UNIT-I
Diversity of Living Organisms

CHAPTER-1
THE LIVING WORLD

TOPIC-1
What is Living ?

Revision Notes

- Non-living things do not have life while all living things have life. All living things possess some unique characteristics that make them different from non-living things.
- **Characteristics of Living organisms :**
  - Growth, reproduction, ability to sense environment and mount a suitable response are some unique features of living things.
  - Besides these, metabolism, ability to self-replicate, self-organise, interact and emergence are some other characteristics of living things.

(i) Growth :

- All organisms (unicellular and multicellular) exhibit growth. It is the permanent increase in cell number and size of the organism. Growth involves cell division. Dead organisms do not grow.
- Plants grow faster and continuously throughout their life span but animals grow slowly and upto a certain age. After reaching a certain size and age, animals stop growing.
- Some non-living objects like mountains, boulders and sand mounds exhibit an increase in their size, i.e, they also show growth. But this kind of growth exhibited by non-living objects is by accumulation of materials on the surface. But in living organisms, growth is from inside. Therefore, growth cannot be an all-inclusive defining property of living organisms.

(ii) Reproduction :

- The ability of an organism to produce progeny, more or less similar to itself, is called reproduction. Two main modes of reproduction found in organisms are asexual reproduction and sexual reproduction.
- In unicellular organisms growth is synonymous with reproduction.
- Some organisms like mules, sterile worker bees, infertile human couples, etc., do not reproduce. Therefore reproduction cannot be an all-inclusive defining characteristic of living organisms.

(iii) Metabolism :

- Conversions or chemical reactions taking place in the body of an organism are collectively known as metabolism. All plants, animals, fungi and microbes show metabolism. Non-living objects do not exhibit metabolism.
- Metabolism is broadly divided into two categories : (i) anabolism and (ii) catabolism. Both catabolic and anabolic reactions occur simultaneously within the cells.
- Metabolism is a defining feature of all living organisms. Metabolic reactions can be demonstrated outside the body in a test-tube. A metabolic reaction preformed in a test-tube *(in vitro)* is neither living nor non-living but surely living reaction.

(iv) Organization :

- Each cell contains different types of cell organelles to perform specific functions. A cell is an organised structure.
- Unicellular organisms carry out all life processes within a single cell but multicellular organisms have different types of cells, each specialized to perform a particular function.
- In multicellular organisms, related cells work together to perform a specific function, such a group of cells

is called tissue. Different types of tissues group together and function in coordination to constitute an organ and different organs performing a related task altogether form an organ system. Various organ systems in turn together form a complete organism. Thus, in multicellular organisms body is differentiated into smaller units and sub-units which are arranged in orderly manner in such a way to form larger part. This is known as organization. In multicellular organisms, cell represents the lowest level of organization and tissue, organ, organ system are the other levels of organization.

(v) Consciousness :

- All organisms are sensitive and respond to various stimuli. Various environmental factors to which plants respond are light, water, temperature, other organisms, pollutants, etc.
- Animals have sense organs and nervous system and hence they are comparatively more sensitive than plants. thus, all organisms are aware of their surroundings. But human is superior to them because it possess self-consciousness.

TOPIC-2
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.
- **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-3
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 aggregates 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

TOPIC-4
Taxonomic Aids

Revision Notes

➢ **Taxonomic Aids :**

- Taxonomic studies of various species of plants, animals and other organisms are useful in agriculture, forestry, industry and in general in knowing our bio-resources and their diversity.

- Taxonomic studies involve collection of actual specimens of plant and animal species and preservation of these specimens for future studies. Biologists have established certain procedures and techniques to store and preserve the information as well as the specimens.
- Some of the taxonomic aids used by biologist for identification are herbarium, botanical gardens, museums, zoological parks, keys, etc.

(i) Herbarium :

- Herbarium is a store house of collected plant specimens that are dried, pressed and preserved on sheets.
- Each herbarium sheet carries a label which has information about date and place of collection, English, local and botanical names, family, collector's name, etc. All the herbarium sheets are then arranged according to the universally accepted system of classification.

(ii) Botanical Gardens :

- These are specialised gardens which have collections of living plants for reference.
- In a botanical garden, each plant species has label indicating botanical/scientific name and family of the plant.
- **Some famous botanical gardens are given in the following table.**

Botanical Garden	Location
Royal Botanical garden	Kew (England)
Indian Botanical Garden	Howrah (India)
National Botanical Research Institute	Lucknow (India)
New York Botanical Garden	New York (USA)

(iii) Museums :

- It is a place where collections of preserved plant and animal specimens are present for study and reference.
- In a museum, specimens can be preserved in the following ways :
  (i) They can be preserved in the containers or jars in preservative solutions.
  (ii) They can also be preserved as dry specimens.
  (iii) Killed and pinned insects are preserved in insect boxes.
  (iv) Larger animals like birds and mammals are usually stuffed and then preserved.
  (v) Museums also have skeletons of animals as specimen.

(iv) Zoological Parks :

- These are the places where wild animals are kept in protected environments under human care. They enable us to learn about the food habits and behaviour of animals.

(v) Key :

- Key is a taxonomical aid used for identification of plants and animals. It is based on the similarities and dissimilarities.
- The keys are based on the contrasting characters generally in a pair called couplet.
- Each statement in the key is called a lead.
- Separate taxonomic keys are required for each taxonomic category such as family genus and species.

(vi) Other Means of Recording Descriptions :

- Flora, manuals, monographs and catalogues are some other means of recording descriptions. They help in correct identification.
- Flora contains the actual account of habitat and distribution of plants of a given area. It provides an index to the plant species found in a particular area.
- Manuals are useful in providing information for identification of names of species found in an area.
- Monographs contain information on any one taxon.

Know the Terms

- **Growth :** It is permanent increase in the cell number and size of the organism.
- **Metabolism :** The sum total of all the chemical reactions taking place in the body of an organism is known as metabolism.
- **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 categorized 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.
- **Key :** It is a taxonomic aid which is used for identification of plants and animals based on similarities and dissimilarities.
- **Monograph :** It is a book which contains information about any one taxon.

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CHAPTER-2
BIOLOGICAL CLASSIFICATION

TOPIC-1
Need of 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. Thallus organisation

3. Mode of nutrition
4. Reproduction
5. Phylogenetic relationships

➢ **Points of 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.

➢ 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 symbionts. 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 dianoflagellates such as *Gonyaulax* undergo rapid multiplication. Due to 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 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

1. They are heterotrophs and live as predators or parasites.
2. **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)

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 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

Revision Notes

Kingdom Animalia

- The members of this kingdom are eukaryotic multicellular organisms. Their cells lack cell walls.
- 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 crystallized 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.

Know the Terms

- **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. In this, each character is given equal importance and 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 (lichen) 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.
- 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 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 fertilization, 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 of 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.
- **E.g.** *Marchantia.*

(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.

- 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 fertilization 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 and Angiospermae

Revision Notes

■ **Gymnosperms**

- In gymnosperms ovules are naked without any covering and hence remain exposed. The seeds, which develop after fertilization, 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 are 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 fertilization takes place and a zygote is formed. Zygote develops into an embryo and the ovules into seeds. These seeds are not covered.

■ **Angiosperms**

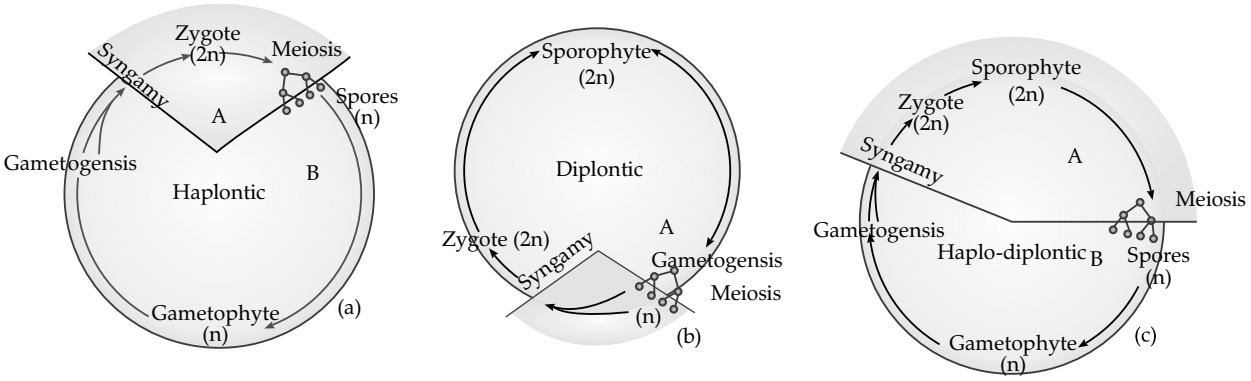
- The angiosperms are found in a wide range of habitats and they also differ in their size. Some of them such as *Wolfia* are microscopic and some such as *Eucalyptus* are tall trees reaching a height over 100 metres. They are valuable to us as they are the source of food, fodder, fuel, medicines and several other commercially important products.
- Angiosperms are also known as flowering plants. In these plants, flower is the reproductive part. Inside the flower, pollen grains and ovules are developed. Another remarkable character of angiosperms is that the ovules are enclosed by ovary.
- On the basis of number of cotyledons present in the seed, angiosperms are classified into two classes– the **dicotyledons** and the **monocotyledons**.
- **Stamen** are the male sex organ in a flower. Each stamen consists of a slender filament with an anther on the tip. The anther produce numerous pollen grains.
- **Pistil** is the female sex organ in a flower. It consists of stigma, style and an ovary. Ovary contains one to many ovules and in each ovule female gametophyte called embryo-sac is present.
- Each embryo-sac has a three-celled egg apparatus—one egg cell and two synergids at one pole, three antipodal cells at another pole and two central nuclei.
- Dehiscence of anther leads to release of pollen grains. The released pollen grains with the help of various agencies like wind, etc., are carried from anther to the stigma of a pistil. This is termed as **pollination**.
- On the stigma, pollen grains germinate and leads to development of pollen tube. This pollen tube grows through the tissues of stigma, style and reach the ovule. It enters the embryo-sac and discharges two male gametes. One of these male gametes fuses with the egg cell to form a diploid zygote, which is called **syngamy**. The second male gamete fuses with the central diploid secondary nucleus to produce a triploid **primary endosperm nucleus** (PEN) which is called triple fusion. As in angiosperms two fusions are involved, this event is termed as **double fertilization**.
- After fertilization, zygote develops into an **embryo** (one or two cotyledons) and the PEN develops into **endosperm.** Endosperm provides nourishment to the developing embryo. After fertilization, synergids and antipodal cells degenerate and ovules develop into seeds and the ovaries develop into fruit.

■ **Plant Life Cycles and Alternation of Generations**

- Different plant groups show different patterns of life cycles – haplontic, diplontic or intermediate (Haplo-diplontic).

(i) Haplontic Life Cycle

In this type of life cycle, sporophytic generation is represented only by the one-celled zygote (2n). There are no free-living sporophytes. Meiosis in the zygote leads to the formation of haploid spores. These spores divide mitotically to form the gametophyte. The dominant, photosynthetic phase in such plants is the free-living gametophyte. Many algae like *Volvox*, *Spirogyra* and some species of *Chlamydomonas* exhibit this pattern.



Life Cycle patterns : (a) Haplontic, (b) Diplontic, (c) Haplo-diplontic

(ii) Diplontic Life Cycle

In this type of life cycle, the diploid sporophyte is the dominant, photosynthetic, independent phase of the plant. The gametophytic phase is represented by the single to few celled haploid gametophyte. This kind of life cycle is found in gymnosperms and angiosperms.

(iii) Haplo-diplontic Life Cycle

In is an intermediate type of life cycle, where both the sporophyte and gametophyte are multicellular and often free-living.

In bryophytes, the dominant phase is the independent haploid gametophyte which alternates with the short-lived multicellular sporophyte totally or lived multicellular sporophyte totally or partially dependent on the gametophyte.

