and continue with tubular parts divided into **proximal convoluted tubules**, **Henle's loop** and **distal convoluted tubule**.
- The malpighian tubules, PCT and DCT of nephron are situated in cortical region whereas loops of Henle's into medulla.
- **Urine formation:**
  - Urine formation includes three processes Glomerular Filtration, reabsorption and Secretion.
- **Function of Tubules**
  - **Proximal Convoluted Tubules (PCT):** All the important nutrients, 70-80% electrolytes and water are reabsorbed.
  - **Henle's Loop:** Maintains high osmolarity of medullary interstitial fluid.
  - **Distal Convoluted Tubules (DCT):** Conditional reabsorption of Na^+ and water. Maintain pH and sodium-potassium balance.

- **Collecting Duct:** Large amount of water is reabsorbed to produce concentrated urine.

Important Diagrams



Nephron



Human Urinary System

Topic-2 Osmoregulation; Regulation of Kidney Function Role of Other Organs in Excretion; Disorders Dialysis and Artificial Kidney

Revision Notes

- **Mechanism of concentration of urine:** The flow of filtrate in two limbs of Henle's loop is in opposite direction to form counter current. The flow of blood in two limbs of vasa recta increase the osmolarity towards the inner medullary interstitium in the inner medulla.
- The transport of substance facilitated by special arrangement of Henle's loop and vasa recta is called counter **current mechanism**.
- **Regulation of kidney function:** Functioning of kidney is monitored by hormonal feedback mechanism of hypothalamus and JGA. Change in blood volume, body fluid and ion concentration activates the osmoreceptors in the body that stimulate the hypothalamus to release ADH or vasopressin hormones. The ADH facilitates water absorption in tubules.
- Decrease in glomerular blood pressure activate JG cells to release renin which converts angiotensinogen to angiotensin I and II that increase the glomerular blood pressure and release of aldosterone that increase absorption of Na^+ ions and water.
- Lungs, liver and skin also play important role in the process of excretion. Lungs remove CO_2 and water, liver eliminates bile containing substances like bilirubin biliverdin, cholesterol and drugs, sweat glands in skin removes, NaCl, urea and lactic acid and Sebaceous glands eliminate substances like sterols, hydrocarbons and waxes as sebum.

- **Disorders of Excretory System**
  - **Uremia:** There is high concentration of non-protein nitrogen in the blood due to the malfunctioning of kidneys (urea, uric acid, creatinine). **Urea can be removed by hemodialysis.**
  - **Renal failure:** Also known as kidney failure in which glomerular filtration is ceased and both kidney stops working. **Kidney transplant** is the ultimate method in correction of acute kidney failure.

Mnemonics

Concept: Excretory Disorders

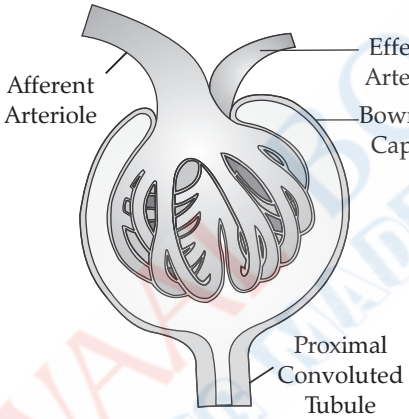
Mnemonic: RUNneR

Interpretation: Renal failure, **U**remia, **N**ephritis, **R**enal calculi.

- **Renal calculi:** Formation of stone or insoluble mass of crystallised salts within the kidney.
- **Glomerulonephritis (Bright's Disease):** Inflammation of glomeruli of kidney due to entry of protein or red blood corpuscles into filtrate due to injury.

