VIJAYABHERI

MALAPPURAM DISTRICT PANCHAYATH EDUCATIONAL

PROJECT 2021-22

STEP-UP

BOTANY-CLASS XI

(Higher secondary / V H S E Supporting Material)

വിദ്യാഭ്യാസപരമായി ഏറ്റവും പുറകിൽ നിന്നിരുന്ന മലപ്പുറം ജില്ല കഴിഞ്ഞ കുറച്ചു വർഷങ്ങൾ കൊണ്ടുണ്ടാക്കിയ നേട്ടങ്ങൾ അഭൂതപൂർവമാണ് . എസ്. എസ്. എൽ. സി , പ്ലസ്ടു , വി. എച്ച്. എസ് . ഇ ഫലത്തിന്റെ കാര്യത്തിൽ മാത്രമല്ല എ പ്ലസ്സ് ലഭിച്ച വിദ്യാർത്ഥികളുടെ എണ്ണത്തിലും വിവിധ മത്സരപരീക്ഷകളിലും നമ്മൾ ഏറെ മുന്നേറി . പൊതുവിദ്യാഭ്യാസ സംരക്ഷണത്തിന്റെ കാര്യത്തിൽ മറ്റു ജില്ലകൾക്ക് നമ്മൾ മാതൃകയാണ് . മലപ്പുറം ജില്ലാ പഞ്ചായത്ത് ആവിഷ്കരിച്ചു നടപ്പിലാക്കി കൊണ്ടിരിക്കുന്ന വിജയഭേരി വിദ്യാഭ്യാസ പദ്ധതി , തദ്ദേശ സ്വയംഭരണ സ്ഥാപനങ്ങളുടെ ഇടപെടലുകൾ , ജനപ്രതിനിധികൾ , എസ് . എസ് . കെ , ഡയറ്റ് , വിദ്യാഭ്യാസ ഓഫീസർമാർ ഒപ്പം എല്ലാ നല്ല പ്രവർത്തനങ്ങൾക്കും കൂടെ നിൽക്കുന്ന അധ്യാപകർ എന്നിവരാണ് ഈ നേട്ടങ്ങൾക്കു പിന്നിൽ .

നേട്ടങ്ങൾ ആഘോഷിക്കുന്നതിനോടൊപ്പം അടിയന്തിര ശ്രദ്ധ പതിയേണ്ടുന്ന മേഖലകൾ ഇനിയും ഏറെയുണ്ട് . 10 - ാം ക്ലാസ്സിൽ നിന്നും വിജയം നേടി പ്ലസ്സ് 1 , വി. എച്ച്. എസ് . ഇ ക്ലാസ്സുകളിൽ എത്തുന്ന വിദ്യാർത്ഥികളിൽ നല്ലൊരു ശതമാനം വിദ്യാർത്ഥികൾ ഹയർ സെക്കണ്ടറി സിലബസ് പിന്തുടരുന്നതിന് ഏറെ പ്രയാസം അനുഭവിക്കുന്നവരാണ് . കോവിഡ് കാരണം സ്കൂൾ പ്രവർത്തി ദിനങ്ങൾ നഷ്ടപ്പെട്ടതോടെ ഭൂരിപക്ഷം വിദ്യാർത്ഥികളും പഠന പ്രയാസങ്ങൾ അനുഭവിക്കുന്നു ഈയൊരു പശ്ചാത്തലത്തിൽ പ്ലസ്ടു , വി. എച്ച്. എസ് . ഇ തലത്തിൽ വിവിധ വിഷയങ്ങൾ അനായാസകരമായി പഠിക്കുന്നതിനും എല്ലാ വിദ്യാത്ഥികളും പ്ലസ്ടു , വി. എച്ച്. എസ്.ഇ പരീക്ഷകളിൽ മികച്ച വിജയം ഉറപ്പു വരുത്തുന്നതിനായി **സ്റ്റെപ്പ് - അപ്പ് 22** എന്ന പേരിൽ പ്രത്യേക മെറ്റീരിയൽ വിജയഭേരി പദ്ധതിയുടെ ഭാഗമായി തയ്യാറാക്കി സ്കൂളുകളിലെത്തിക്കുകയാണ് . തീർച്ചയായും ഈ മെറ്റീരിയൽ അധ്യാപകർക്കും വിദ്യാർത്ഥികൾക്കും ഏറെ സഹായകരമാകുമെന്ന് പ്രതീക്ഷിക്കുന്നു .