In pteridophytes, the dominant phase is the diploid sporophyte represented by the independent vascular plant body and which alternates with the multicellular free-living and autotrophic short-lived haploid gametophytes.

Examples : *Ectocarpus*, *Polysiphonia*, bryophytes and pteridophytes.

Know the Terms

- **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 borne by the same plant.
- **Syngamy :** It is the process of fusion of the male gamete with the female gamete-egg in an angiosperm.
- **Triple Fusion :** It is the fusion involving two polar nuclei and a sperm nucleus that occurs in double fertilization in a seed plant and results in the formation of the endosperm.

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CHAPTER-4
ANIMAL KINGDOM

TOPIC-1
Basis of Classification

Revision Notes

■ **Basis of Classification**

- Animals are classified on the basis of following fundamental features :
  - **Levels of Organisation**
    1. All members of Kingdom Animalia are multicellular, but all of them do not exhibit the same pattern of organisation of cells.

2. In some animals like sponges, the cells are arranged as loose cell aggregates, but they do not form tissues. This type of body organisation is called as **cellular level of organisation**. In this type of organisation, some division of labour (activities) occur among the cells.
3. In coelenterates, the cells are arranged in more complex manner. Here the cells performing the same function are arranged into tissues. This type of level of organisation is called **tissue level of organisation**.
4. In organ level of organisation, tissues are grouped together to form organs, each specialised for a particular function. **Organ level organisation** is exhibited by members of Platyhelminthes.
5. In higher animals like Annelids, Arthropods, Molluscs, Echinoderms and Chordates, organs have associated to form functional systems. Each system is associated with a specific physiological function. This pattern of level of organisation is called **organ system level of organisation**.
6. Organ systems in different groups of animals exhibit various patterns of complexities.

- The digestive system in platyhelminthes has only a single opening to the outside of the body which serves as both mouth and anus. This type of digestive system is called **incomplete**. In contrast to this, complete digestive system has two openings, mouth and anus.
- In animals, circulatory system may be of two types – **open circulatory system** and **closed circulatory system**. In **open circulatory system,** blood is pumped out of the heart and the cells and tissues are directly bathed in it whereas in **closed circulatory system,** blood is circulated through a series of vessels of varying diameters (arteries, veins and capillaries).
- **Symmetry**
  1. In some animals like sponges, any plane that passes through the centre does not divide them into equal halves. Such type of animals are called **asymmetrical.**
  2. In some animals like coelenterates, ctenophores and echinoderms, any plane passing through the central axis of the body divides the organism into two identical halves. Such animals are said to have **radial symmetry.**
  3. In animals like annelids, arthropods, etc., body can be divided into identical left and right halves in only one plane. Such organisms are said to have **bilateral symmetry.**
- **Diploblastic and Triploblastic Organisation**
  1. In some animals like coelentrates, cells are arranged in two embryonic layers – an external ectoderm and an internal endoderm. Such animals are called **diploblastic animals**. These animals also have an undifferentiated layer, called mesoglea, in between the ectoderm and the endoderm.
  2. In contrast to above, the developing embryo of the members belonging from phylum platyhelminthes to phylum chordata has a third germinal layer in between the ectoderm and endoderm. This additional layer is called mesoderm and the animals having such characteristic are called **triploblastic animals**.
- **Coelom**
  1. The body cavity lined by mesoderm is called coelom. Animals which possess coelom are called **coelomates.** Annelids, molluscs, arthropods, echinoderms, hemichordates and chordates are the examples of coelomates.
  2. In some animals, mesoderm is present in the form of pouches in between the ectoderm and endoderm. Because of this mesoderm does not line the body cavity. This type of body cavity is called **pseudocoelom** and the animals possessing this type of coelom are called **pseudocoelomates**. Aschelminthes are pseudocoelomates.
  3. The animals belonging to phylum platyhelminthes do not have body cavity. Such type of animals are called **acoelomates.**
- **Segmentation**
  1. In some animals, the body is externally and internally divided into segments with a serial repetition of at least some organs. For example, in earthworm, the body shows metameric segmentation and the phenomenon is known as **metamerism**.
- **Notochord**
  1. It is a rod-like structure formed during embryonic development in some animals. Notochord is derived from the mesoderm and located on the dorsal side. Animals possessing notochord are called **chordates** and the animals which lack notochord are called **non-chordates**.

TOPIC-2
Classification of Animals

Revision Notes

- **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**.
  - 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. Fertilization 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.
- Fertilization 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. Fertilization is external and development is indirect.
- Common hemichordates are *Balanoglossus* and *Saccoglossus*.

TOPIC-3
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.

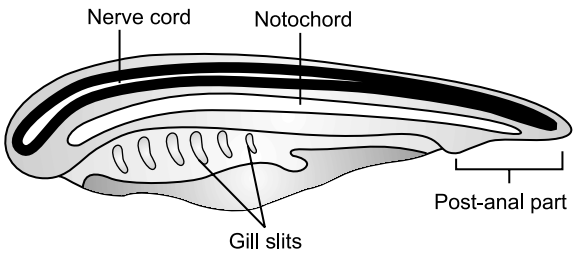

Fig. Chordata characteristics

- 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 section : Agnatha and Gnathostomata.

Section I. 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).

Section II 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.

Know the Terms

- **Radial symmetry :** It is a type of body symmetry whereby body can be divided into two similar parts by any plane along oral/aboral axis of body.
- **Bilateral symmetry :** Body can be divided into two identical right and left halves by a section passing through the longitudinal axis.

- **Coelom :** It is the space between body wall and gut wall.
- **Acoelomate :** Animals that have no coelom.
- **Pseudocoelomate :** Animals that have no true coelom. They have a body cavity partially surrounded by mesoderm.
- **Coelomate (True coelomate or Eucoelomate) :** Animals that have body cavity completely surrounded by mesoderm.
- **Segmentation :** It is the division or differentiation of the body into distinct proportions called segments.
- **Notochord :** It is a rod-like structure formed during embryonic development on the dorsal side.
- **External fertilization :** When fertilization occurs outside the female body, it is called external fertilization
- **Internal fertilization :** When fertilization occurs inside the female body, it is called internal fertilization.
- **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.

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UNIT-II
Structural Organisation in Animals and Plants

CHAPTER-5
MORPHOLOGY OF FLOWERING PLANTS

TOPIC-1
Modification 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 are 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.

- **Modification of roots :**
  - Roots are modified for storage, nitrogen fixation, aeration and support.
  - Tap root of carrot, turnip and adventitious root of sweet potato get swollen to store food.
  - Prop root of Banyan and stilt root of maize and sugarcane have supporting root coming out from lower node of stems.
  - In *Rhizophora,* Pneumatophores help to get oxygen for respiration as it grows in swampy areas.

  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.
- **Modification of stems :**
  - Underground stem of potato, ginger and turmeric are modified to store food. They also act as organs of perennation in unfavourable conditions.
  - Stem tendril help plants to climb as seen in cucumber, pumpkins and grapes.
  - Axillary buds of stem may get modified into woody, straight and pointed thorns as seen in *Citrus* and *Bougainvillea*.
  - Plants of arid regions modify their stem to flattened (*Opuntia*), fleshy cylindrical (*Euphorbia*) structures. They contain chlorophyll for photosynthesis.
  - Underground stems of some plants such as grass and strawberry, etc., spread to new places and when older parts die new plants are formed.
  - In plants like mint and jasmine, a slender lateral branch arises from the base of the main axis and after growing aerially for sometime arch downwards to touch the soil.
  - Offsets are lateral branch with short internodes and each node bears a rosette of leaves and a tuft of roots. *e.g.*, *Pistia* and *Eichhornia*.
  - In banana, pineapple and *Chrysanthemum,* the lateral branches originate from the basal and underground portion of the main stem, grow horizontally beneath the soil and ultimately come out to form a new aerial shoot. These lateral branches are the suckers.

  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 specialized 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.

TOPIC-2

Parts of the Flowering Plants : Flower, Fruits and Seed

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 paterally 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**.
  - 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 overlap each other but not in particular fashion as in Gulmohur.
  - In **vexillary** aestivation, the largest 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.

➢ **Family Fabaceae :**
- This family was earlier known as Papilionoideae. It comprises herbs, shrubs or trees. Root with root nodules. Pinnately compound leaves with reticulate venation.
- **Floral Formula :** $\% \, ♀♂ K_{(5)} C_{1+2+(2)} A_{(9)+1} \underline{G}_{1}$
- Plants belonging to this family are sources of pulses like Gram, Arhar, Bean, Pea, etc., edible oils, like Groundnut, Soyabean etc.

➢ **Family Solanaceae :**
- Plant body : herbs or shrubs, rarely small trees, commonly known as potato family. Leaves simple or pinnately compound. Reticulate venation.
- **Floral Formula :** $\oplus \, ♀♂ K_{(5)} \widehat{C_{(5)} A_{5}} \underline{G}_{(2)}$
- Many of them are source of food (potato, tomato, brinjal etc.), spices (chilli), etc.

➢ **Family Liliaceae :**
- Commonly called the 'Lily family'. It comprises monocots and perennial herbs. Leaves are alternate with parallel venation.
- Stem : Underground bulbs, corms or rhizomes.
- Flower : Bisexual, actinomorphic, sepals and petals are absent, perianth present.
- **Floral Formula :** Br $\oplus ♀♂ \widehat{P_{(3+3)} A}_{3+3\,(3)}$
- It includes ornamental plants (Tulip), Medicine (aloe) and Colchicine.

Know the Terms

➢ **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 fertilization.

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CHAPTER-6
ANATOMY OF FLOWERING PLANTS

TOPIC-1
Plant Tissues, Type of Plant Tissues, Epidermal Tissues System,Vascular Tissues System

Revision Notes

- **Anatomy** is the study of internal structure of organism. In plants, anatomy includes histology, that is, organization 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 Tissue :** A group of cells having a common origin and usually performing common function are called tissues.
- A meristem or meristematic tissue is a simple tissue composed of a group of similar and immature cells which can divide and form new cells.
  - The meristem which occurs at tips of roots and shoots and produce primary tissues are called **apical meristem**.
  - **Intercalary meristem** occurs between mature tissues especially in grasses. They are also called as secondary meristem as they appear later than primary meristem.
  - Both apical meristems and intercalary meristems are primary meristem because they appear early in the life of a plant and contribute to the formation of primary plant body.
  - The meristem that occurs on the sides and takes part in increasing girth of the plants are called **lateral meristem.** Intrafascicular cambium is the primary lateral meristem. Vascular cambium, cork cambium are secondary meristem.
- The cells that have become structurally and functionally specialized and have lost the ability of cell division are called **permanent tissue.** Permanent tissues having all cells similar in structure and function are called **simple permanent tissues** and those having different kinds of cells are called **complex tissue.**
  - Parenchyma is a simple permanent living tissue which is made up of thin-walled similar isodiametric cells. Each cell encloses a large central vacuole and peripheral cytoplasm containing nucleus. They are found in non-woody and soft areas of stem, root, leaves, fruits and flowers. They store the food and provide turgidity to softer parts of plant.
  - Collenchyma consists of cells which are much thickened at corner due to cellulose, hemicellulose and pectin. They are oval, spherical or polygonal and often contain chlorophyll. They provide mechanical support to the growing parts of the plants like young stem and petiole of a leaf.
  - Sclerenchymas are supportive tissue having highly thick walled cells with little or no protoplasm due to deposition of lignin. They are of two types : fibres and sclereids. They give mechanical support to mature plant organs to tolerate bending, shearing, compression, etc. The sclereids are commonly found in the fruit walls of nuts, pulp of fruits like guava, pear and sapota.
  - **Complex Tissues :** Xylem and phloem constitute the complex tissues in plants and work together as a unit.
  - Xylem functions as a conducting tissue for water and minerals from the roots to the stem and leaves.
  - It also provides mechanical strength to the plant parts.
  - It is composed of tracheids, vessels, xylem fibres and xylem parenchyma. Gymnosperms lack vessels in their xylem. The presence of vessels is characteristic feature of angiosperms.
  - In flowering plants, tracheids and vessels are the main water conducting tissues.
  - Vessels, tracheids and xylem fibres are dead and are without protoplasm. Xylem parenchyma cells are living and thin walled and they store food materials.
  - Primary xylem is of two types : protoxylem first formed primary xylem elements and metaxylem (later formed primary xylem). In stem, protoxylem lies in centre and metaxylem towards the periphery. This type of primary xylem is called **endarch**.
  - In roots, protoxylem lies in periphery and metaxylem lies towards the centre. This type of primary xylem is called **exarch**.
  - Phloem transport food material from the leaves to other parts of the plant.
  - In angiosperms, phloem is composed of sieve tube elements, companion cells, phloem parenchyma and phloem fibres.
  - In gymnosperms, albuminous cells and sieve cells are present. They lack sieve tube and companion cells.

