Chapter 2- Biological Classification

- R. H Whittaker proposed 5 kingdom classification. These kingdoms were Monera, Protista, Fungi, Plantae and Animalia
- Spherical bacteria- Coccus, rod shaped -Bacillus, coma shaped -Vibrium, and spiral shaped -Spirillum
- Archaebacteria seen in salty areas are Halophiles, in hot springs are Thermoacidophiles and marshy areas are Methanogens
- Heterocysts are specialised cells which can fix atmospheric nitrogen and are seen in Cyanobacteria like Nostoc and Anabaena
- Mycoplasmas are the smallest living cells
- Economic importance of Chrysophytes (Diatoms):- The cell wall diatoms contain silica. They have left behind large amount of cell wall deposits which accumulated over billions of years is called diatomaceous earth. Diatomaceous earth is used in polishing, filtration of oils, and syrups.
- Red tides are caused by Dinoflagellates (eg:- Gonyaulax)
- Trypanosoma which causes sleeping sickness is a flagellated protozoan
- Plasmodium which causes malaria is a sporozoan protozoan
- Economic importance of Fungi:- 1) Fungi like mushroom are eaten 2) Yeast are used to make bread and beer 3) Some fungi are the source of antibiotics 4) Some fungi cause disease in plants and animals
- Multinucleated cytoplasm is called Coenocytic
- The symbiotic association between fungi and roots of higher plants is called mycorrhiza
- The Kingdom Fungi consists of 4 classes

1. Phycomycetes (eg:- Rhizopus, Mucor). Mostly aquatic habitat, aseptate and coenocytic mycelium
2. Ascomycetes (eg:- Yeast, Penicillium, Neurospora) sac fungi. Mycelium is branched and septate. Their sexual spores are called ascospores and asexual spores are called conidia. Neurospora is used in genetic work
3. Basidiomycetes (eg:- Agaricus) . The mycelium is branched and septate. Sexual spores are called basidiospores, *Puccinia* cause rust disease in wheat
4. Deuteromycetes:- Fungi imperfecti (eg:- Alternaria, Colletotrichum). Only asexual phase of these fungi are known. When the sexual phase of these fungi are discovered they will be moved to other classes of fungi.

- The viruses are made of protein and the genetic material which may be either DNA or RNA.
- Viroids:- Infectious RNA particles devoid of protein coat is called Viroids
- Lichens:- Symbiotic association between algae and fungi is called lichens
- Phycobiont:- Algal component of lichen is called phycobiont
- Mycobiont:- The fungal component of lichen is called mycobiont
- Lichens are very good pollution indicators- they do not grow in polluted areas.

Chapter 3- Plant Kingdom

- Artificial system of classification- example Linnaeus system of classification
- Natural system of classification- example Benthem and Hookers system of classification
- Phylogenetic system of classification- example Whittaker's system of classification and Hutchinson's classification

Division	Class			Example
Algae		Pigment present	Reserve food	Chlamydomonas, Volvox, Ulothrix, Spirogyra and Chara
	Chlorophyceae	Chlorophyll *a, b*	Starch	
	Phaeophyceae	Chlorophyll *a, c,* Fucoxanthin	Laminarin, Mannitol	Ectocarpus, Dictyota, Laminaria, Sargassum and Fucus
	Rhodophyceae	Chlorophyll a, d; phycoerythrin	Floridean starch	Polysiphonia, Porphyra, Gracilaria and Gelidium
Bryophytes	Liverworts (hepaticae)			Riccia, Marchantia.
	Mosses (music)			Funaria, Polytrichum and Sphagnum
Pteridophytes	Psilopsida			Psilotum
	Lycopsida			Selaginella, Lycopodium
	Sphenopsida			Equisetum
	Pteropsida			Dryopteris, Pteris, Adiantum).
Gymnosperms				Cycas, Pinus, Cedrus, Sequoia, Ginkgo
Angiosperms				Wolfia, Eucalyptus

- Isogamy is a method of sexual reproduction where both male and female gametes look similar
- Anisogamy is a method of sexual reproduction where male and female gametes look dissimilar
- Oogamy is a method of sexual reproduction where male gametes is small and motile while female gamete is large and non-motile
- Economic importance (uses) of Algae

1. Used as food (eg:- *Porphyra*, *Laminaria* and *Sargassum)*
2. Algin obtained from brown algae and Carrageen obtained from red algae used commercially
3. Agar obtained from *Gelidium* and *Gracilaria* used to grow microbes and in preparations of ice-creams and jellies
4. Algae like *Chlorella* and *Spirulina* are rich in proteins and are used as food supplements even by space travellers
5. Ecological importance- fix CO_2 – increase level of dissolved oxygen in water and are the primary producers in aquatic ecosystem.

- In Bryophytes male sex organ is called Antheridium and female sex organ is called Archegonium
- Gemmae are specialised green, multi-cellular asexual buds present in liverworts like *Marchantia* and they develop in gemmae cups
- Protonema is a creeping, green, branched and filamentous stage in the life cycle of mosses and are formed from a meiospore (haploid spore).
- Sporophylls:- spore bearing leaf like appendages
- Prothallus: A small, inconspicuous, multicellular, free living, photosynthetic, thalloid gametophytic phase in the life cycle of Pteridophytes. They are usually heart-shaped.
- Heterospory:- The production of two different kinds of spores- large (macro-female) spores and small (micro-male) spores - by a plant is called heterospory.

- Pteridophytes like Selginella and Salvinia shows heterospory

  Seed habit in pteridophytes:- In heterosporous pteridophytes female gametophyte is retained in the parent sporophyte for variable length of time. The development of zygote into young embryos take place within the female gametophytes. This event is a precursor to seed habit in plants.