ഈ പഠനസഹായി സമയബന്ധിതമായി പൂർത്തീകരിക്കുന്നതിന് നേതൃത്വം നൽകിയ മലപ്പുറം ഡയറ്റ് , ഹയർ സെക്കണ്ടറി ജില്ലാ കോർഡിനേറ്റർ / അസിസ്റ്റന്റ് കോർഡിനേറ്റർ , ശില്പശാലയിൽ പങ്കെടുത്ത അധ്യാപകർ എന്നിവർക്കുള്ള നന്ദിയും കടപ്പാടും പ്രത്യേകം അറിയിക്കുന്നു .

സ്കൂൾതലത്തിൽ അനുയോജ്യമായ സമയം കണ്ടെത്തി രക്ഷിതാക്കളുടെ സഹകരണത്തോടെ ഈ പഠനപ്രവർത്തനങ്ങൾ വിദ്യാർത്ഥികൾക്ക് നൽകണം . അതിനായി എല്ലാ അധ്യാപകരുടെയും സഹകരണം പ്രതീക്ഷിക്കുന്നു .

പ്രസിഡണ്ട്	ചെയർപേഴ്സൺ	അസി: ഡയറക്ടർ	ആർ.ഡി.ഡി	പ്രിൻസിപ്പാൾ
ജില്ലാ പഞ്ചായത്ത്	ആരോഗ്യ വിദ്യാഭ്യാസ	വി..എച്ച്. എസ് .ഇ	മലപ്പുറം	ഡയറ്റ്
മലപ്പുറം	സ്ഥിരം സമിതി	മലപ്പുറം		മലപ്പുറം

STEP-UP

BOTANY, CLASS- PLUS ONE

Supporting Material for Higher Secondary/ Vocational Higher Secondary Classes

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Dear students and teachers,

STEP-UP 2022 of botany has been written in accordance with the latest syllabus framed by SCERT and NCERT for class XI by a team of higher secondary botany teachers in Malappuram district for Malappuram District Panchayath VIJAYABHERI PROGRAMME.

Students and teachers will definitely find it very much helpful in understanding the various concepts. This book includes short notes, diagrammes and main points.

It is our sincere hope that the booklet will continue to motivate the students' interest in botany.

With regards,

Botany Team
Malappuram

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CHAPTER 1: BIOLOGICAL CLASSIFICATION

Two kingdom system of classification.

- Proposed by Carolous Linnaeus
- He divided all living organisms in to two - Kingdom Plantae & Kingdom Animalia

Drawbacks

- It did not distinguish between eukaryote & prokaryote, unicellular & multicellular organisms & photosynthetic (green algae) & non- photosynthetic (Fungi) organisms.
- Based on the presence of cell wall prokaryotes (bacteria & cyanobacteria) were included under plants. But they are widely differed in other characteristics.
- Unicellular & multicellular organisms were placed under algae.
  Eg:- Chlamydomonas & Chara.
- Fungi are heterotrophic & they have chitinous cell wall, while the green plants are autotrophic & have cellulose in cell wall. Both comes under same group.

Five Kingdom classification

- Proposed by R.H Whittaker (1969)
- It includes Monera, Protista, Fungi, Plantae & Animalia.
- This classification is based on cell structure, thallus organisation, mode of nutrition, reproduction & phylogenetic relationship

Characteristics of the Five Kingdoms

Characters	Five Kingdoms				
	Monera	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Noncellulosic (Polysaccharide + amino acid)	Present in some	Present with chitin	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multiceullar/ loose tissue	Tissue/ organ	Tissue/organ/ organ system
Mode of nutrition	Autotrophic (chemosyn-thetic and photosynthetic) and Hetero trophic (sapro phytic/para-sitic)	Autotrophic (Photosyn-thetic) and Hetero-trophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosyn-thetic)	Heterotrophic (Holozoic/ Saprophytic etc.)

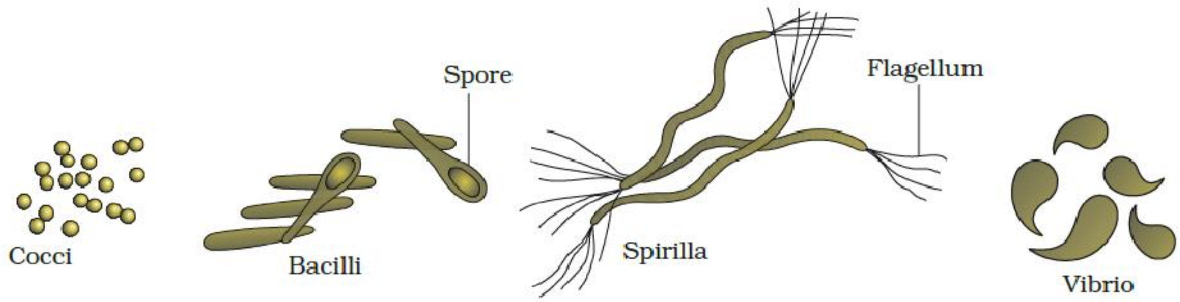
1. Kingdom Monera (BACTERIA)