- The first formed primary phloem consists of narrow sieve tubes and are referred to as **protophloem** and the later formed phloem has bigger sieve tubes and is referred to as **metaphloem**.

➢ **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; Secondary Growth

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.

➢ **Secondary Growth :**
- It is the growth in girth (thickness) due to the formation of secondary tissues by lateral meristems (vascular cambium and cork cambium).
- Vascular cambium is responsible for cutting off vascular tissues- xylem and phloem.
- In dicot stem, cambium present between xylem and phloem is called intrafascicular cambium. The cells of medullary rays become meristematic to form interfascicular cambium, which together form the complete ring of cambium.
- Cambial ring cut off secondary xylem inside and secondary phloem outside the ring.
- In temperate regions, the climatic conditions are not uniform throughout the year. In the spring season, cambium is very active and produces a large number of xylary elements with vessels of wider cavities. The wood formed during this season is called spring wood or early wood.
- In winter, the cambium is less active and forms fewer xylary elements that have narrow vessels and this wood is called autumn wood or late wood.
- The spring wood is light colored and has a low density in comparison to the dark and high density autumn wood.
- The two rings of wood appear as alternate concentric rings and constitute an annual ring.
- Annual rings give an estimate of the age of the tree.
- In old trees, the greater part of secondary xylem is dark brown due to deposition of organic substances like tannins, resins, oils, gums and essential oils. These substances make it hard, durable and resistant to the attacks of microorganisms and insects. This region comprises dead element with high lignified walls and is called heart wood.
- The heart wood does not conduct water but gives mechanical support to the stem.
- The sapwood is involved in the conduction of water and minerals.
- Cork cambium or phellogen is formed in the outer cortex of stem. It cuts cells on both sides. The cells outside the phellogen differentiate to form cork or phellem and inner cell differentiate into secondary cortex or phelloderm.
- Cork is impervious to water due to deposition of suberin in cell wall. Phellogen, phellem and phelloderm are collectively called **periderm**.
- **Bark** refers to all the tissues exterior to the vascular cambium including secondary phloem. Bark that is formed early in the season is called early or soft bark and those formed towards the end of the season, is called late or hard bark.
- **Lenticels** are the aerating pores in the bark of plants. They permit the exchange of gases between the outer atmosphere and the internal tissue of the stem.
- Secondary growth also occurs in stem and root of gymnosperms but not in monocotyledons.

Know the Terms

➢ **Tissue :** Tissue is a group of cells with common origin, structure and function that work together to perform a particular function.

➢ **Meristematic tissues :** Tissues that consist of undifferentiated actively dividing cells.

➢ **Permanent tissues :** Tissues that have lost the ability to divide, and have attained a definite form and size are called permanent tissues.

➢ **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 synthesized 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.

➢ **Primary growth :** The growth of the roots and stems in length with the help of apical meristem is called the primary growth.

➢ **Bark :** It is a non-technical term that refers to all tissues exterior to the vascular cambium, therefore including secondary phloem.

➢ **Periderm :** Phellogen, phellem, and phelloderm are collectively known as periderm.

CHAPTER-7
STRUCTURAL ORGANISATION IN ANIMALS

TOPIC-1
Tissue, Types of Animal Tissue : Epithelial, Connective, Muscular and Nervous Tissue

Revision Notes

- In multicellular organism, a group of similar cells along with intercellular substances perform a specific function. Such organization is called tissue.
- **Epithelial Tissue :**
  - This tissue provides covering or lining for some part of the body. Cells are compactly packed without intercellular space.
  - **Simple epithelium** is composed of single layer of cells and function as lining of body cavities, ducts and tubes.
  - The **compound epithelium** consists of two or more than two layers of cells and has protective function.
  - The **squamous epithelium** is made up of single layer of flattened cells with irregular boundaries. They are present in the walls of blood vessels, air sacs of lungs.
  - **Cuboidal epithelium** is made up of single layered cube-like cells and found in ducts of glands and tubular part of nephron of kidney for absorption and secretion.
  - **Columnar epithelium** is made up of tall and slender cells. The nuclei are located at the base. Free surface may have microvilli found in lining of stomach and intestine. The ciliated one are called as **ciliated epithelium**.
  - Columnar and cuboidal epithelium specialized for secretion are known as **glandular epithelium**, which may be unicellular as in goblet cells of alimentary canal or multicellular as in salivary gland.
  - Main function of **compound epithelium** tissue is to provide protection against chemical and mechanical stress. They cover the dry surface of skin, moist surface of buccal cavity, pharynx, inner lining of ducts of salivary glands and pancreatic ducts.
  - Epithelial cells are held together by intercellular material to form specialized function.
- **Connective Tissue :**
  - They are most abundant and widely distributed tissues which link and support the other tissues. All connective tissue except blood, secretes fibres of structural protein called collagen or elastin to provide elasticity and flexibility.
  - **Loose connective tissues** contain cells and fibres loosely arranged in semi-fluid ground substance. It includes areolar tissue and adipose tissue.
  - **Dense connective tissue** contains fibres and fibroblast compactly packed. The orientation of fibres may be regular or irregular pattern.
  - In dense regular connective tissues, collagen fibres are present in rows between parallel bundles of fibres as in tendons and ligaments.
  - Cartilage, bones and blood are specialized connective tissue.
  - Dense irregular connective tissue has fibroblasts and many fibres (mostly collagen) that are oriented differently, for example skin.
  - **Blood** is fluid connective tissue containing plasma, red blood cells, white blood cells and platelets. It helps in transportation of various substances between organs.
- **Muscle Tissue**
  - Each muscle is made up of long cylindrical fibres arranged parallel to each other. Fibres are composed of fine fibrils called myofibrils. Muscle fibres contract and relax in response to stimulation.
  - Muscle tissue help in movement of the body and specific body parts.
  - The special properties of muscular tissues are contractibility, elasticity, stretchability,etc.
  - **Skeletal muscle** is the muscle tissue attached to the bones and are involved in voluntary activities.
  - **Smooth muscles** are involved in carrying out involuntary activities.
  - **Cardiac muscles** make up the contractile walls of the heart.
- **Neural Tissue :**
  - The unit of neural system is neuron. Neuroglial cell protect and supports the neuron.
  - When neuron gets stimulated, electrical impulses are generated that travel along the plasma membrane (axon).

The tissues organize to form organs which in turn associate to form organ system in multicellular organisms.

TOPIC-2
Morphology of Animals : Earthworm, Cockroach and Frog

Revision Notes

- **Earthworm :**
  - Earthworm is reddish brown terrestrial invertebrate that lives in upper layer of moist soil. The common Indian earthworms are *Pheretima* and *Lumbricus*.
  - Earthworms have long cylindrical body divided into segments called metameres. The ventral surface contain genital pore and dorsal surface contain mid dorsal line.
  - First body segment is called **peristomium** which contains the mouth.
  - Prostomium, a lobe serves as the covering for the mouth and as a wedge to open cracks in thes oil. 14-16 segments are covered by dark band of glandular tissue called **clitellum**.
  - Four pairs of spermathecal apertures are situated on the ventrolateral sides of the inter segmental grooves, i.e., 5th-9th segments.
  - Single female genital pore is present on mid ventral line of 14th segments. A pair of male genital pore is present on 18th segment on ventro-lateral side.
  - All the segment except 1st , last and clitellum contain S-shaped **setae** for locomotion.
  - Alimentary canal is straight tube from 1st to last segment having, buccal cavity, muscular pharynx, oesophagus that leads to gizzard, which help in grinding the soil particles and decaying leaves. Stomach and small intestine leads to anus.
  - Closed vascular system consists of heart, blood vessels and capillaries. Earthworm lacks respiratory organs and respire through moist skin.
  - Excretory organ is coiled segmental tubules called **nephridia**. There are three types of nephridia : Septal nephridia, integumentary nephridia and pharyngeal nephridia.
  - Nervous system is basically represented by ganglia arranged segment wise on the ventral paired nerve cord.
  - Sensory system does not have eyes but have light and touch receptors. They have specialized chemoreceptors which react to chemical stimuli.
  - Earthworm is **hermaphrodite**. Two pairs of testes are present in 10th and 11th segment. Prostate and spermatic duct open to surface as male genital pore on the ventro-lateral side of the 18th segment.
  - One pair of ovaries is attached to the intersegmental septum of 12th and 13th segments. Female genital pore open on ventral side of 14th segment. Mutual exchange of sperms takes place during mating.
  - Mature sperms and egg cells along with nutritive materials are deposited in cocoon in the soil where fertilisation takes place.
  - Earthworms are known as friends of farmer because they make burrows in soil to make it porous for respiration and root penetration. Earthworms are also used for vermicomposting and as bait in game fishing.
- **Cockroach (*Periplaneta americana*)**
  - Cockroaches are nocturnal omnivorous organism that lives in damp places everywhere.
  - The body of cockroach is segmented and divisible into head, thorax and abdomen. The body is covered by hard chitinous exoskeleton. In each segment, exoskeleton has hardened plates called sclerites that are joined to each other by a thin and flexible articular membrane or arthrodial membrane. Head is triangular in shape formed by fusion of six segments to show flexibility. Head bears compound eyes.
  - Anterior the head bears appendages forming biting and chewing type of mouth parts consisting of a labrum (upper lip), a pair of mandibles, a pair of maxillae and a labium (lower lip).
  - Antenna attached on head help in monitoring the environment.
  - Thorax consists of three parts : prothorax, mesothorax and metathorax. Fore wings and hind wings are attached with thorax. Abdomen consists of 10 segments.
  - Alimentary canal is divided into foregut, midgut and hindgut. Food is stored in crop used for storing the food. Gizzard help in grinding the food particles. At the junction of midgut and hindgut, yellow coloured filamentous Malpighian tubules are present, which help in excretion.
  - Blood vascular system is open type having poorly developed blood vessels. The haemolymph is the blood of cockroach composed of colourless plasma and haemocytes.
  - Respiratory system consists of network of trachea which open through 10 pairs of spiracles on lateral side.

- Cockroaches are dioecious. Male reproductive system consists of a pair of testes one lying on each lateral side in 4th - 6th abdominal segments. The female reproductive system consists of two large ovaries situated on 2nd - 6th abdominal segments.
- The fertilized eggs are encased in capsule called ootheca. 9 to 10 ootheca are produced by each female.
- Cockroaches are pests and destroys the food, contaminate with smelly excreta.

➢ **Frog (*Rana tigrina*) :**

- Frogs are cold-blooded organism having ability to change colours to hide from enemies. Body is divisible into head and trunk, bulged eyes covered by nictitating membrane. Male frog is different from female having vocal sacs and copulatory pad on first digit of forelimb.
- Digestive system consists of alimentary canal and digestive glands.
- Digestion starts in stomach and final digestion occurs in small intestine. Digested food is absorbed by villi and microvilli present in the inner wall of small intestine.
- Skin acts as aquatic respiratory organs. On land skin, buccal cavity and lungs acts as respiratory organs.
- Heart is 3-chambered. Blood consist of plasma and blood cells. RBC is absent.