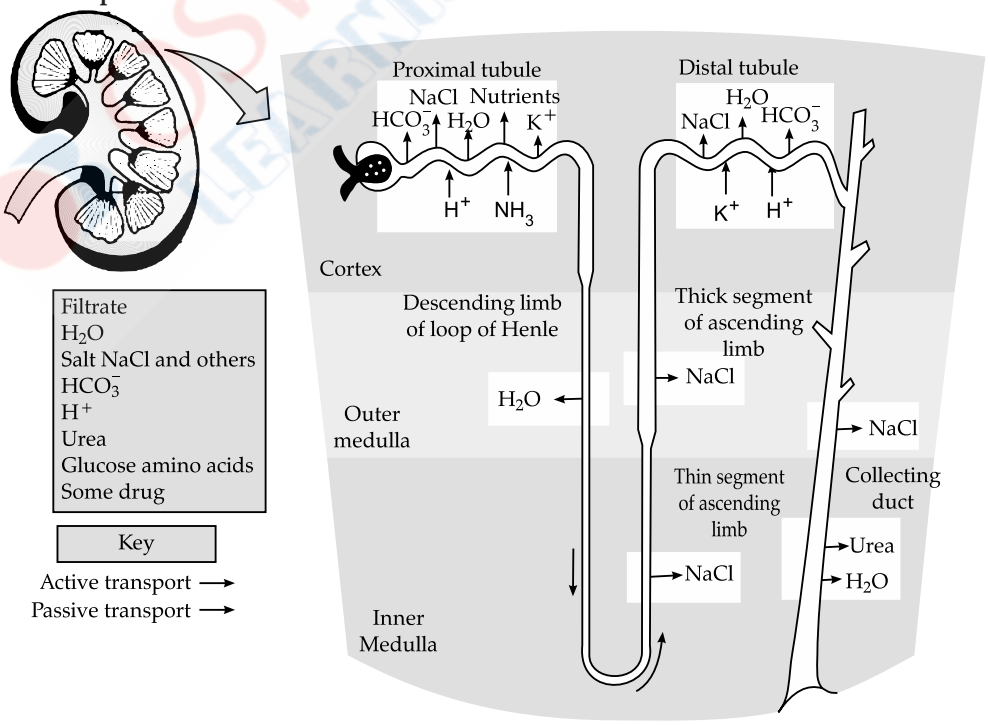
- **Haemodialysis:** In patients with uremia, urea is removed by haemodialysis. During the process, the blood drained from a convenient artery is pumped into a dialysing unit called **artificial kidney.**

Important Diagrams



Malphigian body

Structure of renal corpuscle:



Reabsorption and secretion of major substances at different parts of the nephron

Key Words

- **Ammonotelism:** The process of excretion of ammonia is called ammonotelism.
- **Ureotelism:** The process of excretion of urea is called ureotelism.
- **Uricotelism:** The process of excretion of uric acid is called uricotelism.
- **Juxtaglomerular apparatus:** It is a microscopic structure located between the vascular pole of the renal corpuscle and the returning distal convoluted tubule of the same nephron.
- **Osmoregulation:** Osmoregulation is a homeostatic mechanism that regulates the optimum temperature of water and salts in the tissues and body fluids.
- **Osmolarity:** The total concentration of solutes in a solution.

CHAPTER-17
LOCOMOTION AND MOVEMENT

Topic-1 Types of Movement and Skeletal System

Revision Notes

- **Locomotion** is the voluntary movement of an individual from one place to another. Walking, running, climbing, swimming are the example of locomotory motion. All locomotion are movement but all movements are not locomotion.
- Macrophages and leucocytes in blood exhibit **amoeboid movements**. Coordinated movements of cilia in trachea to remove dusts particles and passage of ova through fallopian tube are examples of **Ciliary movements**.
- **Flagellar movement** helps in the swimming of spermatozoa, maintenance of water current in the canal system of sponges and locomotion of Protozoans like Euglena.
- Movement of limbs, jaw, tongue needs **muscular movement**. Contractile property of muscles are used in movement in higher organism including human beings.
- **Muscles** are specialised tissues of mesodermal origin. They have property like excitability, contractility, extensibility and elasticity.
- Based on their location, three types of muscles are identified:
  - **(a) Skeletal muscles:** They are closely associated with skeletal components of the body and are involved in locomotory actions and changes in body posture. These muscles are striated muscles and voluntary in nature.
  - **(b) Visceral muscles:** They are located in the inner walls of hollow visceral organs of the body. They are non-striated muscles or smooth muscles and involuntary in nature.
  - **(c) Cardiac muscles:** They are the muscles of heart. They are striated and involuntary in nature.

Mnemonics

Concept: Bones of Cranium
Mnemonic: Old **P**eople **F**rom **T**exas **E**at **S**piders
Interpretation: Occipital Parietal Frontal Temporal Ethmoid Sphenoid

- Skeletal muscles are made up of muscles bundles (fascicles), held together by collagenous connective tissue called fascia.
- Each muscle bundle contains a number of muscle fibres. Each muscle fiber is lined by plasma membrane called sarcolemma enclosing sarcoplasm. Partially arranged myofibrils are present in muscle bundle having alternate light and dark bands due to the presence of protein actin and myosin.