- Coralloid roots in *Cycas* are associated with nitrogen fixing *Cyanobacteria*
- Syngamy:- Fusion of male gamete with egg (female gamete) is called syngamy
- Triple fusion: The fusion of haploid male gamete with diploid secondary nucleus in angiosperms is called triple fusion. This event is unique in angiosperms and results in the formation triploid primary endosperm nucleus (PEN).
- Double fertilization:- In angiosperms during sexual reproduction two fertilization or fusion events takes place- syngamy and triple fusion. Therefore this event is called double fertilization.
- Zygote develop into an embryo
- Primary endosperm nucleus develop into endosperm
- Ovules develop into seeds
- Ovary develop into fruit
- Endosperm in angiosperm is triploid while that in gymnosperms is haploid

  Haplontic life cycle:- Here haploid gametophyte represents major phase in the life cycle with no free living sporophyte. Eg:- Many algae like Volvox, spirogyra

  Diplontic life cycle:- Here diploid sporophyte represents the dominant phase in life cycle, and very short gametophytic phase is represented by gametes. Eg:- Gymnopserms and Angiosperms

  Haplo-diplontic and Diplo-haplontic life cycle: When both the diploid sporophyte and haploid gametophytic phase are multi cellular and free living. Eg:- Bryophytes and Pteridophytes. In bryophytes gametophyte is the dominant phase and in pteridophytes sporophyte is the dominant phase in life cycle.

Chapter 5- Morphology of flowering plants

Prop root:- a kind of aerial supporting root formed from aerial branches (eg:- Banyan tree (*Ficus benghalensis*)

Stilt root:-a kind of aerial supporting root developing from lower nodes of the plant body (eg:- Maize, sugar cane)

Pneumatophores:- respiratory roots eg:- *Rhizophora*

Thorns:- are modified stems which are straight and pointed (eg:- Citrus, Bougainvillea)

Alternate phyllotaxy:- Here a single leaf arises at each node in alternate manner. Eg:- Hibiscus, Sunflower

Opposite phyllotaxy:- In this phyllotaxy a pair of leaves are arranged at each node and lie opposite to each other. Eg:- Calotropis, Gauva

Whorled phyllotaxy:- If more than two leaves arise at a node and form a whorl it is called whorled phyllotaxy. Eg:- *Alstonia*

Racemose inflorescence:- Here the inflorescence axis continues to grow, the flower are borne laterally in an acropetal succession. Eg:- Crotalaria

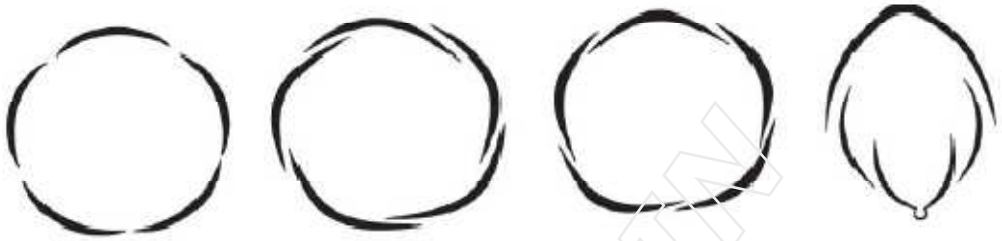
Cymose inflorescence:- In cymose type of inflorescence the main axis terminates in a flower, hence is limited in growth. The flowers are borne in a basipetal order. Eg:- Jasmine

Hypogynous flowers:- Here the gynoecium occupies the highest position while the other parts are situated below it. The ovary in such flower is said to be superior, eg:- mustard.

Perigynous flowers:- If gynoecium is situated in the centre and other parts of the flower are located on the rim of the thalamus almost at the same level it is called perigynous flower. The ovary here is said to be half inferior or half superior, eg:- Rose.

Epigynous flowers:- Here the margin of thalamus grows upward enclosing the ovary completely and getting fused with it, the other parts of flower arise above the ovary. Hence the ovary is said to be inferior, eg:- Cucumber.

Aestivation:- The mode of arrangement of sepals or petals in floral bud with respect to other members of the same whorl is known as AESTIVATION. There are 4 main types of aestivation:-



1 2 3 4

1) **Valvate**:- Here sepals or petals in a whorl just touch one another at the margin, without overlapping, eg:- Calotropis
2) **Twisted**:- If one margin of sepal or petal overlaps that of the next one and so on it is called twisted type of aestivation, eg:- Hibiscus.
3) **Imbricate**:- Here one of the sepal or petal is completely inside and another is completely outside. Other members are partially inside and partially outside, eg:- Cassia
4) **Vexillary**:- This kind of aestivation is seen in the plant family Papilionaceae. Here the largest petal (Standard petals) overlaps the two lateral petals (Wing petals) which in turn overlap the two smallest anterior petals (Keel petals).

Staminodes:- Sterile stamens are called staminodes

Epipetalous stamens:- When stamens are seen attached to petals they are called epipetalous stamens. Eg:- Brinjal

Epiphyllous stamens:- When stamens are seen attached to perianth they are called epiphyllous stamens. Eg:- Lily

- If all the stamens in a flower are united into one bunch or one bundle the condition is called **MONOADELPHOUS**, eg:- Hibiscus. If all the stamens in a flower are united into two bundles the condition is called **DIADELPHOUS**, eg:- Pea. If the stamens are united into more than two bundles the condition is known as **POLYADELPHOUS**, eg:- Citrus.
- If the carpels in a flower are free it is termed APOCARPOUS condition, eg: - Lotus and if the carpels are united they are called SYNCARPUS condition, eg: - Tomato.

- The arrangement of ovules within the ovary is known as placentation. The placentation is of different types

namely, marginal, axile, parietal, basal, central and free central.