Know the Terms

➢ **Histology :** The study of tissue is called histology.
➢ **Epithelial tissue :** It is the simplest animal tissue that forms the continuous sheet of closely packed cells that covers all external and internal surface of the animal body.
➢ **Simple epithelium :** Epithelium composed of only one layer of cells.
➢ **Compound epithelium :** Epithelium composed of many layers of cells.
➢ **Endocrine glands :** Glands that secrete their secretions directly into the blood.
➢ **Exocrine glands :** Glands that release their secretion through ducts (tubes) at specific sites.
➢ **Adipose Tissue :** It is a type of connective tissue that is specialized to store fat.
➢ **Tendon :** Tendon is a tough, non-fibrous, dense, white fibrous connective tissue, which joins a skeletal muscle to a bone.
➢ **Ligament :** Ligament is a dense yellow fibrous connective tissue, which binds a bone with another bone.
➢ **Bone :** Bone is a strong, rigid and non-flexible tissue.
➢ **Blood :** Blood is a bright red coloured fluid connective tissue.
➢ **Lymph :** Lymph is a light, yellow coloured fluid connective tissue, consisting of plasma and white blood cells.
➢ **Neuron :** Neuron is the functional unit of nervous tissue.
➢ **Synapse :** The junction between two neurons (axon-to-dendrite) or between a neuron and a muscle is called synapse.

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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.
- **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 PPLO.
- 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 specialized 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 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 organized nucleus with nuclear membrane. The genetic materials are arranged in chromosomes.
- Plants 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.

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.
- The main function of plasma membrane is the transport of 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**.

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 prokaryotic, 70S and in eukaryotic, 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 protein.
- 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.

Know the Terms

- **Cell :** Cell is the smallest unit of matter capable of independent existence and performing the essential functions of life.
- **Totipotency :** It is the ability of living cells to form the whole organism, unless and until they have become extremely specialized.
- **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 formed nucleus is known as prokaryotes.
- **Eukaryotes :** Organisms whose cells have a nucleus with a 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.

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CHAPTER-9

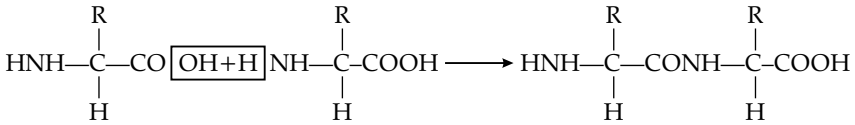
BIOMOLECULES

TOPIC-1

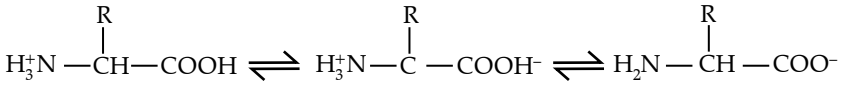
Chemical Constituents of Living Cells : Biomolecules; Structure and Function of Proteins, Carbohydrates, Lipids, Nucleic Acids

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 polymerization 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.

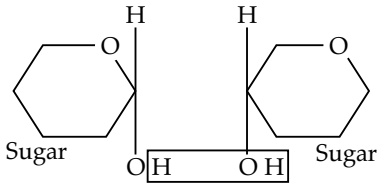


- A particular property of amino acids is the ionizable nature of $–NH_2$, and –COOH groups.
  Hence, in solutions of different pHs the structure of amino acids changes.



B is a zwitter ionic form

- Lipids could be simply fatty acids. A fatty acid has a carboxyl group attached to a R group where 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.



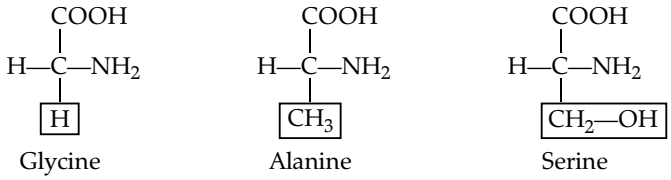
Glycosidic bond

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 1-4 α in straight chain and 1-6 linkage in branching.

Protein :

- Proteins are polypeptide chains made up of amino acids. There are 20 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.



Amino acids

- **The main functions of protein in living cell are :**
  - Transport of nutrient across the membrane.
  - Fight infectious organisms.
  - Produce enzyme and proteins.
- **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. *E.g.*, 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).
- All biomolecules have a tun over *i.e.*, they are constantly being changed into some other biomolecules and also made from other biomolecules. This breaking and making is through chemical process called **metabolism**.
- In living organism, all the metabolic reactions are enzyme catalyzed. Catalysts are those substances that alter the rate of reaction. The protein with catalytic power is called **enzyme**.

Metabolic basis for living organism :

- The metabolic pathways that lead to more complex structure from simpler structure are called biosynthetic or **anabolic pathways** and those pathways that lead to simpler structure from complex structure are called **catabolic pathways**.

- Photosynthesis and protein synthesis are example of anabolic and respiration and digestion are the example of catabolic pathways.
- ATP (**Adenosine Triphosphate**) is the most important form of energy currency in living world.
- All living organisms exist in steady state characterized by concentration of each of the metabolites. The living state is a non-equilibrium steady state to be able to perform work.

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.**

Factors influencing Enzyme Activity :

- **Temperature :** An enzyme is active within a narrow range of temperature. Temperature at which enzyme is most active is called optimum temperature. The enzyme activity decreases above and below this temperature.
- **pH :** Every enzymes has an optimum pH at which it is most active. Most of the intracellular enzymes work at neutral pH.
- **Concentration of Substrate :** Increase in substrate concentration increases the rate of reaction due to occupation of more active sites by substrate.

- **Competitive Inhibitor :** When the molecular structure of inhibitor resembles the substrate that inhibits the function of enzymes is called competitive inhibitor.
- **Enzymes are classified as**
  - **Oxidoreductases/Dehydrogenases :** Enzymes which catalyse oxido reduction between two substrates.
    S reduced + S′ oxidised $\longrightarrow$ S oxidised + S′ reduced.
  - **Transferases :** $S - G + S' \longrightarrow S + S' - G$
  - **Hydrolases :** It catalyzes the hydrolysis of peptide, ester, glycosidic bonds etc.
  - **Lyases :** It remove the groups from substrate.
  - **Isomerases :** It causes inter-conversion of optical, geometrical or positional isomers.
  - **Ligases :** It catalyzes the linking together of two compounds.
- **Co-factors** are the non-protein constituent of an enzyme to make the enzyme catalytically more active. The protein portions of enzyme are called **apoenzymes.**
- The essential chemical components of any co-enzymes are vitamins.

Know the Terms

- **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 synthesized 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 synthesized 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.
- **Ribozymes :** They are nucleic acids (RNA) that behave like enzymes.
- **Co-factors:** They are non-protein constituents bound to the enzyme to make the enzyme catalytically active.
- **Apoenzyme :** The protein portion of the enzyme is called apoenzyme.
- **Prosthetic group :** They are non-protein organic factors which are firmly attached to the apoenzyme.
- **Co-enzymes :** It is a non-protein organic compounds which is loosely attached to an apoenzyme.

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CHAPTER-10
CELL CYCLE AND CELL DIVISION

TOPIC-1
Cell Cycle, Mitosis and its Significance

Revision Notes

- The sequence of events by which a cell duplicates its genome, synthesizes 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 synthesized 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.
- Mitosis 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.

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 recombination of them.
  - 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 **Panchytene** 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 recognized 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.

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.

Know the Terms

- **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.

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UNIT-IV
Plant Physiology

CHAPTER-11
TRANSPORT IN PLANTS

TOPIC-1
Movement of Water, Gases & Nutrients and Plant Water Relations

Revision Notes

- Plant transport various substances like gases, minerals, water, hormones, photosynthates and organic solutes to short distance (one cell to another) or long distance as water from roots to tips of stem.
- Long distance transport occurs through vascular system, xylem and phloem called **translocation** through mass flow.
- The direction of translocation may be unidirectional as in case of water.

Simple Diffusion

- Movement by diffusion is passive and slow along the concentration gradient through permeable membrane.
- No energy expenditure takes place. It occurs in liquid and gases.
- Rate of diffusion are affected by gradient of concentration, permeability of membrane, temperature and pressure.

Facilitated Diffusion

- Lipid soluble particles easily pass through cell membrane but the hydrophilic solute movement is facilitated.
- For facilitated diffusion, membrane possesses **aquaporins** or water channels. **Aquaporins** are membrane proteins for passive transport of water soluble substances without utilization of energy.
- The protein forms channels in membrane for molecules to pass through. The porins are proteins that forms huge pores in the outer membrane of the plastids, mitochondria etc.
- Water channels are made up of eight different types of aquaporins. Some carrier or transport proteins allow diffusion of only two types of molecules together. This is called co-transport.
  - In **Symport,** both molecules cross the membrane in the same direction.
  - In **Antiport,** both molecules moves in opposite direction.
  - When a molecule moves across a membrane independent of other molecules, the process is called **uniport.**

Active Transport

- It uses energy to pump molecules against the concentration gradient. It is carried out by membrane proteins.
- In active transport, movable carrier proteins are called pumps.
- The pumps can transport substance from low concentration to high concentration. The carrier proteins are very specific in what it carries across the membrane.

Plant-Water Relationship

- Water is essential for all physiological activities of plants along with all living organisms. It provide medium for most substances to dissolve in it.
- Protoplasm of cells contains water in which different molecules are dissolved and suspended.
- Terrestrial plants take lot of water and release most of it in the form of water vapours by the process of transpiration.
- Water is the limiting factor for plant growth and productivity in both agricultural and natural environments.
- Water Potential (Ψw)- is a concept fundamental to the understanding of water movement.
- Water potential is determined by solute potential (Ψs) and pressure potential (Ψp).
- Water molecules possess kinetic energy. The greater the concentration of water in the system, the greater is its kinetic energy or water potential. So pure water has greatest water potential.
- Water potential is denoted by Greek symbol Psi (Ψ) and is expressed in pressure unit Pascal (Pa).
- Water pressure of pure water is taken as zero at standard temperature and pressure. A solution has less water potential due to less water concentration.
- The magnitude of lowering of water potential due to dissolution of solute is called solute potential (Ψs). Solute potential is always negative. More the solute molecules in the solution lesser the solute potential.
- If a pressure greater than atmospheric pressure is applied to pure water or solution, its water potential increases. Pressure potential is usually positive. Pressure potential is denoted by (Ψp).
- Water potential of a cell is affected by both solute and pressure potential. The relationship is as follows :

$$\Psi \mathbf{w} = \Psi s + \Psi p$$

- **Osmosis :** It is the diffusion of water across a semi-permeable membrane. The net direction and rate of osmosis depends upon the pressure gradient and concentration gradient. Water will move from its region of higher concentration to region of lower concentration until equilibrium is reached.
- **Osmotic potential** is the pressure required to prevent water from diffusing. More the solute concentration greater will be the pressure required to prevent water from diffusing it.
- Numerically, osmotic pressure is equal to osmotic potential but sign is opposite. Osmotic pressure is the positive pressure while osmotic potential is negative.
- If the surrounding solution balances the osmotic pressure of cytoplasm, the solution is called **isotonic**.
- If the external solution is more dilute than cytoplasm, it is **hypotonic**. The cells swell up when placed in hypotonic solution.
- If the external solution is more concentrated than cytoplasm, it is **hypertonic**. Cell will shrink in hypertonic solution.
- **Plasmolysis** is the shrinkage of the cytoplasm of the cell from its cell wall under the influence of hypertonic solution. The pressure of plasmolysis is usually reversible when the cell is placed in hypotonic solution.
- The pressure build up against the wall due to movement of water inside is called **turgor pressure**. It is responsible for enlargement and extension growth of cells.
- **Imbibition** is a special type of diffusion when water is absorbed by solid colloids causing them to increase in volume. For example absorption of water by seeds and dry woods.
- Imbibition is also a kind of diffusion because movement of water is from higher concentration to lower concentration.
- Water potential gradient between the absorbent and liquid imbibed is essential for imbibition.

TOPIC-2

Long Distance Transport of Water, Uptake and Translocation of Mineral Nutrients.