- Bacteria are the most abundant micro organisms. Bacteria occur almost everywhere.
- Hundreds of bacteria are present in a handful of soil.
- They also live in extreme habitat such as hotsprings, deserts, snow & deep oceans where few other life forms can survive. Many are parasites.
- Bacteria are grouped under 4 categories based on their shape
  Coccus - Spherical

  Bacillus - rod - shaped

  Vibrium - comma - shaped

  Spirillum - spiral



Bacteria of different shapes

- Bacterial structure is very simple but, they are complex in behaviour.
- Bacteria show most extensive metabolic diversity.
- Some bacteria are autotrophic (they synthesis their own food from inorganic substrate.)
- The vast majority of bacteria are heterotrophic. (They do not synthesis their own food, but depend on other organism/ on dead organic matter for food).

Kingdom monera is classified into three

1. Archaebacteria

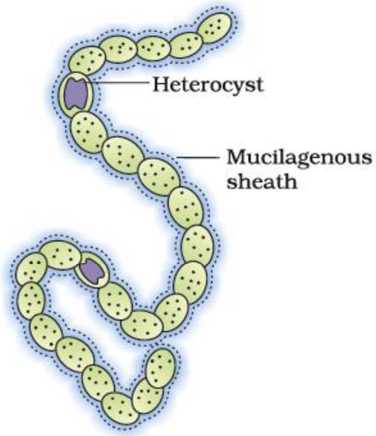
- These bacteria live in extreme salty areas (halophiles), hot springs (thermoacidophiles), & marshy areas (methanogens).
- Archaebacteria survive in extreme condition because they have different cell wall structure.
- Methanogens are present in the gut of several ruminant animals (cow, buffaloes etc.). They produce methane (biogas) from dung of these animals.

2. Eubacteria (True bacteria)

- Known as true bacteria
- They are characterized by the presence of rigid cell wall & flagellum (if motile).
- Cyanobacteria, chemosynthetic autotrophic bacteria and heterotrophic bacteria are included in Eubacteria.

(i) Cyanobacteria (Photosynthetic autotrophs)

- Known as Blue green algae
- They are unicellular, colonial or filamentous, fresh water or marine or terrestrial algae.
- The colonies are generally covered by a gelatinous sheath.
- They often form bloom in polluted water.
- Some of these organisms can fix atmospheric nitrogen in specialized cell called heterocyst.
  Eg:- Nostoc & Anabaena.



A filamentous blue-green algae – *Nostoc*

(ii) Chemosynthetic autotrophic bacteria.

- It oxidizes various inorganic substrate such as nitrite, nitrate & ammonia & use the released energy for ATP production.
- They play a great role in recycling nutrients like nitrogen, phosphorus, iron & sulphur.

(iii) Heterotrophic bacteria

- They are the most abundant in nature. They are important decomposers.
- They have significant impact on human affair.
- They are helpful in making curd from milk, production of antibiotics, fixing nitrogen in legume root etc..
- Some are pathogens causing damage to human beings, crop, farm animal & pets.
  Eg:- Cholera, typhoid, tetanus, citrus canker.

Reproduction

- Bacteria reproduce mainly by fission.
- Under unfavorable conditions they produce spores.
- They reproduce sexually by adopting a primitive type of DNA transfer from one bacterium to other.

(iii) Mycoplasma

- They completely lack a cell wall.
- They are the smallest living cell known.

- They can survive without oxygen.
- They are pathogenic in animals & plants.

II. Kingdom protista

- It includes all single celled Eukaryotes.
- They are aquatic.
- This kingdom form a link with others dealing with plants, animals & fungi.
- Their cell body contain a well defined nucleus & other membrane bound cell organelles.
- Some have flagella/Cilia.

Reproduction

- They reproduce asexually & sexually by a process involving cell fusion & zygote formation.
- It includes chrysophytes, Dinoflagellates, Euglenoids, slime moulds & protozoans.

(a) Chrysophytes

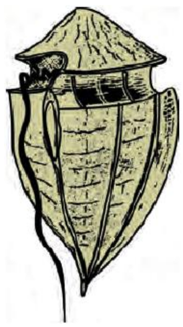
- It includes diatoms & golden algae (desmids)
- They are found in freshwater as well as marine environment.
- They are microscopic & float passively in water current (plankton)
- Most of them are photosynthetic.

Diatoms

- In diatom, the cell wall form 2 thin overlapping shell, which fit together as a soap box.
- Cell walls are embedded with silica, thus walls are indestructible. Thus, diatoms have left behind large amount of cell well deposit on their habitat, this accumilation over billions of years is referred as diatomaceous earth. Being gritty, this soil is used in polishing, filteration of oil & syrups.
- Diatoms are the chief producers in ocean.