- In marginal placentation (a) the placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge forming two rows, as in pea.
- When the placenta is axial and the ovules are attached to it in a multilocular ovary, the placentation is said to be axile (b), as in china rose, tomato and lemon.
- In parietal placentation(c), the ovules develop on the inner wall of the ovary or on peripheral part. Ovary is one-chambered but it becomes two chambered due to the formation of the false septum, e.g., mustard and *Argemone*. When the ovules are borne on central axis and septa are absent, as in *Dianthus* and *Primrose* the placentation is called free central (d).
- In basal placentation (e), the placenta develops at the base of ovary and a single ovule is attached to it, as in sunflower, marigold.

Parthenocarpy:- Formation of a fruit without fertilization of ovary

Pericarp:- The fruit wall is called pericarp. It consists of 3 layers- outer epicarp, middle mesocarp and inner endocarp

Testa and tegmen:- Outer seed coat is called testa and inner one is called tegmen.

Aleurone layer:- The outer proteinaceous covering of endosperms in seeds like rice is called aleurone layer

Chapter-6 Anatomy of Flowering Plants

Intercalary meristem:- The meristem which occurs between mature tissues is known as **intercalary meristem**. They occur in grasses and regenerate parts removed by the grazing herbivores.

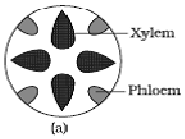
- Examples for primary meristems- Apical meristem and intercalary meristem
- Examples for secondary/lateral meristems- Fascicular vascular cambium, interfascicular cambium, Cork cambium
- Parenchyma, collenchyma and sclerenchyma are examples for simple permanent tissues
- Parenchyma are found in the soft parts of the plant body like leaves, fruits etc.,
- Collenchyma cells have cellulose thickening in their corners
- Sclerenchyma cells are dead and found in regions like seed coat, fruit wall etc., They are of two types- elongated fibres and round shaped Sclereids.
- Xylem and Phloem are examples for complex permanent tissues.
- The first formed primary xylem elements are called protoxylem and later formed primary xylem elements are called metaxylem.

Endarch Xylem:- In primary xylem if the protoxylem is lies towards the pith and metaxylem lies towards the periphery the condition is called endarch xylem. Example:- stem

Exarch Xylem:- In primary xylem if the protoxylem lies towards the periphery and metaxylem lies towards the centre the condition is called Exarch xylem. Eg:- Root

- Mature sieve tubes lack nucleus
- Phloem parenchyma is absent in monocots
- Phloem fibres of Jute, Flax and Hemp are used commercially

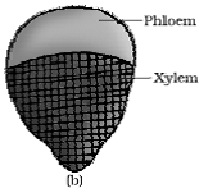
Stoma(Pl. Stomata):- composed of two kidney shaped cells called guard cells. Guard cells are dumb-bell shaped in the case of monocot leaves. The specialized cells around the guard cells are called subsidiary cells. The stomatal aperture, guard cells and subsidiary cells together is called stomatal apparatus.



(a)

Trichomes:- Epidermal hairs of stem are called trichomes. They are multicellular.

- If Xylem and phloem are arranged on the same radius of the vascular bundle the condition is called conjoint vascular bundle, eg:- stem and leaves

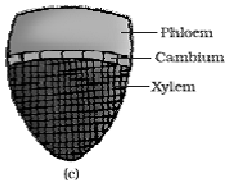


(b)

- If xylem and phloem in a vascular bundle are arranged in an alternate manner on different radii the arrangement is called radial type, eg:- roots

Open Vascular bundle:- When cambium is there between xylem and phloem in a vascular bundle, eg:- dicot stem

Closed Vascular bundle: When there is no cambium between xylem and phloem in a vascular bundle, eg:- monocot stem



(c)

- The endodermis of roots possess water impermeable waxy material – suberin- in the form of Casperian strips
- The parenchymatous cells between xylem and phloem of roots is called conjunctive tissue.
- In roots lateral roots take their origin from pericycle
- All the tissues inner to endodermis is called Stele. It includes pericycle, vascular bundles and pith.

Bulliform cells:- large, colourless, empty cells seen on the upper surface of monocot leaves . They help the leaf to curl inward during water stress.

- The secondary wood formed during favourable growth season (spring) is called Spring wood or early wood.
- The secondary wood formed during unfavourable growth season (autumn) is called Autumn wood or late wood.

Annual ring:- The concentric rings seen on the trunk of a tree due to the formation of light coloured spring wood and dark coloured autumn wood is called annual rings. They helps to determine the age of a tree (two annual rings per year)

Heartwood:- The dead secondary xylem tissues seen at the central part of trees is called heartwood. Heart wood is dark brown in colour due to deposition of tannins, resins, gums, oils, aromatic substances and essential oils. These substances make heartwood hard, durable and resistant to the attack of microbes and insects.

Sapwood:- The light peripheral part of secondary xylem on a tree is called sapwood. Sapwood has living cells and involved in the conduction of water and minerals.

- During extrastelar secondary growth cork cambium (Phellogen) produces cork (phellum) towards outer side and secondary cortex (phelloderm) towards inner side.

Periderm:- Phellum, phellogen and phelloderm are collectively called periderm

- Bark consists of periderm and secondary phloem

- Lenticels are lens shaped opening on the epidermis of bark, which helps in gaseous exchange between outer atmosphere and internal tissues of the stem.

Chapter 8- Cell: The Unit of Life

Cell is the structural and functional unit of life

Cell theory- proposed by Schleiden (for plants), Schwann (for animals) and Virchow states that

1. All living organisms are composed of cells and products of cells -Schleiden and Schwann
2. All cells arise from pre-existing cells (*Omnis cella-e-cellula)*- Virchow

Plasmids:- Extra chromosomal circular DNA seen in bacteria. They carry genes for characters like antibiotic resistance.