Revision Notes

Mass or Bulk flow system in plants

- Long distance transport of water in plants takes place by **mass or bulk flow system**. It is the movement of substance in bulk from one point to another as a result of pressure difference between two points.
- The bulk movement of substances through the conducting or vascular tissue of plants is called **translocation**. Xylem is associated with translocation of water and mineral salts, some organic nitrogen and hormone from roots to aerial parts of plants.
- Phloem transport organic and inorganic solutes from leaves to other part of plants.

Absorption of water by plants

- Water is absorbed along with mineral solutes by roots hairs by diffusion. The absorbed water passes to deeper layer by two pathways : **apoplast** and **symplast**.
- Most of the water flows in roots via apoplast pathway because cortical cells are loosely packed and offers no resistance to water movement. The apoplastic movement of water occurs exclusively through the intercellular spaces and the walls of the cells. The apoplast does not provide any barrier to water movements.
- The inner boundary of cortex, endodermis is impervious to water due to suberized matrix called **Casparian strip**. Water molecules are directed through wall regions that are not suberized.
- In the symplast pathway, the water passes from cell to cell through their protoplasm. The cytoplasm of adjacent cells are connected through **plasmodesmata**. Water has to enter the cells through the cell membrane hence the movement is relatively slow.
- A **mycorrhiza** is the symbiotic association between a fungus and angiospermic roots. The fungal filaments forms a network around the young root to have large surface area that absorb mineral ions and water from the soil. The fungus provide minerals and water and roots in turn provide organic and nitrogen containing compounds.

Ascent of sap (Translocation of water)

- The upward movement of water from roots towards the tips of stem branches and their leaves is called ascent of sap.
- **Vital force theory** was forwarded by J.C.Bose in 1923. This theory believes that the innermost cortical cells of the root absorb water from the outer side and pump the same into xylem channels.
- **Root pressure theory** is positive pressure that develops in the xylem sap of the root of plants. It is responsible for pushing up water to small heights in plants.
- Loss of water in liquid phase by herbaceous plants from the tips of leaf blades is known as **guttation**.
- Water rises in tubes of small diameters, kept in vessels having water due to force of surface tension. Similarly water rises up in the walls of xylem channels due to adhesion and cohesion. This theory is called **Theory of Capillarity**.
- **Cohesion Tension theory** was put forwarded by Dixon and Jolly in 1894. According to this theory, water is mostly pulled due to driving force of transpiration from the leaves. The water molecules remain attached with one another by cohesion force. The water molecule does not break in vessels and tracheid due to adhesive force between their walls and water molecules. On account of tension created by transpiration, the water column of plant is pulled up passively from roots to great heights.
- **Transpiration** is the loss of water in the form of water vapour from aerial parts of plants. The following purpose is fulfilled by transpiration.
  - It creates transpirational pull for absorption and transportation in plants.
  - It supplies water for photosynthesis.
  - It transport minerals and salts from soil to other parts of plant.
  - It cools the leaves and maintain their shape and size.
  - Several external factors such as temperature, light, humidity, wind speed affect transpiration. Plant factors that affect transpiration include number and distribution of stomata, percent of open stomata, water status of the plant, canopy structure etc.
- Photosynthesis is limited by available water. C_4 plants are twice as efficient as C_3 plants in terms of fixing carbon. C_4 plants uses half as much water as C_3 plants for the same amount of CO_2 fixed.

Uptake and transport of mineral nutrients

- Most of the minerals enter the roots by **active absorption** into the cytoplasm of epidermal cells because :
  - Minerals are present in the soil as charged particles (ions) which cannot move across cell membranes.
  - The concentration of ions in soil is usually lower than concentration in roots.
- Active absorption needs energy in form of ATP. Active uptake of ions is also responsible for water potential gradient in roots.
- Transport proteins of epidermal cells are control point where quantity and type of solutes that reach the xylem is adjusted.
- The ions that reach xylem by active or passive transport moves further upward along with transpirational pull.
- The chief sinks of mineral elements are growing region of plants like apical meristem, young leaves, growing flower and fruit, and the storage organs.
- Minerals are frequently remobilized from older senescing part of plants to young growing parts of plant.
- The elements most readily mobilized include phosphorus, sulphur, nitrogen and potassium. The element like calcium is not mobilized as it is the structural components of plant body.

Phloem transport : Flow from Source to Sink

- Food (sucrose) is transported by phloem from source to sink. The part of plant that synthesize the food is called source and part where food is used or stored is called sink.
- The source and sink can be reversed by the plants depending upon the season or plant's need. So, the direction of movement in the phloem is bi-directional.
- Phloem sap is mainly water and sucrose but other sugars, hormones and amino acids are also translocated through it.

Pressure flow or Mass flow hypothesis

- It is the most accepted theory for the translocation of sugar from source to sink.
- Glucose is prepared at source by photosynthesis which is converted into disaccharides (sucrose). Sucrose moves into companion cells and then into sieve tube cells by active transport.
- Loading of phloem at source creates a water potential gradient that facilitates the mass movement in the phloem.
- Sieve tube cells of phloem forms a long column with holes in their wall called sieve plates.
- Cytoplasmic strands pass through the whole in the sieve plates to form continuous filament. Hydrostatic pressure developed in sieve tube cells moves the sap in the phloem.
- At sink incoming sugar is actively moved out of the phloem as complex carbohydrates. The loss of solute produces a high water potential in the phloem and water passes out, returning into xylem.

Know the Terms

- **Translocation :** Transport of substances in plants over longer distances through the vascular tissue (Xylem and Phloem) is called translocation.
- **Diffusion :** Diffusion is a passive movement of substance from a region of higher concentration to region of lower concentration across the permeable membrane.
- **Aquaporins :** Aquaporins are proteins that facilitate diffusion of water molecules.
- **Water potential :** The water potential of a cell is expressed as sum of solute potential (Ψs) and pressure potential (Ψp).
- **Osmosis :** Osmosis is movement of solvent or water molecules from the region of their higher diffusion pressure or free energy to the region of their lower diffusion pressure or free energy across a semi-permeable membrane.
- **Osmotic pressure :** It is the external pressure applied to prevent the diffusion of water.
- **Imbibition :** It is the phenomenon of adsorption of water or any other liquid by the solid particles of a substance without forming a solution.
- **Root pressure :** A hydrostatic pressure existing in roots which push the water up in xylem vessels is called root pressure.
- **Guttation :** It is the loss of water in the form of liquid droplets from the vein endings of certain herbaceous plants.
- **Transpiration :** It is the loss of water through stomata of leaves and other aerial parts of plants in form of water vapour.
- **Stomata :** Stomata are tiny pores present on the surfaces of the leaves that help in exchange of gases.

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CHAPTER-12
MINERAL NUTRITION

TOPIC-1
Essential Minerals, Macro- and Micronutrients and their Role; Elementary Idea of Hydroponics as a Method to Study Mineral Nutrition

Revision Notes

- Mineral nutrition is the study of source, mode of absorption, distribution and metabolism of various inorganic substances (minerals) by plants for their growth, development, structure, physiology and reproduction.
- **Methods to study the Mineral Requirement of Plants :**
  - **Hydroponics** is the technique of growing plants in a nutrient solution in complete absence of soil. This method is used to determine the nutrients essential for plants.

- In this method, plant is cultured in soil-free, defined mineral solution. These methods require purified water and mineral nutrients.
- Essential elements are identified and their deficiency symptoms are discovered by hydroponics methods. It is also used for commercial production of vegetables, like tomato and cucumber.

➢ **Essential mineral nutrients :** About 65 elements are found in different plants. Following criteria is used to determine the essentiality of an element :
- Element must be absolutely necessary for the normal growth and reproduction to complete their life cycle.
- The requirement of element must be specific and not replaceable by another element.
- Element must be directly involved in the metabolism of plants.

➢ **Types of nutrients :**
- Macronutrients are present in plant tissues in larger quantity. C, H and O is obtained from water and rest are absorbed from soil.
- Micronutrients or trace nutrients are required in very small quantity.

➢ **Essential elements are categorised into 4 categories :**
- As elements or components of biomolecules and hence structural elements of cells *e.g.*, carbon, hydrogen, oxygen and nitrogen.
- As components of energy-related compounds in plants *e.g.*, Magnesium in chlorophyll and phosphorus in ATP.
- As activator or inhibitor of enzymes, *e.g.*, Zn^{2+} is an activation of alcohol dehydrogenase, Mg^{2+} is an activator or inhibit enzymes, etc.
- As elements that can alter the osmotic potential of a cell, *e.g.*, potassium plays an important role in the opening and closing of stomata.

➢ **Role of Macro and Micro nutrients :**
- Essential elements participate in various metabolic processes in plants such as permeability of cell membrane, maintenance of osmotic potential, electron transport systems, etc.
- Act as major constituents of macromolecules and co-enzymes.

➢ **Various forms and function of essential nutrients :**
- **Nitrogen :** Required by plants in greatest amount, it is absorbed by plants as NO_2^-, NO_3^- and NH_4^+ . It is one of the major constituent of proteins, nucleic acids and vitamins.
- **Phosphorus :** Absorbed by plants from soil in the form of phosphate ions. It is the constituent of cell membrane, all nucleic acids and nucleotides.
- **Potassium :** Absorbed as potassium ions (K^+). Help to maintain cation-anion balance in cells. It is involved in protein synthesis, opening and closing of stomata.
- **Calcium :** Absorbed by plants from soil in the form of calcium ions (Ca^{2+}). Used in synthesis of cell wall. It activates certain enzymes.
- **Magnesium :** Absorbed by plants in the form of Mg^{2+} ions. It activates the enzymes for respiration, photosynthesis, and involved in DNA and RNA. Constituent of chlorophyll.
- **Sulphur :** Plants obtain sulphur in the form of sulphate (SO_4^{2-}). Present in amino acids (cysteine, methionine) and is main constituent of coenzymes and vitamins.
- **Iron :** Obtained in the form of ferric iron (Fe^{3+}). It is important constituents of protein involved in transfer of electrons like ferredoxin and cytochromes.
- **Manganese :** Absorbed in the form of Mn^{2+} ions. Main function is splitting of water to liberate hydrogen and oxygen during photosynthesis.
- **Zinc :** Obtained as Zn^{2+} ions. Activate enzymes like carboxylases. Needed in formation of auxin.
- **Copper :** Absorbed as cupric ions (Cu^{2+}). Involved in various metabolic activities and redox reactions.
- **Boron :** Absorbed as BO_3^{3-} or $B_4O_7^{2-}$ ions. Required for uptake of calcium, cell elongation and pollen germination.
- **Chlorine :** It is absorbed in the form of Cl^- ions. Determine the solute concentration and splitting of water during photosynthesis.