- Light bands contain actin and is called I-band (isotropic band) and the dark band contain myosin, and is called A-band (anisotropic band). Both bands are present parallel to each other in longitudinal fashion.
- In centre of each I-band is elastic fibre called 'Z' line. In the middle of A-band is thin fibrous 'M' line. The protein of myofibrils between two successive 'Z' lines is the functional unit of contraction called a **sarcomere**.
- At resting stage, thin filament overlaps the thick filament. The part of thick filament not overlapped is called 'H' zone.
- **Structure of contractile protein:** Each thin filament (actin) is made of two 'F' actins helically wounded to each other. Two filaments of other protein tropomyosin and troponin run parallel to each other. The thick filament consists mainly of myosin protein which contributes 55% of muscle protein by weight. Myosin is split by enzyme trypsin into two fragments called light meromyosin and heavy meromyosin. Each meromyosin has globular head with short arm and tails. Globular head has ATP binding sites.
- The mechanism of muscle contraction is explained by sliding filament theory in which thin filament slide over thick filament.
- Muscle contraction start with signal sent by CNS via motor neuron. Neural signal releases neurotransmitter (Acetylcholine) to generate action potential in the sarcolemma.
- **Red fibres** (aerobic muscles) contain myoglobin (a red coloured oxygen storing pigment) that has plenty of mitochondria to utilise large amount of oxygen stored in them. The muscle fibres containing less number of myoglobin are called white fibres.

Skeletal System:

- Framework of bones and cartilage forms the skeletal system. In human beings, it consists of 206 bones and some cartilage.
- The two principle division of skeletal system are:

  (a) Axial Skeleton (80 bones): Skull, vertebral column, sternum and ribs constitute axial system.
  - The skull (22 bones) is composed of cranial and facial bones. Cranial (8 bones) forms protective covering for brain (cranium). The facial region consists of 14 skeletal systems that form front part of skull. Hyoid bone (U-shaped) forms the base of buccal cavity. Each middle ear contains three tiny bones Malleus, Incus and stapes.
  - Vertebral column consists of 26 serially arranged vertebrae. First vertebra is atlas that combines with occipital condyle. Other include cervical-7, thoracic -12, lumbar -5, sacral – 1 coccygeal -1.
  - 12 pairs of ribs are connected dorsally to vertebral column and ventrally to sternum. 11th and 12th rib bones are not connected with sternum and are called floating ribs.

  (b) Appendicular Skeleton (126 bones): It comprises bones of limbs and girdles. Each limb contains 30 bones.

Topic-2 Joints; Disorders of Muscular and Skeletal System

Revision Notes

- **Joints** are points of contact between bones, or between bones and cartilage.
  - **I. Fibrous joints:** Do not allow any movements. Present in flat skull bones to form cranium.
  - **II. Cartilaginous joints:** Bones are held together with the help of cartilage present in vertebrae. Permits limited movements.
  - **III. Synovial joints:** Fluid filled synovial cavity, provide considerable movements. e.g., Ball and socket joint, hinge joints, pivot joints, gliding joints etc.
- **Disorders of Muscular and Skeletal System**
  - **Myasthenia gravis:** Auto immune disorder affecting neuromuscular junction causing fatigue, weakening and paralysis of skeletal system.
  - **Muscular Dystrophy:** Degeneration of skeletal muscles due to genetic disorder.
  - **Osteoporosis:** Decreased bone mass in old age leading to chance of fracture due to decreased estrogen.
  - **Arthritis:** Inflammation of joints.

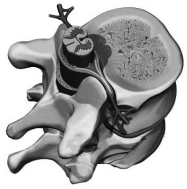
- **Gout:** Inflammation of joints due to accumulation of uric acid crystals.
- **Tetany:** Rapid spasm (Wild contractions) in muscle due to lesser Ca^{2+} in body Fluid.