(b) Dinoflagellates

- They are mostly marine & photosynthetic.
- They appear yellow, green, brown, blue or red depending on main pigment present in their cell wall.
- Their cell wall has stiff cellulose plate on the outer surface.
- Most of them have two flagella. One lies longitudinally & other transversely in the furrow between wall plates.
- Red dinoflagellates (Eg:- Gonyaulax) undergo rapid multiplication that they make the sea appear red (red tide). Toxin released by such large number may even kill other marine animal such as fishes.



(c) Euglenoids

- They are freshwater organisms found in stagnant water.
- Instead of a cell wall, they have a protein rich layer called pellicle which makes their body flexible.
- They have 2 flagella a short & long one.
- Though they are photosynthetic in the presence of sunlight, when deprived of sunlight they behave like heterotrophs by predating other small organism.
- The pigment of Euglenoids are identified to those present in higher plants.
  Eg:- Euglena.

(d) Slime moulds

- They are saprophytic protists.
- The body moves along decaying twigs & leaves engulfing organic material.
- Under suitable conditions, they form an aggregation called plasmodium which may grow & spread over several feet.
- During unfavourable condition, plasmodium differentiate & form fruting bodies bearing spores at their tip.
- The spore possess true wall. They are extremely ressistant & survive for many years, even under adverse conditions. The spores are dispersed by air currents.

(e) Protozoans

- They are heterotrophs and behave as predator or parasitic
- There are primitive relatives of animals.
- Their are 4 major group of protozoans.

(i) Amoeboid Protozoans

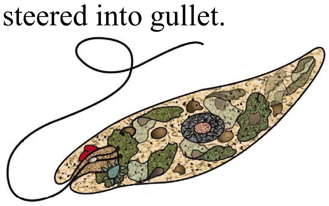
- These organisms grow in fresh water, sea water or moist soil.
- They move & capture prey by putting out pseudopodia (false feet)
  Eg:- Amoeba.
- Marine forms have silica shell on their surface.
- Some are parasite Eg:- Entamoeba.

(ii) Flagellated protozoans.

- They are free- living or parasite.
- They have flagella.
- The parasite form cause disease.
  Eg:- Trypanosoma causing sleeping sickness.

(iii) Ciliated protozoans

- They are aquatic
- They have thousands of cilia.
- They have a cavity (gullet) that opens to outside of cell surface.
- The co- ordinated movement of rows of cilia cause the water laden with food to be steered into gullet.



Eg:- Paramoecium

(iv) Sporozoans.

- It includes diverse organisms that have infectious spore like stage in their life cycle.
- Plasmodium (malarial parasite) cause malaria.

III. KINGDOM FUNGI

- It's a unique kingdom of heterotrophic organism.
- Fungi are cosmopolitan & occur in water, soil, air & on animals &plants.
- They prefer to grow in warm & humid places.
  Eg:- bread mould, orange rots, mushroom, toadstool etc..
- Some unicellular fungi are used to make bread & beer. Eg:- yeast
- Fungi cause disease in plants & animals.
  Eg:- Puccinia causing rust in wheat.
- Some are source of antibiotics.
  Eg:- Penicillium.
- Except yeast, fungi are filamentous.
- Their body consist of long, slender thread like structure called hyphae. The network of hyphae is called mycelium.
- Some hyphae are continuous tube filled with multinucleated cytoplasm called **coenocytic hyphae.** Others have septae or cross wall in their hyphae.
- Cell walls of fungi are composed of chitin and polysacchrides.
- Most fungi are heterotrophic and absorb soluble organic matter from dead substrate and are called **saprophytes.**
- Some are parasites
- Some are symbiotics.
  Eg:- Lichen (Fungi in association with algae).

  Mycorrhiza (Fungi inhabiting in the root of higher plants).

Reproduction

- Vegetative reproduction:- By fragmentation, Fission and budding.
- Asexual reproduction :- By spore called conidia or sporangiospore or zoospores
- Sexual reproduction:- By Oospore, ascospore, and basidiospore.
  - They are produced in distinct fruiting bodies.
  - The sexual cycle involves 3 steps.

Plasmogamy - Fusion of protoplast between two motile or non- motile gametes.

Karyogamy - Fusion of two nuclei

Meiosis in zygote results in haploid spores.

- When a fungus reproduce sexually, two haploid hyphae of compatible mating type come together and fuse.
- In some fungi, fusion of two haploid cell immediately results in diploid cell (2n)
- In other fungi (ascomycetes & basidiomycetes) an intervening dikaryotic stage (n+n ie, 2 nuclei per cell) occurs. Such a condition is called **dikaryon**& the phase is called **dikaryotic phase** of fungus. Later, the parental nuclei fuse & cell become diploid.