Mesosomes:- Extension of plasma membrane in the form of vesicles, tubules and lamellae into cytoplasm of bacteria. They help in cell wall formation, DNA replication and distribution to daughter cells. They also help in respiration, secretion processes, to increase the surface are of the plasma membrane and enzymatic content.

Ribosomes:- are the only cell organelles seen in both prokaryotes and Eukaryotes. Ribosomes are non-membrane bound organelles and concerned with protein synthesis. Ribosomes present in prokaryotes are of 70s type and eukaryotes are 80s type.

Polyribosomes/polysomes:- several ribosomes attached to a single mRNA

Fluid Mosaic Model:- Cell membrane(Plasma membrane) model proposed by Singer and Nicolson- states that lipid bilayer of cell membrane is quasi-fluid in nature allowing lateral movement of proteins within it.

- Endomembrane system includes Endoplasmic reticulum, Golgi apparatus, lysosomes and vacuoles.
- Endoplasmic reticulum bearing ribosomes on their surface is called rough endoplasmic reticulum (RER) and without ribosomes are called smooth endoplasmic reticulum (SER)

Lysosomes are rich in hydrolytic enzymes capable of digesting biomolecules

Tonoplast:- the membrane of vacuole is called tonoplast

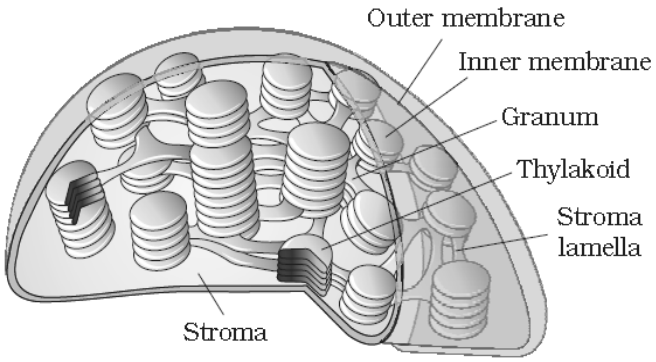
- Mitochondria are the sites of aerobic respiration to produce ATP- hence they are called 'power house of the cell'

Mitochondrial cristae:- Infolding of inner membrane of mitochondria

Chloroplasts:- contains chlorophyll as the major pigment

Chromoplasts:- contains pigments other than chlorophyll – xanthophylls and carotenes

Leucoplasts:- colourless plastids which store nutrients. For example **Amyloplasts** store starch, **Aleuroplasts** store protein **Elaioplasts** store fats and oils.



- Cell organelles which contain small circular DNA are Mitochondria and Chloroplasts
- Cell organelles which contain prokaryotic (70s type) ribosomes are mitochondria and chloroplasts
- Nucleus was first described by Robert Brown
- Nucleoli inside nucleus represents regions of active synthesis of ribosomal RNA
- Chromosomes contains DNA, RNA, histones and non-histone proteins
- Double membrane bound cell organelles include Nucleus, Mitochondria, Chloroplasts,
- Single membrane bound cell organelles include Vacuole, lysosomes, endoplasmic reticulum etc.,

Chapter 10 - Cell Cycle and cell division

Cell cycle is divided into two basic phases- Interphase and M phase (Mitosis phase)

Cytokinesis:- Division of cytoplasm

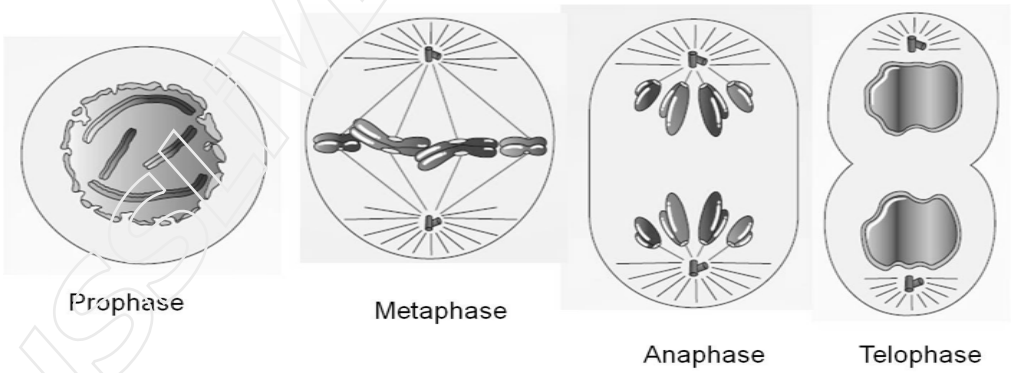
Karyokinesis:- Division of nucleus

The S phase consists of 3 phases

- **G_1 phase (Gap 1)**:- During this phase the cell is metabolically active and continuously grow, but, does not replicate its DNA
- **S phase**:- During this period DNA synthesis or replication takes place so that the amount DNA doubles but the number of chromosomes remains the same.
- **G_2 phase (Gap 2)**:- During this phase the cell continues to grow and synthesis proteins required for the division of cell.

G_0/Quiescent stage:- is an inactive stage shown by cells that do not divide further. During quiescent stage the cells remain metabolically active but no longer proliferate unless called on to do so depending on the requirement of the organism.

- Mitosis is otherwise called equational division because daughter cells formed after mitosis are qualitatively and quantitatively similar among themselves and to mother cell.
- After mitosis number of chromosomes in daughter cells remains the same as that of mother cell.
- Mitosis is for growth and repair
- The karyokinesis in mitosis consists of 4 steps in the order of Prophase, Metaphase, Anaphase and Telophase
- Prophase:- Chromosomes thickens and nuclear membrane disappears at the end
- Metaphase: chromosomes have maximum thickness so that they can be best studied during this phase. Chromosome are arranged at the equator (centre) of the cells and their alignment is referred as Metaphase plate.