Mnemonics

Concept: Disorders of Muscular and skeletal system
Mnemonic: **M**ukesh **M**ishra bought a **GOAT**
Interpretation: **M**yasthenia, **M**uscular dystrophy **G**out **O**steoporosis, **A**vanitis **T**etany

Important Diagram

Fibrous joints



Cartilaginous joints

Synovial joints

CHAPTER-18

NEURAL CONTROL AND CO-ORDINATION

Revision Notes

- **Coordination** is the process through which two of more organs interact and complement the function of each other.
- **Neural** system provides an organised network of point to point connection for quick coordination. The endocrine system provides chemical integration through hormones.
- **Neural system** of animals is composed of specialised cells called neuron, which can detect, receive and transmit different kinds of stimuli. In *Hydra* neural system is composed of network of neuron, in insects, it consists of brain and a number of ganglia and in vertebrates, it is highly developed neural system.
- **Central nervous system** (CNS) includes brain and spinal cord. It is the site for information processing and control.
- **Peripheral nervous system** (PNS) includes all nerves associated with CNS.
- **Visceral nervous system** is the part of peripheral nervous system that comprises whole complex of nerves, fibres, ganglia and plexuses by which impulses travel from the CNS to the viscera and from viscera to the CNS.
- The nerve fibres of the PNS are of two types:
  - **Afferent fibres:** transmit impulses from tissue/organ to CNS.
  - **Efferent fibres:** transmit regulatory impulses from CNS to concerned peripheral organs.
- The PNS is divided into two divisions.

  Somatic neural system relay impulses from CNS to skeletal muscles. Autonomic neural system transmits impulses from CNS to involuntary system and smooth muscles. The autonomic neural system is further classified into sympathetic neural system and parasympathetic neural system.
- Neuron is structural and functional unit of neural system. It is made up of three major parts: cell body, dendrite and axon.
- Cell body contains cytoplasm, cell organelles and Nissl's granules.
- Short fibres projecting out from cell body is called dendrites. The axon is long fibre having branched structure at the end that terminates into knob like structure called synaptic knob.
- **Based on number of axon and dendrites, neuron are of three types:**
  - **Multipolar:** One axon and two or more dendrite found in cerebral cortex.
  - **Bipolar:** One axon and one dendrite found in retina of eyes.
  - **Unipolar:** Cell body with one axon, only found in embryos.
- **There are two types of nerve fibres:**
  - **Myelinated nerve** fibres are enveloped with **Schwann cells** to form myelin sheath around the axon. The gap

between two myelin sheaths is called nodes of Ranvier. Found in spinal and cranial nerves.

- **Unmyelinated nerve** fibre is enclosed by **Schwann cells** that do not form myelin sheath around the axon. Found in autonomous and somatic neural system.

Generation and Conduction of Nerve Impulse

- Ions channels are present in neural membrane which is selectively permeable to different ions. When neuron is not conducting impulse (resting), axonal membrane is more permeable to K^+ ions and impermeable to Na^+ ions.
- Ionic gradient across the resting membrane is maintained by active transport of ions by sodium-potassium pump. This will develop positive charge outside the axonal membrane and negative charge on inner side.
- The electrical potential difference across the resting membrane is called **resting potential**.
- When stimulus is applied at site A, the membrane becomes permeable to Na^+ ions to make rapid influx of Na^+ ions. This creates outer surface negatively charged and inner membrane positively charged. This electrical potential difference across membrane is termed as a nerve impulse.

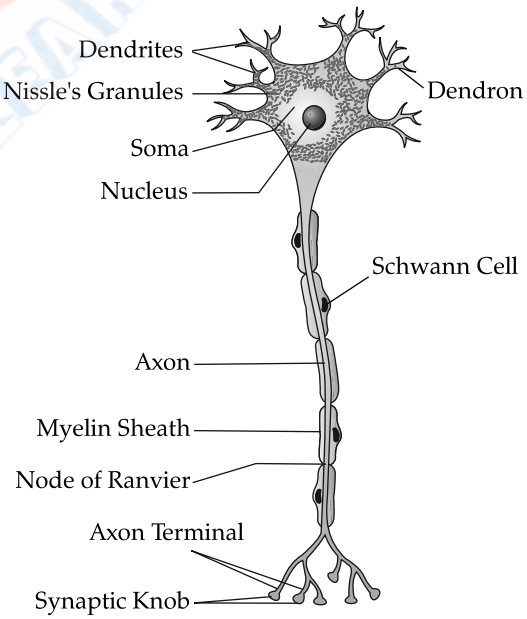
Mnemonics

Concept: **F**orebrain consists
Mnemonic: **F**actory of **CD**
Interpretation: **F**actory labe, **C**erebrum, **D**iencephalon