TOPIC-2
Deficiency Symptoms; Mineral Toxicity;Nitrogen Metabolism, Nitrogen Cycle, Biological Nitrogen Fixation

Revision Notes

- **Deficiency Symptoms of Essential elements :**
  - When supply of essential elements becomes limited, plant growth is retarded. The concentration of essential elements below which plant growth is retarded is called **critical concentration**.
  - In absence of any particular element, plant shows certain morphological changes. These morphological changes are called deficiency symptoms.
  - The parts of plant that show deficiency symptoms depend upon mobility of elements in the plants. Elements that are actively mobilized (N,Mg,K) shows deficiency in older regions. On the other hand, symptoms appear first in young region if the elements are relatively immobile (Ca) and not transported out of mature tissues.
  - Deficiency of any element may cause many symptoms or same symptoms may be caused by different elements. To identify the deficient elements various symptoms are compared with standard chart.
- **Toxicity of micronutrients :** In higher doses, micronutrients become toxic. Any tissue concentration which reduces dry weight of tissue by 10% is called toxic concentration.
  - Critical toxic concentration is different for different elements.
  - Mechanism of absorption of elements takes place in two phases. In first phase, rapid intake of ions occur in free space or outer space of the cells, apoplast. In second phase, ions are taken slowly into inner space, the symplast of the cells.
  - Passive movement of ions in apoplast occurs through ion channels and trans-membrane protein. On the other hand, movement of ions into symplast occurs by expenditure of energy by active process.
  - The movement of ion is called **flux**. The inward movement is called influx and outward movement is called efflux.
  - Translocation of solutes occur through xylem along with ascending stream of water.
- **Soil as reservoir of essential elements :** Most of the nutrients required for growth and development is obtained from soil by roots. These minerals are formed by weathering of rocks. Soil also harbor nitrogen fixing bacteria and other microbes, holds water and supplies air to roots. Deficiency of essential elements affect the crop yield so, fertilizers are used to supplement these elements.
- **Metabolism of Nitrogen**
  - Nitrogen is the most prevalent elements in living world along with C, H and O. It is the main constituent of proteins, nucleic acids, fats, hormones, enzymes etc.
  - The process of conversion of nitrogen to ammonia is called nitrogen fixation. In nature, lightning and ultraviolet radiation provide energy to convert atmospheric nitrogen into nitrogen oxide (NO, NO_2 and N_2O).
  - Industrial combustion, forest fire and automobiles along with thermal power plants produce nitrogen oxides.
  - Nitrogen is a limiting nutrient for both natural and artificial eco-systems.
  - The decomposition of organic nitrogen of dead plants and animals into ammonia is called **ammonification**.
  - Ammonia is first oxidized to nitrite by bacteria *Nitrosomonas* or *Nitrococcus*, which is further oxidized to nitrate with help of bacteria *Nitrobacter*. These process are called nitrification.

$$2NH_3 + 3O_2 \longrightarrow 2NO_2^- + 2H_2^- + 2H^+ + 2H_2O$$

$$2NO_2^- + O_2 \longrightarrow 2NO^-_3$$

  - Nitrates formed is absorbed by plants and transported to leaves. Nitrates is converted into free nitrogen by the process called **denitrification** by bacteria *Pseudomonas* and *Thiobacillus*.
  - Reduction of nitrogen to ammonia by living organism is called biological nitrogen fixation. The enzyme nitrogenase, present in prokaryotic organism are called nitrogen fixers.

$$N \equiv N \xrightarrow{\text{Nitrogenase}} NH_3$$

  - Nitrogen fixing microbes may be symbiotic (*Rhizobium*) or free living (*Azotobacter* and *Beijernickia* – aerobes, *Rhodospirillum*-anaerobic). A number of cyanobacteria such as *Anabaena* and *Nostoc* are also free-living N_2-fixers.

- Symbiotic biological nitrogen fixation includes legume-bacteria relationship in which rod shaped *Rhizobium* lives with symbiotic relation with nodules of Leguminous plants.
- Central portion of nodule is pink or red due to presence of leguminous haemoglobin or leghaemoglobin.

➢ **Nodule formation** involves sequence of interaction between root and *Rhizobium* as follows :

- Rhizobia increase in number and attach with epidermis of roots. Root hairs curls and bacteria invade it. An infection thread is formed carrying the bacteria into the cortex of root.
- Nodule formation starts in cortex of root. Bacteria is released from the thread into the cells which leads to formation of specialized nitrogen fixing cells.
- Nodules establish direct vascular connection with host for exchange of nutrients.
- Nodule contain all necessary biochemical components like enzyme nitrogenase and leghaemoglobin.
- Enzyme nitrogenase is a Mo-Fe protein and catalyses the conversion of atmospheric nitrogen into ammonia.

The reaction is as follows :

$$N_2 + 8e^- + 8H^+ + 16ATP \longrightarrow 2NH_3 + H_2 + 16ADP + 16Pi$$

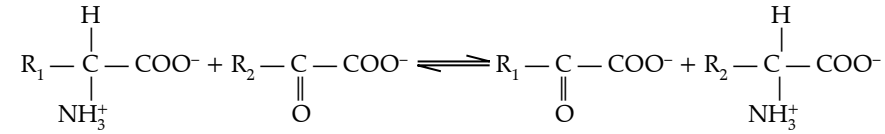
- The enzyme nitrogenase is highly sensitive to molecular oxygen and needs anaerobic condition. To protect this enzyme from oxygen, the nodules contain an oxygen scavenger called leg-haemoglobin.
- The ammonia synthesized by nitrogenase enzyme require large amount of energy (8ATP for each NH_3 produced).

➢ **Fate of ammonia :** In physiological pH, ammonia is protonated into ammonium ions (NH_4^+).It is toxic for plants in larger concentration. Ammonium ion is converted into amino acids by two methods.

- **Reductive animation :** In this process, ammonia reacts with α-ketoglutaric acid to form glutamic acid.

$$\alpha\text{-ketoglutaric acid} + NH_4^+ + NADPH \xrightarrow[\text{Dehydrogenase}]{\text{Glutamate}} \text{Glutamate} + H_2O + NADP$$

- **Transamination :** It involves the transfer of amino group from amino acids to the keto group of keto acid. Glutamic acid is the main amino acid from which transfer of NH_3 takes place and another amino acid is formed by transamination.



Amino-donor Amino-acceptor

- Two important amides, asparagine and glutamine found in plants are proteins. They are formed from aspartic acid and glutamic acid by addition of another amino groups to it.

Know the Terms

➢ **Hydroponic :** Hydroponic is growing of plants in a defined nutrient solution, in the absence of soil.

➢ **Macronutrients :** Nutrients that is generally present in the plant's tissues in large amount.

➢ **Micronutrients :** Nutrients that are needed in very small amounts (less than 10 mmole Kg^{-1} of dry matter).

➢ **Chlorosis :** Chlorosis or loss of chlorophyll leads to yellowing of leaves.

➢ **Nitrogen cycle :** It is a cyclic process that involves conversion of elemental nitrogen of atmosphere into simple molecules that enter living beings forming complex molecules.

➢ **Nitrogen fixation :** It is the process of converting atmospheric nitrogen into usable forms like nitrates.

➢ **Ammonification :** It is the process of conversion of complex organic compounds like proteins into ammonia, in the presence of ammonifying bacteria or putrefying bacteria.

➢ **Nitrification :** It is the process of conversion of ammonia into nitrites and nitrates.

➢ **Denitrification :** It is the process of conversion of nitrate salts present in the soil and water to gaseous nitrogen which escapes into atmosphere.

➢ **Biological nitrogen fixation :** The process of reduction of nitrogen to ammonia by living organisms is called biological nitrogen fixation.

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CHAPTER-13
PHOTOSYNTHESIS IN HIGHER PLANTS

TOPIC-1
Photosynthesis as a Mean of Autotrophic Nutrition, Site of Photosynthesis, Pigments Involved in Photosynthesis (Elementary Idea)

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.

  $6CO_2 + 12H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6H_2O + 6O_2$
- 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.

Early Experiments

- **Joseph Priestley** in 1770, on the basis of his experiments showed the essential role of air in growth of green plants. A mouse kept in closed space could get suffocated and die but if a mint plant is kept in bell jar neither candle will extinguish nor will the mouse die. He concluded that foul air produced by animal is converted into pure air by plants. Priestley discovered oxygen gas in 1774.
- **Jan Ingenhousz** (1730–1799) showed that light is essential for the process by which green plants absorb carbon dioxide and release oxygen.
- **Julius van Sachs** in 1854 showed that green part in plants produces glucose which is stored as starch. Starch is the first visible product of photosynthesis.
- **T. W. Engelmann** (1843-1909) splitted light into components by prism and then illuminated *Cladophora* (an algae) placed in a suspension of aerobic bacteria. He found that bacteria illuminated in blue and red light of the split spectrum. He thus discovered the effect of different wavelength of light on photosynthesis (action spectrum).
- **Cornelius Van Neil** (1897-1985) on the basis of studies with purple and green sulphur bacteria showed that photosynthesis is a light dependent reaction in which hydrogen from an oxidisable compound reduces CO_2 to form sugar.

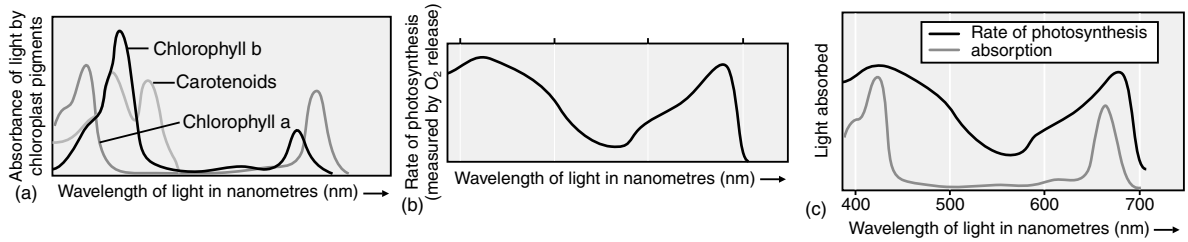
  $2H_2A + CO_2 \xrightarrow{\text{Light}} 2A + CH_2O + H_2O$

  In green sulphur bacteria, when H_2S, instead of H_2O was used as hydrogen donor, no O_2 was evolved. He inferred that O_2 evolved by green plants comes from H_2O but not from CO_2 as thought earlier.

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 synthesizing light energy for the 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

Photochemical and Biosynthetic Phases of Photosynthesis; Cyclic and Non-cyclic Photophosphorylation; Chemiosmotic Hypothesis; Photorespiration; C_3 and C_4 Pathways; 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 organized 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 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 (AAO) 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), characterized 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.

Know the Terms

- **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 utilization of ATP with release of CO_2.

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CHAPTER-14
RESPIRATION IN PLANTS

TOPIC-1

Exchange of Gases; Cellular Respiration-Glycolysis, Fermentation (Anaerobic), 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 oxidized is called respiratory substrates.
- Energy released during oxidation is not used directly but utilized 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 utilized 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.
- 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 $2FADH_2$.

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

➢ **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

Electron Transport System (Aerobic), Number of ATP Molecules Generated; 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 oxidized 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 synthesized 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

Know the Terms

- **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-15
PLANT GROWTH AND DEVELOPMENT

TOPIC-1
Seed Germination; Phases of Plant Growth Rate; Conditions of Growth; Differentiation, Sequence of Developmental Processes in a Plant Cell

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 flower and fruits are formed for continuations 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.

Growth is measurable

- At cellular level, growth is the increase in amount of protoplasm. It is difficult to measure the increase in amount of protoplasm but increase in cell, cell number and cell size can be measured.
- The parameter used to measure growth are : increase in fresh weight, dry weight, length, area, volume and cell number. All parameters are not used for every kinds of 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 are 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.
- **Arithmetic Growth :** The rate of growth is constant and increase in growth occurs in arithmetic progression- 2,4,6,8 ……. It is found in root and shoot elongation.
- In arithmetic growth, following mitotic cell division, only one daughter cell continues to divide while the other differentiates and matures.

  Mathematically, arithmetic growth is expressed as $L_t = L_o + rt$

  Where
  L_t = Length at time 't'
  L_o = length at time 'zero'
  r = growth rate/elongation per unit time.
- **Geometric Growth -** Here initial growth is slow and it increases rapidly thereafter every cell divides at an exponential rate. Here both the progeny cells following mitotic cell division retain the ability to divide and continue to do so.
- Geometrical growth is common in unicellular organisms when grown in nutrient rich medium.

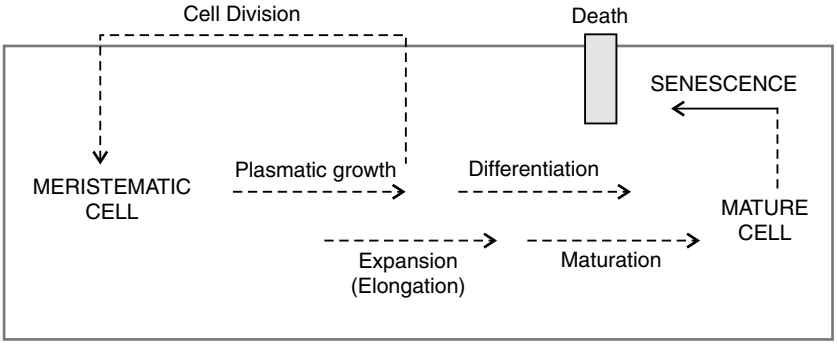
- **Sigmoid growth curve** consists of fast dividing exponential phase and stationary phase. It is typical of most living organisms in their natural environment.
- **Exponential growth can be represented as follows :**
  $W_1 = W_0 e^{rt}$, where W_1 = final size, W_0 = initial size, r = growth rate, t = time of growth and e is the base of natural logarithms (2.71828).
- The relative growth rate r, is also the measure of the ability of the plant to produce new plant materials, referred to as efficiency index.
- 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 specialized 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.