- Fungi form fruting bodies, in which reduction division (meiosis) occurs, leading to formation haploid spore.

Based on the morphology of mycelium, mode of spore formation and fruting body the kingdom is divided into various classes such as **Phycomycetes, Ascomycetes, Basidiomycetes & Deuteromycetes.**

1. Phycomycetes

- They are found in aquatic habitat and on decaying wood in moist and damp places or as obligate parasite in plants.
- The mycelium is aseptate & coenocytic

Asexual Reproduction

It takes place by zoospore (motile) or by aplanospore (non - motile). These spores are endogenously produced in the sporangium.

Sexual Reproduction

Zygospore is formed by the fusion of two gametes. These gametes are similar in morphology (isogamous) or dissimilar (anisogamous or oogamous).

Eg:- Mucor, Rhizopus (bread mould) and Albugo (the parasitic fungi on mustard).

2. Ascomycetes (Sac- fungi).

- Known as sac fungi
- They are rarely unicellular, Eg:- yeast (saccharomyces).
- Mostly multicellular, Eg:- penicillium.
- They are saprophyte, decomposers, parasite or coprophilous (growing on dung).
- Mycelium is branched and septate.

Asexual reproduction

Asexual spores are **conidia** produced exogenously on special mycelium called **conidiphores.** Conidia on germination produce mycelium.

Sexual reproduction

Sexual spores are ascospores produced endogenously in Sac - like asci (singular ascus). These asci are arranged in fruting bodies called ascocarps.

Eg:- Aspergillus, claviceps and Neurospora.

Economic Importance

- Neurospora is extensively used in bio - chemical and genetic work.
- Morels & truffles are edible and are considered delicacies.

3. **Basidiomycetes (bracket fungi)**

- They are called mushrooms, bracket fungi or puff balls etc.
- They grow in soil, on log and tree stumps and living in plant body as parasite.
  Eg:- rusts & smuts.
- The mycelium is branched and septate.

Asexual reproduction.

Generally not found.

Vegetative reproduction.

By fragmentation.

Sexual reproduction

- Sex organs are absent
- Plasmogamy is brought about by fusion of 2 vegetative/ somatic cells of different strains or genotypes. The resultant structure is dikaryotic which gives rise to basidium.
- Karyogamy and meiosis take place in basidium producing four basidiospore.

Basidiospores are exogenously produced on basidium (plural :- basidia)

Basidia are arranged in fruting body called basidiocarp.

Eg:- Agaricus (mushroom) Ustilago (smut fungus) Puccinia (rust fungus)

4. **Deuteromycetes (Imperfect fungi).**

- They are known as imperfect fungi because only the asexual or vegetative phase of the fungi are known.
- When the sexual form of the fungi where discovered, they were moved into classes they rightly belong to.
- It's also possible that asexual & vegerative phase has been given one name (and placed under deuteromycetes) and the sexual stage another (and placed under another class). Later when linkages were established, fungi were correctly identified & moved out of deuteromycetes.
- Once perfect (sexual) stage of members of deuteromycetes were discovered, they were often moved to ascomycetes and bascidiomycetes.
- Deuteromycetes reproduce only by asexual spores (conidia).
- Mycelium is septate and branched. Majority are decomposers of litter and help in mineral cycling.

  Eg:- Alternaria, Colletotrichum and Trichoderma.

IV. KINGDOM PLANTAE

- It includes all eukaryotic, chlorophyll containing organisms commonly called plants.
- Some are partially heterotrophic such as insectivorous plants eg:- Bladderwort and venus fly trap and parasite Eg:- cascuta.
- Plant cells have an eukaryotic structure with prominant chloroplast and cell wall mainly made of cellulose.
- Plants include algae, bryophytes, pterido phytes. Gymnosperms and angiosperms.
- Life cycle of plants has 2 distinct phases.
- The diploid sporophyte and the haploid gametophyte, that alternate with each other.
- The length of haploid and diploid phase are free living or dependent on others, vary among different group in plants.
- This phenomenon is alternation of generation.

V. KINGDOM ANIMALA

- Its characterized by heterotrophic eukaryotic organisms, that are multicellular and their cell lack cell wall.
- They directly or indirectly depend on plants for food.
- They digest their food in an internal cavity and store food reserve as glycogen or fat.

- Their mode of nutrition is holozoic - by ingestion of food.
- They follow definite growth pattern and grow into adult that have definite size and shape.
- Higher forms show elaborate sensory and neuromotor mechanism.
- Most of them are capable of locomotion.

Sexual reproduction

It's by copulation of male and female followed by embryogenal developement.