- Anaphase:- splitting of centromere and movement of chromatids to opposite poles starts during this phase
- Telophase:- Chromosomes reach at the opposite poles and nuclear membrane reappears.
- In animal cells cytokinesis is due to furrow formation and in plant cells it is due to cell plate formation.
- Meiosis is for the formation of gametes
- The daughter cells formed as a result of meiosis will contain half the number of chromosomes compared to their parent/mother cell
- Meiosis helps to keep the chromosome number same in a sexually reproducing species.
- Meiosis increases genetic variability in sexually reproducing organisms
- Prophase I of Meiosis consists of 5 steps.

1. Leptotene- Chromosome starts thickening
2. Zygotene:- Pairing of homologous chromosomes is called synapsis. Synapsis is helped by a complex called Synaptonemal complex.

3. Pachytene:- During this phase crossing over or recombination takes place. Crossing over is the exchange of genetic material between two homologous chromosomes. Crossing over is assisted by an enzyme called recombinase. Crossing over is a reason for the development of variation among sexually reproducing organisms.
4. Diplotene:- Here the homologous chromosomes starts separate from one another after crossing over. The X-shaped regions of attachment between homologous chromosomes during diplotene stage is called Chiasmata.
5. Diakinesis:- Final stage of Prophase I of Meiosis I. During this stage chiasma is completely terminalised and chromosome thickening continues. At the end nucleolus disappears and nuclear membrane breaks down.

Chapter 11- Transport in Plants

Diffusion:- Movement of molecules from a region of higher concentration to a region of lower concentration is called diffusion

Osmosis:- Movement of molecules from a region of higher concentration to a region of lower concentration through a semi-permeable membrane is called osmosis.

Facilitated diffusion:- Diffusion of molecules with the help of carrier proteins

Porins are a kind of carrier proteins seen in the outer membranes of the plastids, mitochondria and some bacteria.

Symport:- Facilitated diffusion of 2 types of molecules in the same direction is called symport

Antiport:- Facilitated diffusion of 2 types of molecules in the opposite direction is called antiport

Uniport:- Facilitated diffusion of a molecule independent of other molecule is called uniport.

Water potential:- The free energy/kinetic energy available per molecule of water is called water potential

- The water potential is represented by the letter Ψ_w
- Water potential is affected by solute potential (Ψ_s) and pressure potential (Ψ_p), represented as follows

$$\Psi_w = \Psi_s + \Psi_p$$

- An increase in solute potential cause a decrease in water potential and an increase in pressure potential causes an increased water potential.
- Maximum value of water potential is 0 and is given by pure water

Isotonic solution:- When the concentrations of solutions are same on both sides of a semi permeable membrane they are said to be isotonic.

Hypotonic solution:- When a solution of low concentration is separated from a solution of high concentration by a semipermeable membrane it is called a hypotonic solution.

Hypertonic solution:- When a solution of high concentration is separated from a solution of low concentration by a semipermeable membrane it is called a hypertonic solution.

Plasmolysis:- When a plant cell is placed in a hypertonic solution its cell membrane shrinks away from the cell wall. This phenomenon is called plasmolysis.

Imbibition:- Absorption of water by solids leading them to enormously increase their volume is called imbibitions. Eg:- imbibitions of water by seeds, raisins (dried grape) etc.,

Apoplast pathway:- The movement of water through intercellular spaces and walls of the cells is called apoplast

Symplast pathway:- Movement of water through cells via plasmodesmata and cytoplasm is called symplast

The apoplastic movement of water in roots thorough cortical cells is prevented by endodermis due to the presence of casperian strip.

Guttation:- Loss of water in the form of liquid through hydathodes present in leaves is called Guttation. Guttation is due to root pressure, low temperature and high humidity.

- The upward movement of water is mainly due to the joint action of transpiration pull, cohesion, adhesion and surface tension of liquid water.
- Xylem (water) transport is unidirectional while phloem (food) transport is bidirectional
- The most accepted mechanism for phloem transport of food is pressure flow or mass flow hypothesis.

Chapter 12- Mineral Nutrition

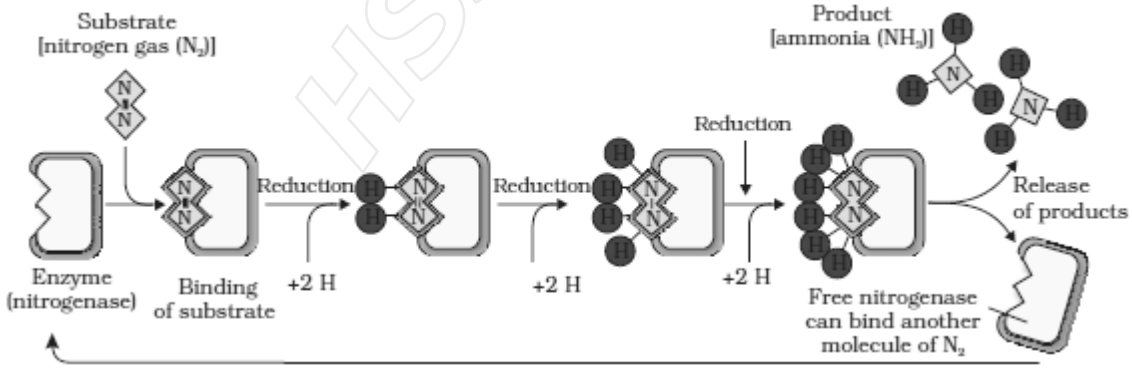
Hydroponics:- The technique of growing plants in nutrient solution is called hydroponics. It was first demonstrated by Julius Von Sachs.

Macronutrients:- The nutrients which are required by plants in large quantities, for eg:- C, H, O, N, P, S, K, Ca.