Sequence of development process in plant cell

- 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.

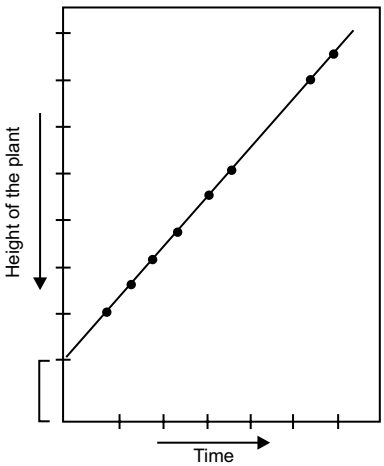


Fig: Constant linear growth, a plot of length (l) against time (t).

TOPIC-2

Growth Regulators—Auxin, Gibberellin, Cytokinin, Vernalisation; Photoperiodism

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, 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.
- 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 biotic 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 crystallized 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 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

  Functions
  - Cell enlargement
  - Apical dominance
  - Cell division and controls xylem differentiation.
  - Inhibition of abscission
  - Induce Parthenocarpy

  Gibberellins- These are promotary 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 synthesized 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

  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

Photoperiodism :

- The effect of photoperiods or day duration of light hours on the growth and development of plant, especially flowering is called photoperiodism. On the basis of photoperiodic response, flowering plants have been divided into the following categories :
  - **Short Day Plants :** They flower when photoperiod is below a critical period. Example- *Xanthium*, Rice, Sugarcane, Potato etc.
  - **Long Day Plants :** These plants flower when they receive long photoperiod of light, greater than critical period. Example- Radish, Barley, Lettuce.
  - **Day Neutral Plants :** The plant can blossom throughout the year. Example- Bean, Wild Kidney.

- Critical photoperiod is that continuous duration of light which must not be exceeded in short day plants and should always be exceeded in long day plants in order to bring them flower.

Vernalisation :

- It is the process of shortening of the juvenile or vegetative phase and hastening flowering by a previous cold treatment. The stimulus of vernalisation is perceived by meristematic cells.
- Vernalisation helps in shortening of vegetative period of plant and brings about early flowering.
- It is applicable to temperate plants like Wheat, Rice, Millets etc.

Seed dormancy :

- It is the state in which seeds are prevented from germinating even under favourable conditions.
- **Reasons for seed-dormancy :**
  - Impermeable and hard seed coat.
  - Presence of chemical inhibitors.
  - Immature embryos.
- **Methods to overcome seed dormancy :**
  - Weakening of seed coats by mechanical abrasions using knives, sand paper etc.
  - Weakening of seed coats by microbial action.
  - By subjecting to chilling conditions.
  - By application of chemicals like gibberellic acid and nitrates.
  - By changing the environmental conditions.

Know the Terms

- **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.
- **Photoperiodism :** It is the response of plants with respect to the duration of light (i.e., period of day and light).
- **Long day plant :** Plants that flower when they are exposed to light for a period more than the critical day length.
- **Short day plant :** Plants that flower when they are exposed to light for a period less than the critical day length.
- **Day neutral plant :** Plants in which there is no such correlation between exposure to light duration and induction of flowering response.
- **Vernalisation :** Vernalisation refers to the promotion of flowering by exposure to low temperature.

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UNIT-V
Human Physiology

CHAPTER-16
DIGESTION AND ABSORPTION

TOPIC-1
Alimentary Canal and Digestive Glands, Role of Digestive Enzymes and Gastrointestinal Hormones; Peristalsis

Revision Notes

- The process of conversion of complex food into simpler absorbable form is called digestion and is carried out by digestive system by mechanical and biochemical methods.
- **Digestive System :** Human digestive system consists of alimentary canal and associated glands.
- Alimentary canal begin with anterior opening—mouth and opens out posteriorly through anus.
- It comprises of following parts—

- **Mouth :** Leads to oral cavity or buccal cavity which contains teeth and tongue. Each teeth is embedded in socket of jaw bone (thecodont). Milk teeth is replaced by permanent or adult teeth, this type of dentition is called diphyodont. Four different types of teeth are incisors (I), canine (C), premolar (PM) and molar (M). Upper surface of tongue has small projections called papillae, some of which contain taste buds.
- **Pharynx :** Oral cavity opens into pharynx which acts as common passage for food and air. Cartilaginous flaps called epiglottis prevents the entry of food into wind pipe (glottis) during swallowing.
- **Stomach :** Oesophagus leads to stomach. The opening of stomach is guarded by a sphincter (gastro esophageal). Stomach is divided into three parts – cardiac, fundic and pyloric.
- **Small intestine :** Is the longest part of alimentary canal divided into duodenum, jejunum and ileum. Pyloric sphincter is present between stomach and duodenum.
- **Large intestine :** Ileum opens into large intestine, which is divided into caecum, colon and rectum. Caecum is a blind sac which host microbes. Vermiform appendix arises from caecum. Rectum opens through anus to exterior.

➢ **Histology of Alimentary canal :**

The wall of alimentary canal from oesophagus to rectum consists of four layers.

- **Serosa :** It is the outermost layer made up of squamous epithelium and areolar connective tissue.
- **Muscularis :** It is composed of outer longitudinal and inner circular muscle fibres. Muscles fibres are smooth and network of nerve cells.
- **Submucosa :** It consists of loose connective tissue richly supplied with blood and lymphatic vessels. Meissner's plexus is present between the muscular coat and mucosa that controls the secretion of intestinal juice.
- **Mucosa :** It is the innermost layer lining the lumen of the alimentary canal that secretes mucus from goblet cells. It has irregular folding in stomach called rugae and villi in small intestine. Mucosa also forms glands in the stomach (gastric glands) and crypts in between the bases of villi in the intestine–crypts of Lieberkuhn.

➢ **Salivary Glands :** Secrete salivary juice into oral cavity. In human beings salivary glands are three pairs – parotid, sublingual, and sub-mandibular.

➢ **Liver :** It is the largest gland in human body situated in the upper right side of the abdominal cavity just below the diaphragm. Hepatic lobules, covered by Glisson's capsule, are structural and functional unit of liver made up of hepatic cells. The secretion is stored and concentrated in gall bladder. Bile duct and pancreatic duct open together in duodenum by common duct guarded by sphincter of Oddi.

➢ **Pancreas :** It is soft lobulated greyish pink gland which weighs about 60 g. It consists of exocrine and endocrine portion. The exocrine portion secretes alkaline pancreatic juice and the endocrine portion secretes hormones, insulin and glucagon.

TOPIC-2

Digestion, Absorption and Assimilation of Proteins, Carbohydrates and Fats; Calorific Values of Proteins, Carbohydrates and Fats; Egestion; Nutritional and Digestive Disorders-PEM, Indigestion, Constipation, Vomiting, Jaundice, Diarrhoea

Revision Notes

Digestion of food

➢ Carbohydrates, fats, proteins and nucleic acids occur in food in the form of large and complex insoluble macromolecules (polymers). These macromolecules are converted into small monomers by the action of enzyme.

➢ In buccal cavity, teeth and tongue help in mastication and mixing of food. Mucus in saliva is mixed with masticated food to form bolus. Bolus is passed to pharynx and then into oesophagus by swallowing or deglutition.

➢ Chemical digestion of food starts in oral cavity by the action of enzyme salivary amylase and lysozyme. Lysozyme acts as antibacterial agent in mouth to prevent infection. About 30 percent of the starch is hydrolysed by the salivary amylase into a disaccharide-maltose.

➢ Mucosa of stomach have gastric glands that have three types of cells- mucus neck cells that secrete mucus, peptic or chief cells that secretes proenzyme pepsinogen and parietal or oxyntic cells that secretes HCl and castle's intrinsic factor essential for absorption of vitamin B_{12}. Food mix with gastric juice due to churning action of muscular wall to form chyme. HCl activates the pepsinogen to pepsin to digest protein.

- Mucus and bicarbonates present in gastric juice play important role in lubrication and protecting inner wall of stomach from the action of HCl. Rennin is a proteolytic enzyme found in gastric juice of infants to digest milk protein.
- The bile, pancreatic juice and intestinal juice are released in small intestine. Pancreatic juice contains inactive trypsinogen, chymotrypsinogen, procarboxypeptidases, amylases, lipases and nucleases.
- Trypsinogen is activated by enzyme enterokinase into trypsin, which further activates the other enzyme of intestinal juice.

$$\left.\begin{matrix}\text{Proteins}\\ \text{Peptones}\\ \text{Proteoses}\end{matrix}\right\} \xrightarrow[\text{Carboxypeptidase}]{\text{Trypsin/Chymotrypsin}} \text{Dipeptides}$$

$$\text{Polysaccharides (starch)} \xrightarrow{\text{Amylase}} \text{Disaccharides}$$

$$\text{Fats} \xrightarrow{\text{Lipases}} \text{Diglycerides} \longrightarrow \text{Monoglycerides}$$

$$\text{Nucleic acids} \xrightarrow{\text{Nucleases}} \text{Nucleotides} \longrightarrow \text{Nucleosides}$$

- Bile contains bile pigments (bilirubin and biliverdin), bile salts, cholesterol and phospholipids which help in emulsification of fats.
- The intestinal mucosal epithelium has goblet cells which secrete mucus. The Secretions of the brush border cells of mucosa along with secretions of the goblet cells constitute the intestinal juice or succus entericus, which contains variety of enzymes to complete the process of digestion.

$$\text{Dipeptides} \xrightarrow{\text{Dipeptidases}} \text{Amino acids}$$

$$\text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose} + \text{Glucose}$$

$$\text{Lactose} \xrightarrow{\text{Lactase}} \text{Glucose} + \text{Galactose}$$

$$\text{Sucrose} \xrightarrow{\text{Sucrase}} \text{Glucose} + \text{Fructose}$$

$$\text{Nucleotides} \xrightarrow{\text{Nucleotidases}} \text{Nucleosides} \xrightarrow{\text{Nucleosidases}} \text{Sugars} + \text{Bases}$$

$$\text{Di and Monoglycerides} \xrightarrow{\text{Lipases}} \text{Fatty acids} + \text{Glycerol}$$

  - The simple substances thus formed are absorbed in the jejunum and the ileum regions of the small intestine.
- **Function of large intestine :**
  - Absorption of water, minerals and certain drugs.
  - Secretion of mucus for adhering the undigested food and lubricating it for easy passage.
- The undigested, unabsorbed substances called faeces enters into the caecum of the large through the ileo-caecal valve, which prevents the back flow of the faecal matter. It is temporarily stored in the rectum till defaecation.
  - The activities of the gastro-intestinal tract are under neural and hormonal control for proper co-ordination of different parts.

Absorption of Digested Food

- Absorption is the process by which nutrients pass from the alimentary canal into the blood and lymph through its mucous membrane.
- Amino acids, monosaccharide, fatty acids, glycerol, salts, vitamins and water are to be absorbed. About 90% of absorption occurs in small intestine and rest 10% in stomach, mouth and large intestine.
- The passage of different absorbent depends upon concentration gradient and some substances like glucose and amino acids and electrolytes.
  - Small amounts of glucose, amino acids and some electrolytes likes chloride ions are generally absorbed by simple diffusion.
  - Some substances like glucose and amino acids are absorbed with the help of carrier proteins : The mechanism called facilitaled transport.
  - Nutrients like amino acids, glucose, electrolytes like Na^+ are also absorbed by active transport.