VI. Viruses, Viroids, Prions And Lichens.

- In five kingdom classification of Whittaker, there is no mention of some acellular organisms like virus, viroid and lichens.
- Viruses are not 'truly living'. So they are not included in five kingdom classification.
- Viruses are non - cellular organisms that are characterized by having an inert crystalline structure outside the living cell.
- They are obligate parasite (They require a host cell to complete their life cycle).
- Once they infect a cell, they take over machinery of host cell to replicate themselves and kill the host.
- In addition to protein, viruses also contain genetic material, it can be either RNA or DNA. No virus contains both DNA and RNA.
- So virus is a nucleoprotein and the genetic material is infectious.
- In general, viruses that infect plant have single stranded RNA and virus that infect animal have either single or double stranded RNA or double stranded DNA.
- The name virus means venom or Poisonous fluid was given by Louis Pasteur
- D.J. Ivanowsky (1892) recognized certain microbes as casual organism of mosaic disease of tobacco.
- These are found to be smaller than bacteria, because they passed through bacteria-proof filters.
- M.W. Beijerinek (1898) demostrated that the extract of infected plant of tobacco can cause infection in healthy plants. The fluid is called **Contagium vivum fluidum** (infectious living fluid).
- W.M.Stanley (1935) showed that viruses could be crystallized and crystals consist largely of proteins.
- Viruses that infect bacteria are called Bacteriophages.
- Bacterialviruses or bacteriophages are usually double stranded DNA virus.
- The protein coat called capsid made of small subunit called capsomeres. It protects the nucleic acid.
- Capsomeres are arranged in helical or polyhedral geometric forms.
- Virus cause disease like mumps, small pox, herpes & influenza.
- AIDS in human is also caused by a virus (HIV).
- In plants, the attacks of virus can cause the symptom like mosaic formation, rolling of leaf, curling of leaf, yellowing and vein clearing, dwarfness and stunted growth.

Viroids

- In 1971, T.O. Diener discovered a new infectious agent that was smaller than virus and cause potato spindle tuber disease.
- It was found to be a free RNA, it lack protein coat that is found in viruses, hence the name viroid.
- RNA of viroid was of low molecular weight.

Prions

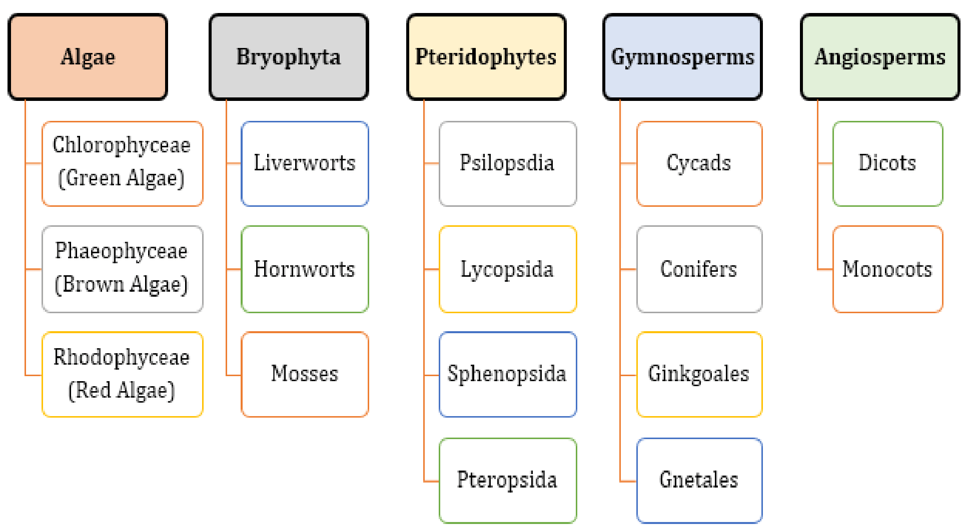
- It is an agent consisting of abnormally folded protein which can cause infectious neuroligical diseases.
- It is similar in size to viruses
- The disease caused by prions are bovine spongi form encephalopathy (BSE) Commonly called mad cow disease in cattle and its analogous variant of Cr - Jacob desease (CJD) in
humans

Lichens

- Lichens are symbiotic associations. ie, mutually usefull associations between algae and fungi. Algal component is phycobiont & Fungal component is mycobiont, which are autotrophic and heterotrophic respectively.
- Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients & water for its partner.
- Lichens are very good pollution indicator they do not grow in polluted area.
- Litmus is obtained. It is commonly used as acid - base indicator in laboratories

CHAPTER 1: PLANT KINGDOM

Eukaryotic, multicellular, chlorophyll containing and having cell wall, are grouped under the kingdom Plantae. It is popularly known as plant kingdom.