Micronutrients:- are elements which are needed in very small quantities, for eg:- Fe, Mn, Cu, Mo, Zn, B, Cl, Ni.

- Conversion of Ammonia to Nitrite during nitrification is done by nitrifying bacteria (chemoautotrophs) like *Nitrosomonas* and/or *Nitrococcus*
- Conversion of Nitrite to Nitrate during nitrification is done by nitrifying bacterium (chemoautotrophs) like *Nitrobacter*..
- Microbes like *Rhizobium* and *Frankia* are examples for **symbiotic nitrogen fixing** organisms.
- Leg-haemoglobin is a pink pigment which aid in symbiotic nitrogen fixation by leguminous plants.

Role of leghaemoglobin in nitrogen fixation:- During symbiotic nitrogen fixation, the enzyme nirogenase catalyses the conversion of nitrogen to ammonia. This enzyme is highly sensitive to the molecular oxygen and therefore requires an anaerobic condition for its activity. Leghaemoglobin act as an oxygen scavenger to protect nitrogenase enzyme.



Steps in the Conversion of Nitrogen to Ammonia by nitrogenase enzyme present in Rhizobium bacteria.

Plants use NH_4^+ ions to synthesise amino acids through 2 main ways- reductive amination and transamination.

Chapter 13- Photosynthesis in higher plants

- The oxygen liberated during photosynthesis is coming from water molecule.
- Sulfur bacteria use H_2S instead of H_2O as the source of hydrogen during photosynthesis

- Photosynthesis is divided into two stages- light reactions of photosynthesis and dark reactions of photosynthesis. Light reactions of photosynthesis can takes place only in the presence of light while dark reactions of photosynthesis can takes place in the presence or absence of light.
- During light reactions energy rich molecules like ATP and NADPH are produced and during dark reactions by using energy rich molecules CO_2 is reduced to carbohydrates (glucose).
- There are 4 major pigments present in higher plants- **Chlorophyll a, chlorophyll b, xanthophylls and carotenoids.**
- All the pigments except Chlorophyll-*a* are called accessory pigments. They absorb light, transfer light energy to chl-a and protect chl-a against photo-oxidation (high light intensities). Chl-a molecules form the reaction centre of photosynthesis.

Absorption spectra:- The rate of absorption of different wavelength of visible light by a plant pigment is called absorption spectra. Chlorophylls mainly absorb in the violet-blue and red parts of the spectrum.

Action spectra:- The rate of photosynthesis at different wavelengths of radiation is called action spectra. Actions spectra show that maximum photosynthesis takes place at blue and red part of the spectrum.

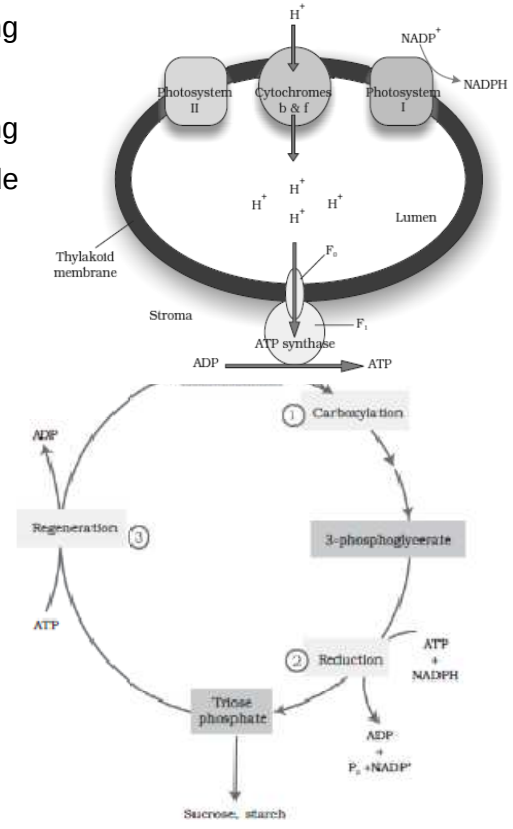
In PS I the reaction centre chlorophyll *a* have an absorption peak at 700 nm, hence is called **P700**, while in PS II it has absorption maxima at 680 nm, and is called **P680**.

Non-cyclic electron transport is also called **Z-scheme**.

	Cyclic photophosphorylation	Non-cyclic photophosphorylation
1.	Only photosystem I is involved in cyclic photophosphorylation	Both photosystem I and II are involved in noncyclic photophosphorylation
2.	It involves only the synthesis of ATP	It involves the synthesis of ATP and NADPH.
3.	In this process, photolysis of water does not occur. Therefore, oxygen is not produced.	In this process, photolysis of water takes place and oxygen is liberated.
4.	Electrons move in a cyclic manner	Electrons move in a non cyclic manner. They never return to the photosystem from where they were ejected

The best explanation for the mechanism of ATP generation during photosynthesis is given by **Chemiosmotic hypothesis**.

According to chemiosmotic hypothesis the synthesis of ATP during photosynthesis is the result of the formation of a proton gradient inside the thylakoids and its eventual breakdown.



Calvin cycle or C_3 pathway

Proposed by Melvin Calvin and his co-workers. The first product of this pathway is a 3 carbon compound 3-phosphoglycerate (3-PGA) and hence is called C_3 pathway. Calvin cycle consists of 3 steps.

1. **Carboxylation**:- Here CO_2 is fixed into a stable intermediate product. In this step Ribulose biphosphate (RuBP) a five carbon compound is carboxylated into two molecules of 3 carbon compound called 3-phosphoglycerate (3-PGA). This

reaction is catalysed by an enzyme RuBP Carboxylase-oxygenase or RuBisCO.