Fatty acids and glycerol being insoluble cannot be absorbed into the blood. They are first incorporated into small droplets called micelles which move into the intestinal muscosa. Here they are re-formed into chylomicrons which are then transported into the lacteals in the villi.

Absorption in different part of alimentary canal :

- **Mouth :** Certain drugs coming in contact with the mucosa of mouth and lower side of tongue are absorbed into the blood capillaries lining them.
- **Stomach :** Absorption of water, simple sugar and alcohol takes place.
- **Small intestine :** Glucose, fructose, fatty acids, glycerol and amino acids are absorbed through the mucosa into the blood stream and lymph.
- **Large intestine :** Absorption of water, some minerals and drug takes place.

Disorder of Digestive System

- **Jaundice :** It is a disease of liver. In jaundice, the skin and the eyes turn yellow due to large quantities of bilirubin pigments in the extra-cellular fluid.
- **Vomiting :** It is the ejection of stomach content through the mouth. This reflex action is controlled by the vomit centre in the medulla.
- **Diarrhoea :** Frequent defecation of liquid faeces is known as Diarrhoea. It reduces the absorption of food.
- **Constipation :** In constipation, the faeces are retained within the rectum as the bowel movements occur irregularly.
- **Indigestion :** Incomplete digestion usually accompanied by one or more of the following symptoms- pain, nausea, vomiting, heartburn, acid regurgitation, accumulation of gas and release of gas from the stomach.
- **Protein-energy malnutrition (PEM) :** PEM affects infants and children to produce marasmus and kwashiorkar.
- **Marasmus :** Produced by simultaneous deficiency of proteins and calories.
- **Kwashiorkar :** Produced by protein deficiency only.

Know the Terms

- **Digestion :** The process of conversion of complex food into simple absorbable form.
- **Thecodont :** Thecodont are the teeth embedded in the sockets of the jaw bone.
- **Dental formula :** The arrangement of teeth in each half of the upper jaw and the lower jaw
- **Diphyodont :** The teeth formed twice in life time are called diphyodont.
- **Digestion :** It is the process in alimentary canal by which the complex food is converted mechanically and biochemically into simple substances suitable for absorption and assimilation.
- **Peristalsis :** Wave of contraction of the circular muscle fibres passing along the stomach and oesophagus wall just behind a wave of relaxation.
- **Absorption :** It is the transfer of end products of digestion from the intestine to the circulatory fluids (blood and lymph).
- **Assimilation :** It is anabolic process in which the absorbed food is taken in by body cells and used for energy, growth and repair.
- **Egestion :** It is the process of elimination of faeces (waste matter) from the alimentary canal.

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CHAPTER-17

BREATHING AND EXCHANGE OF GASES

TOPIC-1

Respiratory Organs in Animals; Respiratory System in Humans; Mechanism of Breathing and Its Regulation in Humans

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 organism according to their body structure and habitat.

Respiratory Organs	Organisms
Entire body surface	Sponges, Coelenterate, flatworms
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, vascularized 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.
- Utilization 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.

TOPIC-2

Exchange of Gases, Transport of Gases and Regulation of Respiration, Respiratory Volume; Disorders Related to Respiration-Asthma, Emphysema, Occupational 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.

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

Regulation of Respiration :

- Human beings have ability to maintain and moderate the rate of respiration to fulfill 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.
- Chemo-sensitive 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, Asbestoses due to exposer 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.

Know the Terms

- **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.

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CHAPTER-18
BODY FLUIDS AND CIRCULATION

TOPIC-1
Composition of Blood, Blood Groups, Coagulation of Blood; Composition of Lymph and Its Function; Human Circulatory System-Structure of Human Heart and Blood Vessels

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 5-5.5 million per mm^3 of blood which is slightly less in females due to menstruation. It is formed in the red bone marrow.
- Nucleus is absent in mammalian RBCs which are biconcave in shape.
- Every 100 ml of blood contain 12-16 gm of haemoglobin. They have life span of 120 days.
- RBCs are destroyed in spleen (graveyard of RBCs).
- 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 specialized 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)

Circulatory Pathways

- All vertebrates have a muscular chambered heart.
  - Fish – 2 chambered heart.
  - Amphibian and Reptiles (except crocodile) – 3 chambered heart.
  - Crocodile, Birds and Mammals – 4 chambered heart.
- **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. Interatrial 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})

TOPIC-2

Cardiac Cycle, Cardiac Output, ECG; Double Circulation; Regulation of Cardiac Activity : Disorders of Circulatory System : Hypertension, Coronary Artery Disease, Angina Pectoris, Heart Failure.

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 tricuspid and bicuspid 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.
- 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 (depolarization) which leads to contraction of atria.
- The PRS-wave represents the depolarization of ventricles, which initiates the ventricular contraction.
- The T-wave represents the return of ventricle from excited to normal state (repolarization).
- 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 to 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 checks the 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 medullar 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. It leads to heart disease and affect vital organs like brain and kidney.

(b) **Coronary Artery Disease (CAD) :** Commonly called 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).

(e) **Coronary Thrombosis :** Formation of clot in the coronary artery is coronary thrombosis. It occurs most frequently in the left anterior descending coronary artery.

Know the Terms

- **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.

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CHAPTER-19
EXCRETORY PRODUCTS AND THEIR ELIMINATION

TOPIC-1
Modes of Excretion – Ammonotelism, Ureotelism, Uricotelism; Human Excretory System – Structure and Function; 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 intersitial 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.

TOPIC-2
Osmoregulation; Regulation of Kidney Function - Renin – Angiotensin, Atrial Natriuretic Factor, ADH and Diabetes Insipidus; Role of Other Organs in Excretion Disorder - Uraemia, Renal Failure, Renal Calculi, Nephritis; 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.

- **Micturition :** The process of expulsion of urine from the urinary bladder is called micturition.
- The neural mechanism that causes it is called micturition reflex. Urine formed in nephron is stored in urinary bladder till a voluntary signal is received by CNS. The stretch receptors present in the wall of urinary bladder send signals to the CNS, which initiates contraction of smooth muscles of bladder to relax the urethral sphincter to release urine.
- 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.
  - **Renal calculi :** Formation of stone or insoluble mass of crystalized 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.

Know the Terms

- **Ammonotelism :** The process of excreting 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.
- **Micturition :** It is the process by which the urine from the urinary bladder is excreted.
- **Glomerulonephritis :** The inflammation of glomeruli of kidney is known as glomerulonephritis.

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CHAPTER-20
LOCOMOTION AND MOVEMENT

TOPIC-1

Types of Movement-Ciliary, Flagellar, Muscular; Skeletal Muscle-Contractile Proteins and Muscle Contraction; Skeletal System and its Functions

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 specialized 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.
- **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.
    - 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: Myasthenia Gravis, Tetany, Muscular Dystrophy, Arthritis, Osteoporosis, Gout

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.

Know the Terms

- **Neuromuscular junction :** It is a junction between a neuron and the sarcolemma of the muscle fibre.
- **Isotonic contractions :** In this type of contraction, the tension remains the same but the change occurs in the length of the muscle fibres.
- **Isometric contraction :** In this type of contraction, the length of the muscle fibres remains the same but the tension continues to increase.
- **Muscle twitch** : A single response of a muscle fibre to a single stimulus is called muscle twitch.
- **Tetany :** The period of sustained contraction without any rest or relaxation is called tetany.
- **Motor unit :** All the muscle fibre supplied by a single motor nerve fibre, is collectively called a motor unit.
- **Rigor mortis :** The rigidity of muscles that occurs after death is caller rigor mortis.
- **Muscle Fatigue :** The reduction in the force of contraction of a muscle after prolonged stimulation is called muscle fatigue.
- **Sprain :** It is caused due to unusual twisting or forcible tearing of joints. In this case, haemorrhage from ruptured blood vessels causes swelling and pain.
- **Dislocation :** It is the displacement of a bone from a joint with dislodging of ligaments, articular capsules, tendons etc.
- **Rheumatoid arthritis :** It is an inflammation of the synovial membrane in synovial joints.
- **Gout :** Gout is an inflammation of joints due to accumulation of uric acid crystals.

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CHAPTER-21
NEURAL CONTROL AND CO-ORDINATION

TOPIC-1
Neuron and Nerves; Nervous System in Humans-Central Nervous System; Peripheral Nervous System and Visceral Nervous System; Generation and Conduction of Nerve Impulse

Revision Notes

- **Coordination** is the process through which two of more organs interact and complement the function of each other.
- **Neural system** provides an organized network of point to point connection for quick coordination. The endocrine system provides chemical integration through hormones.
- **Neural system** of animals is composed of specialized 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 para sympathetic 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.
- The nerve impulse from A moves to B on inner surface and B to A on outer surface. This process is repeated several times to transmit the impulse.
- Nerve impulse is transmitted from one neuron to another neuron through synapse. There are two types of synapses :
  - **Electrical synapse :** Here, the membrane of pre-and-post synaptic neuron is very close to each other and current flow directly from one neuron to another.
  - **Chemical synapse :** Pre- and post- synaptic neuron is separated by fluid filled space called synaptic cleft. Neurotransmitters are involved in transmission of impulses.

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.

TOPIC-2
Reflex Action; Sensory Perception; Sense Organs; Elementary Structure and Functions of Eye and Ear.

Revision Notes

- **Reflex action** is a spontaneous autonomic mechanical response to a stimulus without the will of the organism. It is controlled by spinal cord. The afferent neuron receives the signal from sensory organs and transmits the impulse to CNS. The efferent neuron carries the impulse from CNS to effector. Example knee-jerk reflex. The path followed by reflex action is called reflex arc.
- **Human Eye :** Spherical structure consists of three layers, external layer is sclera whose anterior portion is called **cornea**, middle layer **choroid** and innermost layer is called **retina.**
  The light rays of visible wavelength fall on retina through cornea and lens to generate impulses in rods and cones. The photoreceptor cells viz. rods and cones contain the light-sensitive proteins called the photopigments. The rods contain rhodopsin and is responsible for twilight vision while the cones are responsible for daylight vision and colour vision.
- **Human Ear :** It is divided into three regions–outer ear, middle ear and inner ear. External ear receives the sound wave and directs them to ear drum. Vibration of ear drum leads to vibrate ear bones - malleus, incus and stapes. The vibration reaches to cochlea that generate wave in lymph. This waves generate ripples in basilar membrane. Nerve impulses are generated in afferent neuron that passes to brain via auditory nerves.
- The inner ear also contains a complex system located above the cochlea called vestibular apparatus. It helps in maintaining as in maintaining balance of the body and posture.

Know the Terms

- **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.
- **Reflex action :** It is the rapid, involuntary and unconscious actions of the body brought about by any part of the CNS through sudden stimulation from receptors.
- **Receptors :** Receptors are sensory structures (organs/tissues or cells) present all over the body.

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CHAPTER-22
CHEMICAL CO-ORDINATION AND INTEGRATION

TOPIC-1
Endocrine Glands and Hormones; Human Endocrine System-Hypothalamus, Pituitary, Pineal, Thyroid, Parathyroid, Adrenal, Pancreas, Gonads

Revision Note

- 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), luteinizing 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.
- **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.
- **Thymus—**It is located on the dorsal side of heart and the aorta. This gland release peptide hormone thymosins that help in differentiation of T-Lymphocytes. It also promotes production of antibodies to provide humoral immunity.
- **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.
- **Glycogen** 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 hemeostasis. 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 synthesized 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.
- Atrial wall of heart secretes peptide hormone called **atrial natriuretic factor (ANF)** that cause dilation of blood vessels. The juxtaglomerular cells of kidney produce **erythropoietin hormone** which stimulate erythropoiesis.

TOPIC-2

Mechanism of Hormone Action (Elementary Idea); Role of Hormones as Messengers and Regulators, Hypo- and Hyperactivity and Related Disorders; Dwarfism, Acromegaly, Cretinism, Goitre, Exophthalmic Goitre, Diabetes, Addison's Disease

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 with hormone receptor complex with the genome. The biochemical effect results 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. **Gigantism** 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.

Know the Terms

- **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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