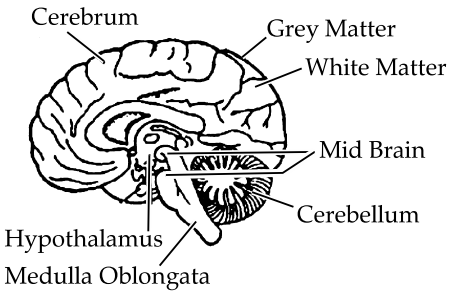
Central Neural System

- Brain is the central information processing unit of our body and act as command and control centre. Human brain is protected by skull (cranium) and cranial meninges consisting of three layered membrane outer dura mater, middle arachnoid and inner pia mater.
- Brain can be divided into 3 parts: forebrain, midbrain and hindbrain.
- **Forebrain** consists of cerebrum, thalamus and hypothalamus.
  - Cerebrum is divided into left and right cerebral hemispheres which are covered by cerebral cortex (grey matter).
  - Cerebral cortex contains sensory neuron, motor neuron and association area. Association area controls the memory and communication like complex process. Inner part of cerebral hemisphere forms the white matter that control sensory and motor signaling.
  - The cerebrum wraps around a structure called thalamus, which is a major co-ordinating centre for sensory or motor signaling. The hypothalamus lies at the base of the thalamus.
- **Midbrain** is located between hypothalamus and pons of hindbrain. Dorsal portion consists of four round lobes called corpora quadrigemina. They are involved in relay of impulses back and forth between cerebrum, cerebellum, pons and medulla.
- **Hind brain** consists of pons, medulla oblongata and cerebellum. Pneumatic centre is present in hindbrain that control inspiration. They also relay impulses between the medulla and superior part of brain. Cerebellum controls balance and posture.

Important Diagrams



Structure of a Neuron



Structure of a Brain

Key Words

- **Myelinated axon:** Axon that has myelin sheath is known as myelinated axon
- **Non-myelinated axon:** Axon without myelin sheath is known as non-myelinated axon.
- **Afferent (sensory) fibres:** It carries impulses from tissues or organs (such as sense organs) to CNS.
- **Efferent (motor) fibres:** It carries impulses from CNS to tissues or organs (such as muscles and glands).
- **Threshold stimulus:** The minimum strength of a stimulus required to stimulate a neuron is called Threshold stimulus.
- **Resting potential:** It is the potential difference across the nerve fibre when there is no conduction of nerve impulse.
- **Action potential:** It is the potential difference across nerve fibre when there is conduction of nerve impulse.
- **Synapse:** It is a functional junction between axon of one neuron and dendrite of next neuron.
- **Gyrus (pl. gyri) :** It is a ridge-like elevation found on the surface of the cerebral cortex. They are surrounded by sulci. Together, the gyri and sulci help to increase the surface area of the cerebral cortex.
- **Sulcus (pl.sulci) :** It is a groove in the cerebral cortex.
- A neuron which releases acetylcholine as neurotransmitter.

CHAPTER-19
CHEMICAL CO-ORDINATION AND INTEGRATION

Topic-1 Endocrine Glands and Hormones

Revision Notes

- In animals, control and coordination is performed by neural system and endocrine system jointly. As the nerve fibres do not innervate all cells of the body, the endocrine or hormonal system is required to coordinate the functions.

Endocrine Glands

- Endocrine glands have no ducts and their secretion get absorbed into the immediate surrounding blood circulation to reach the specific organs to initiate a particular metabolic change.
- The endocrine glands secrete chemicals called **hormones**. Hormones are non-nutrient chemicals which act as intercellular messengers and are produced in trace amount.

Human Endocrine System

- The endocrine glands and hormone producing tissues/cells are located in different parts of the body.
- Gastrointestinal tract, kidney, liver and heart also produce small quantity of hormones to control and coordinate the function of respective organs.