2. **Reduction**:- Reduction step consists of series of reactions that will lead to the formation of glucose from 3-PGA. This step requires 2 ATP molecules for phosphorylation and 2 NADPH molecules for reduction for each CO_2 molecule. Reduction of six CO_2 molecule is required for the generation of one molecule of glucose.
3. **Regeneration**:- Here RuBP, the CO_2 acceptor is regenerated with the use of an ATP molecule.

During photosynthesis fixation of each CO_2 molecule requires 3 ATP and 2 NADPH molecules. One Glucose molecule is formed from the fixation of six CO_2 molecules and therefore each molecule of glucose requires 18 ATP and 12 NADPH during its formation.

Kranz anatomy:- Special leaf anatomy shown by C_4 plants. Here the vascular bundles are surrounded by particularly large bundle sheath cells which in turn are surrounded by mesophyll cells. The cells of mesophyll contains smaller chloroplasts which are rich in grana and bundle sheath cells contain bigger chloroplasts which are rich in stroma.

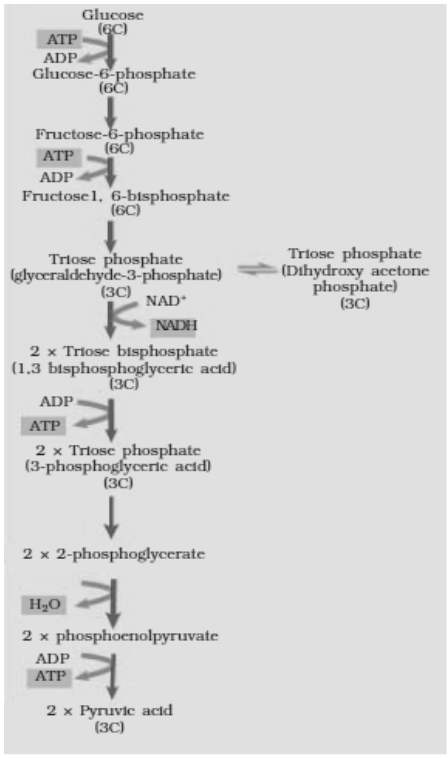
C_4 pathway/Hatch and Slack pathway/Dicarboxylic acid pathway:- At first in the mesophyll cells of C-4 plants the primary CO_2 acceptor Phospho Enol Pyruvate (PEP) which is a C-3 compound fixes CO_2 into a C-4 dicarboxylic acid called Oxalo Acetic Acid (OAA). This reaction is catalysed by the enzyme PEP carboxylase or PEPcase.

OAA later forms other 4-carbon compounds like malic acid and aspartic acid in the mesophyll itself which are transported to the bundle sheath cells. In bundle sheath cells C-4 acids break down into CO_2 and pyruvic acid. The CO_2 released into bundle sheath cells will fixed just like C-3 pathway and pyruvic acid will transported back to mesophyll cells where it is converted into PEP.

Photorespiration:- The pathway which first gives phosphoglycerate and phosphoglycolate due to the affinity of RuBisCO to oxygen instead of CO_2 for reacting with RuBP is called Photorespiration. It is a wasteful process as it doesn't lead to the formation of any sugars and ATP is consumed during this process. Photorespiration is shown by C-3 plants and absent in C-4 plants.

C_3 Plants	**C_4 Plants**
Carbon pathway in photosynthesis is C_3 pathway i.e., Calvin cycle	**Carbon pathway in photosynthesis is C_4 Dicarboxylic acid pathway i.e., Hatch and Slack pathway**
First stable product is 3-carbon compound phosphoglyceric acid (PGA)	**First stable product is 4-carbon comound Oxaloacetic acid**
The leaves have diffused mesophyll and only one type of chloroplasts	**The leaves have 'Kranz anatomy' and two types of chloroplasts**
Photorespiration occurs	**No photorespiration**
Photosynthetically less efficient	**Photosynthetically more efficient**
Eg: - Wheat, oats, rice, cotton, beans, chlorella etc.,	**Eg: - Sugarcane,maize, sorghum, Amaranthus etc.,**

Chapter 14- Respiration in Plants



Glycolysis occurs in the cell cytoplasm

Glycolysis is otherwise called Embden, Meyerhof, Paranas pathway or EMP pathway

As result of glycolysis one molecule of glucose is broken down into two molecules of pyruvic acid.

During glycolysis 2 ATP molecules were consumed

During glycolysis 2 $NADPH+2H^+$ and 4 ATP were released

Net energy gain of glycolysis is 6 ATP molecules

Glycolysis is the common step for aerobic and anaerobic respiration.

Fermentation is the anaerobic and incomplete oxidation of glucose where pyruvic acid formed through glycolysis is converted into ethanol or lactic acid with the release of CO_2.

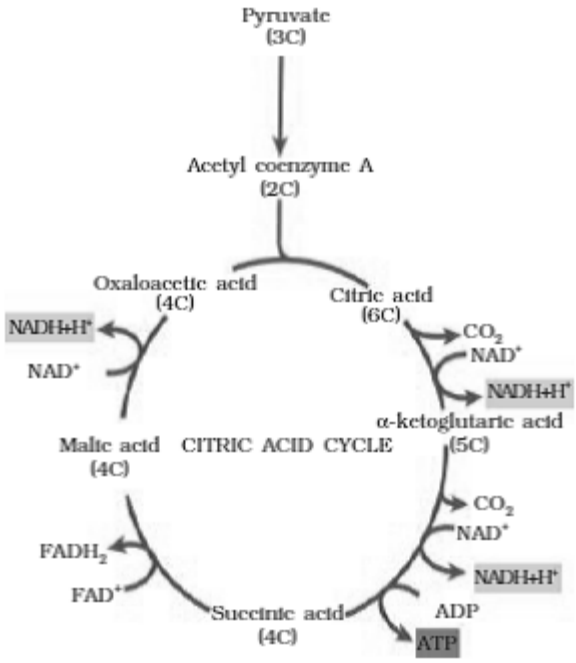
Yeasts and some bacteria (*Lactobacillus*) are examples for anaerobic organisms

In skeletal muscles of animal cells during exercise pyruvic acid is reduced to lactic acid by the enzyme lactate dehydrogenase (acid fermentation).