Types of Classification System

These includes artificial system, natural system and phylogenetic system of classification.

Artificial System of Classification

This system is based on comparison of one or a few superficial characteristics, which are helpful in easy identification of organisms. This system use only few superficial characters (i.e., habits, numbers, colours and shapes of leaves, etc) which leads to many organisms grouped together,

Natural System of Classification

It is also known as phenetic system of classification. The natural system of classification is based on natural affinities among the organisms. It considers both external and internal features like structure, anatomy, embryology and phytochemistry.

Phylogenetic System of Classification

The phylogenetic system of classification indicates the evolutionary as well as genetic relationships among organisms. This system is based on fossil records of biochemical, anatomical, morphological, physiological, embryological and genetical.

If there is no supporting fossil evidences, we now use information from many other sourses to help to resolve the difficulties in classification.These are the following branches

- **Numerical Taxonomy** use computer by assigning code for each character and analyzing the features.
- **Cytotaxonomy** is based on cytological information like chromosome number, structure and behaviour.
- **Chemotaxonomy** uses chemical constituents of plants to resolve the confusion.

ALGAE: These include the simplest plants which possess undifferentiated or **thallus like forms**, reproductive organs single celled called gametangia. It includes only Algae.

Characteristic of Algae

- Plant body is thallus, which may be unicellular, colonial, filamentous or parenchymatous.
- Usually aquatic but a few are also found in moist terrestrial habitats like tree trunks, wet rocks, moist soil, etc.
- Vascular tissues and mechanical tissues are absent.
- Reproduction is vegetative by fragmentation, asexual by spore formation (zoospores) and sexual reproduction by fusion of two gametes which may be Isogamous (*Spirogyra*), Anisogamous (*Chlamydomonous*) or Oogamous (*Volvox*).
- Life cycle is various- haplontic, diplontic or diplohaplontic.

Green Algae	Brown Algae	Red Algae
Mostly fresh water and sub aerial.	Mostly marine.	Mostly marine.
Unicellular organisms abundant.	Unicellular species are absent. The plant body has holdfast, stipe and frond	Unicellular species fewer.
Chlorophyll a,b	Chlorophyll a, c ,Fucoxanthin	Chlorophyll a,d ,Phycoerythrin
Reserve food is starch. Members have storage bodies	Reserve food is laminarin.	Reserve food is floridean starch.

called **pyrenoids** in chloroplast		
Cell wall is of cellulose.	Cell wall contains cellulose and algin.	Cell wall contains cellulose and poly-sulphate esters.
Zoospores present.2-8 equal flagella,apical	Zoospores are pyriform.2 flagella,unequal and lateral	Zoospores absent.Sexual reproduction is oogamous . Post fertilisation developments present
Chlamydomonas, Ulothrix, spirogyra.	Focus, Sargassum, ectocarpus.	Polysiphonia, Gelidium, Porphyra etc.

Economic importance-

1. A number of brown algae (*Porphyra*,*Laminaria, Sargassum*) are used as food in some countries.
2. Fucus, and Laminaria are rich source of Iodine.
3. Certain brown algae and red algae produce large amount of hydrocolloids (Algin and carageen)
4. Agar obtained from Gelidium and Gracilaria used to grow microbes,used for the preparation of icecreams and jelliies
5. Chlorella,a unicellular green algae is used as a food suppliment

BRYOPHYTES – They are non-vascular mosses and liverworts that grow in moist shady region. They are called amphibians of plants kingdom because these plants live on soil but dependent on water for sexual reproduction.

Characteristic features-

- Live in damp and shady habitats, found to grow during rainy season on damp soil, rocks, walls, etc. Sporophyte is dependent on gametophyte for nourishment
- The dominant phase or plant body is free living gametophyte.
- Roots are absent but contain rhizoids
- Vegetative reproduction is by fragmentation, tubers, gemmae, buds etc. sex organs are multicellular and jacketed. The male sex organ is called **antheridium.** They produce biflagellate antherozoids. The female sex organ called **archegonium** is flask-shaped and produces a single egg.

Economic importance

- Some mosses provide food for herbaceous animals
- Peat moss Sphagnum provide peat that have long been used as fuel,packing materials for transhipment of living materials
- Mosses along with lichens are the first organism to colonise on rocks
- Prevent soil erosion

Bryophytes are classified into-

1. **Liverworts.**

- The plant body of a liverwort is thalloid, e.g., Marchantia. The thallus is dorsiventral and closely appressed to the substrate.
- Asexual reproduction in liverworts takes place by fragmentation, or by the formation of specialised structures called **gemmae.**
- Gemmae are green, multicellular, asexual buds, which develops in small receptacles called gemma cups. The gemmae becomes detached from the parent body and germinate to form new individuals
- During sexual reproduction, male and female sex organs are produced either on the same or on different thalli. The sporophyte is differentiated into a foot, seta and capsule. Spores produced within the capsule germinate to form free-living gametophytes.