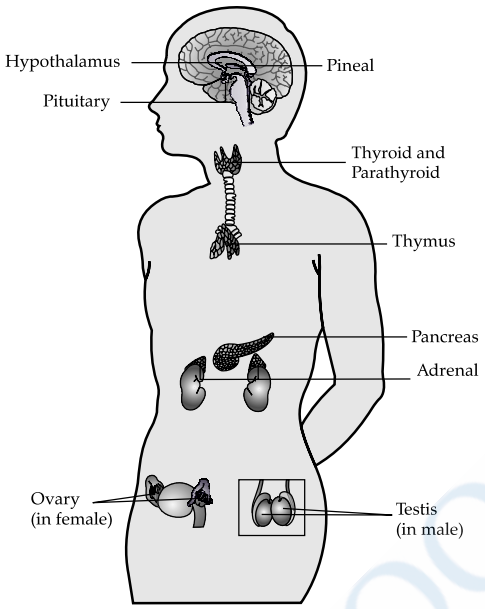
- **Hypothalamus** contains several groups of neurosecretory cells called nuclei which produce hormones. These hormones control and regulate the synthesis and secretion of pituitary hormones.
- The hormones released from hypothalamus reaches to pituitary gland through portal circulatory system and regulate the function of anterior pituitary. The posterior pituitary is under direct control of hypothalamus.
- **Pituitary Gland** is located in a body cavity called sella turcica and is attached to the hypothalamus by a stalk. Pituitary is divided into adenohypophysis and neurohypophysis. Adenohypophysis consists of two parts: pars distalis or anterior pituitary secreating growth hormone (GH), prolactin (PRL), thyroid stimulating hormone (TSH), adrenocorticotrophic hormone (ACTH), luteinising hormone (LH) and follicle stimulating hormone (FSH) and pars intermedia secreating melanocyte stimulating hormone (MSH).
  - Neurohypophysis (pars nervosa) known as posterior pituitary releases two hormones: oxytocin and vasopressin.
  - Over secretion of GH (growth hormone) causes overgrowth of the body leading to gigantism and low secretion causes stunted growth called dwarfism.
  - **Prolactin** stimulates growth of mammary gland, and secretion of milk.
  - TSH stimulates and regulates thyroid hormone secretion from the thyroid gland.
  - **LH and FSH** stimulates gonadal activity. In male, **LH** stimulates synthesis and secretion of androgen hormone from testis. In female, LH induce ovulation of fully mature ovum from ovary.
  - **Oxytocin** helps in contraction of uterus during child birth and milk ejection from mammary glands.
  - **Vasopressin** stimulates absorption of water and electrolyte in kidney. Vasopressin is also known as **Anti-diuretic hormone (ADH).** Deficiency of ADH leads to diabetes insipidus.

Mnemonics

Concept: Endocrine glands
Mnemonic: **P**lease **P**ickup **T**hat **APP**le
Interpretation: **P**ituitary, **P**rolactic, **T**hyroid, **A**drenal, **P**arathyroid, **P**ancreas.

- **Pineal gland:** It is located on dorsal side of forebrain and releases melatonin hormone that help in the regulation of 24-hour rhythm of body like sleep—wake cycle and body temperature.
- **Thyroid gland:** Composed of two lobes on either side of trachea connected by isthmus. Iodine is essential for synthesis of thyroid hormones. Deficiency of iodine leads to hyperthyroidism (Goitre).
- **Exophthalmic goitre** is a form of hypothyroidism. It is characterised by enlargement of thyroid gland. It is also known as Grave's disease.
- During pregnancy, hypothyroidism may cause stunted growth of baby and mental retardation.
- **Parathyroid gland:** It is located on the back side of thyroid gland, secretes peptide hormone called parathyroid hormone (PTH). PTH regulates the circulating level of calcium ions. It also helps in reabsorption of calcium from renal tubules and digestive tracts.
- **Adrenal gland—** It is located on anterior part of each kidney, composed of two types of tissues—central adrenal medulla and outside adrenal cortex. **Adrenal medulla** secretes adrenaline and no-adrenaline hormone, together called emergency hormone. **Adrenal cortex** secretes many hormones together called corticoids which are involved in metabolism of carbohydrates and maintaining water and electrolyte balance. Underproduction of adrenaline leads to Addison's disease.
- **Pancreas—**It acts as both endocrine and exocrine gland. **Endocrine pancreas** consists of **"Islets of Langerhans"** which contain α-cells and β-cells. The α-cells secrete hormone glucagon and β-cells secrete insulin. Both hormones are involved in maintenance of blood sugar levels.
- **Glucagon** is a peptide hormone that stimulates glycogenolysis resulting in increased blood sugar (hyperglycemia).
- **Insulin** is a peptide hormone that play major role in regulation of glucose homeostasis. The rapid movement of glucose to hepatocytes and adipocytes results in decreased blood glucose levels (hypoglycemia).
- **Testis:** It perform dual functions as a primary sex organ as well as endocrine glands. Leydig cells or interstitial cells produce androgen mainly **testosterone** which regulate regulation and maturation of primary sex organs.
- **Ovary:** Produces two groups of steroid hormones called estrogen and progesterone. **Estrogen** is synthesised and secreted by growing ovarian follicles. After ovulation, **ruptured** ovum called corpus luteum, secretes progesterone. Estrogen produces wide range of actions like growth of female secondary sex organs. **Progesterone** regulates pregnancy.