Alcohol fermentation (formation of ethanol from pyruvic acid) is catalysed by the enzymes pyruvic acid decarboxylase and alcohol dehydrogenase.

Disadvantages of anaerobic respiration (Fermentation)Energy release is very less – $NADH + H^+$ is reoxidised during this process and net gain is 2 ATP per glucose molecule.

1. The processes are hazardous



Aerobic respiration takes place within mitochondria.

The first product of Krebs' cycle is Citric acid which is a tricarboxylic organic acid. So Krebs' cycle is also called Citric acid cycle or Tricarboxylic acid cycle.

The formation of GTP from GDP during the conversion of succinyl coA to succinic acid in Krebs' cycle is called substrate level phosphorylation.

During aerobic respiration Krebs' cycle takes place in mitochondrial matrix and electron transport coupled with oxidative phosphorylation takes place in the inner mitochondrial membrane.

Role of oxygen during aerobic respiration:- The role oxygen during aerobic respiration is limited to the terminal stage of electron transport . During electron transport the H-atoms from $NADH+H^+$ and $FADH+H^+$ ultimately combine with oxygen to form water. Thus the vital role of oxygen during aerobic respiration is the removal of hydrogen from electron transport system. Oxygen acts as the final hydrogen acceptor.

The net gain of ATP during aerobic respiration is 36 ATP per glucose molecule

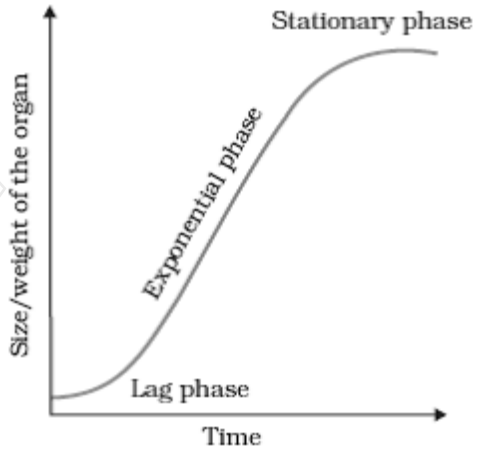
Respiration is traditionally considered as a catabolic or destructive pathway. But the respiratory intermediates can take part in the formation various biomolecules. For example acetyl coA formed during respiratory pathway can be used for the synthesis of fatty acids and α-ketoglutaric acid formed can be used in the synthesis of amino acids. Therefore it is better to consider respiratory pathway as an **amphibolic pathway** rather than a catabolic pathway.

Respiratory quotient:- The ratio of the volume of CO_2 evolved to the volume of O_2 consumed in respiration is called the respiratory quotient (RQ) or respiratory ratio.

RQ is unitary or 1 for carbohydrates less than 1 for fats and more than 1 for organic acids.

Chapter 15 – Plant growth and development

Sigmoid or S-curve is the typical growth curve of all cells, tissues, organs and organisms growing in a natural environment. Here the initial growth is slow and is called lag phase. Subsequently there is a rapid increase in growth which is called log phase or exponential phase of growth. At last the growth slows down leading to another phase called stationary phase.



Examples for natural auxins are Indole-3-acetic acid (IAA) and indole Butyric acid (IBA)

NAA (naphthalene acetic acid) and 2, 4-D (2,4-dichlorophenoxyacetic acid) are examples for synthetic auxins.

Properties/Uses of auxins

1. To initiate rooting in stem cuttings
2. Promote flowering
3. Prevents abscission of young leaves and fruits.
4. Apical dominance:- Inhibition of growth of lateral buds by apical bud is called apical dominance and this property is attributed to the auxins present in shoot apices. Therefore removal of shoot tip (decapitation, pruning) will promote the growth of lateral branches and this property is widely applied in tea plantations, hedge-making etc.,
5. Auxins induce parthenocarpy
6. 2, 4-D is used as a weedicide (herbicide).

Properties and uses of gibberellins

1. Internode elongation- causes bolting in cabbages if sprayed with GAs
2. Delay senescence
3. Hastens maturity period

Cytokinins are adenine (nitrogenous base present in DNA- a purine base) derivatives

Properties and uses of Cytokinins

1. Promote cell division
2. Overcome apical dominance
3. Delay senescence
4. Promote nutrient metabolism

Ethylene- a unique plant hormone because it is a gas

Ethylene shows both growth promoting and growth inhibiting properties in plants

Properties and uses of Ethylene

1. Fruit ripening
2. Initiates flowering and promote female flowering
3. Used for synchronizing fruit set in pineapples
4. Promotes root growth and root hair formation
5. Promotes senescence and abscission

The increase in respiratory rate during fruit ripening due to ethylene is called respiratory climactic.

Ethephon- commercial ethylene solution used for stimulating latex yield from rubber, hastens fruit ripening.

Abscisic acid (ABA)

A plant growth regulator (PGR) which has a negative effect on plant growth.

Properties of ABA

1. Inhibits plant growth
2. Inhibits seed germination (seed dormancy)
3. Stress hormone- promotes closure of stomata during water stress

The plants which require long day and short night period for their flowering are called Long Day Plants

The plants which require short day and long night period for their flowering are called Short Day Plants

The response of plants to the relative length of light and dark periods of the day in the form of flowering is called Photoperiodism.

Hastening of flowering by a chilling or cold treatment is called vernalisation