Important Diagram



Topic-2 Mechanism of Hormone Action Role of Hormones and Related Disorders

Revision Notes

Mechanism of Hormone Action

- Hormone produce their effects on target tissues by binding to specific protein called hormone receptors located in the target tissue.
- Binding of hormones to receptor leads to the formation of hormone receptor complex. This binding leads to change in target tissue.

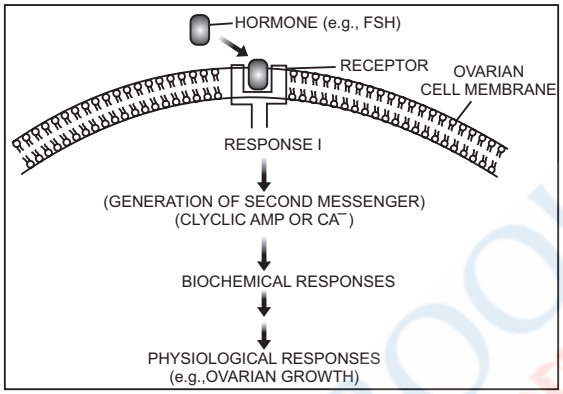
  On the basis of chemical nature, hormones are grouped as:
  - **Peptide, polypeptide and protein hormones:** Insulin, glucagon, pituitary hormone, hypothalamus hormones.
  - **Steroids:** Cortisol, testosterone, progesterone.
  - **Iodothyronines:** Thyroid hormones.
  - **Amino acid derivatives:** Epinephrine.
- The hormones that bound with membrane bound receptors (steroid hormones) normally do not enter the target cells but generate second messenger which in turn regulate cellular metabolism.
- The hormones (protein hormones) which interact with membrane bound receptors mostly regulate gene expression or chromosome function by interaction of hormone receptor complex with the genome. The biochemical effect results in physiological and developmental effects.

Hypo and Hyper activity of hormones.

- Deficiency of hormones leads to hypoactivity of the hormones.
- Excess secretion of the hormones increases hormones action which is called hyperactivity of the hormones.
- Hypoactivity or hyperactivity of the hormones can cause disorders.
- **Pituitary dwarfism** is caused by the deficiency of growth hormone (GH) from childhood. It is characterised by small but proportionate body and sexual maturity. **Acromegaly** is caused by excess of growth hormone from early age. It is characterised by disproportionate increase in size of bones of face, hands and feet.
- **Cretinism** is caused by deficiency of thyroid hormone in infants. It is characterised by slow body growth and mental development with reduced metabolic rate.
- **Goitre** is caused by deficiency of iodine in diet because iodine is needed for the synthesis of thyroxine. It causes thyroid enlargement.

- **Exophthalmic goitre** is a thyroid enlargement (goitre) in which the thyroid secretes excessive amount of thyroid hormone. It is characterised by exophthalmia, i.e., protrusion of eye balls, loss of weight, rapid heart beat, nervousness and restlessness.
- **Diabetes mellitus** is caused by the failure of the beta-cells in the islet of langerhans situated in the pancreas to produce adequate amount of insulin. Some of the glucose is excreted in the urine. This causes excess thirst and the person becomes very weak.
- **Addision's disease** is caused by the deficiency of mineralocorticoids and glucocorticoids. Its symptoms include low blood sugar, low plasma Na^+, high K^+ plasma, nausea, vomiting, diarrhoea, etc.

Important Diagram



Key Words

- **Exocrine glands:** These are glands that release their secretions with the help of ducts at specific site.
- **Endocrine glands:** These are glands that pour their secretions directly into the blood.
- **Heterocrine glands:** The glands that are partly exocrine with duct and partly endocrine without duct is known as heterocrine glands.
- **Hormones:** Hormones are chemical messengers of the body that transfers information from one set of cells to another.
- **Goitre:** It is an enlargement of thyroid gland due to deficiency of iodine.

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