2. **Mosses**

- The gametophyte consists of two stages- the first stage is **protonema** stage, which develops directly from spores. It is creeping, green and frequently filamentous. The second stage is the **leafy stage**, which develops from secondary protonema as lateral bud having upright, slender axes bearing spirally arranged leaves.
- Vegetative reproduction is by the fragmentation and budding in secondary protonema. In sexual reproduction, the sex organs antheridia and archegonia are produced at the apex of the leafy shoots.
- Sporophytes in mosses are more developed and consist of foot, seta and capsule.Common examples are *Funaria, Polytrichum, Sphagnum* etc.

PTERIDOPHYTES

- They are seedless vascular plants that have sporophytic plant body and inconspicuous gametophyte. Sporophytic plant body is differentiated into true stem, roots and leaves.
- Vascular tissue are present but vessels are absent from xylem and companion cells and sieve tube are absent.
- Sporophytes bear sporangia that are subtend by leaf like appendages called **sporophylls**. In some plants (*Selaginella*) compact structure called strobili or cone is formed.
- Sporangia produce spores by meiosis in spore mother cells. Spores germinate to produce multicellular thalloid, **prothallus.**
- Gametophyte bears male and female sex organ called antheridia and archegonia. Water is required for fertilisation of male and female gametes.
- Most of Pteridophytes produce spores of similar kind (**homosporous**) but in *Selginella* and *Salvinia*, spores are of two kinds (**heterosporous**) larger called megaspore that produce female gametophyte and smaller microspore that produce male gametes.
- Heterospory is a precursor to seed habit:The development of zygote into young embryos takes place within the female gametophyte which is retained on the parent sporophyte.This event is a precursor to seed habit.

GYMNOSPERMS:

- Gymnosperms are those plants in which the ovules are not enclosed inside the ovary wall and remain exposed before and after fertilisation.

- They are perennial and woody, forming either bushes or trees. Some are very large (*Sequoia sempervirens*) and others are very small (*Zamia pygmia*).
- Stem may be unbranched(Cycas) or branched(Pinus). Root is taproot. Leaves may be simple or compound.
- Roots of Pinus have fungal association to form mycorhiza
- Cycas have small specilised roots called coralloid root which are associated with nitogen fixing cyanobacteria.
- Leaves of gymnosperms are well adapted to withstand extreme environmental conditions.Eg.Needle leaves reduce surface area,sunken stomata,thick cuticle
- They are heterosporous, produce haploid microspore and megaspore in male and female Strobili respectively.
- Male and female gametophytes do not have independent free-living existence. Pollination occurs through air and zygote develops into embryo and ovules into seeds. These seeds are naked.
- Example- Pines, Cycus, Cedrus, Ginkgo, etc.

ANGIOSPERMS

- Pollen grain and ovules are developed in specialized structure called flower. Seeds are enclosed inside the fruits.
- Size varies from almost microscopic Wolfia (0.1cm)to tall tree Eucalyptus (more than 100m
- The male sex organs in a flower is the stamen. It contains pollen grain.
- The female sex organs in a flower is the pistil or the carpel. Pistil consists of an ovary enclosing one or many ovules. Within ovules are present highly reduced female gametophytes termed **embryo-sacs**.
- Each embryo-sac has a three-celled egg apparatus – one egg cell and two synergids, three antipodal cells and two polar nuclei. The polar nuclei eventually fuse to produce a diploid secondary nucleus.

Angiosperms are further classified into:

- Monocotyledons
- Dicotyledons

Monocotyledons	Dicotyledons
1. Single cotyledons. 2. Parallel venation. 3. Fibrous root system. 4. Closed vascular bundle. 5. More number of vascular bundles. 6. Banana, wheat, rice.	1. Two cotyledons. 2. Reticulate venation. 3. Tap root system. 4. Open vascular bundle. 5. Less number of vascular bundles. 6. Gram, mango, apple.

- **Double fertilisation-** Each pollen grain produce two male gametes. One gametes fuse with egg to form embryo. This is called Syngamy. Other gametes fuse with two polar nuclei to form endosperm, triple fusion. Since fertilisation takes place twice, it is called double fertilisation.

Alternation of generation

Different plant groups complete their life cycles in different patterns. Angiosperms complete their life cycle in two phases- a diploid sporophytes and haploid gametophyte. The two follows each other. This phenomenon is called alternation of generation.

Haplontic- Saprophytic generation is represented by only the one-celled zygote. Meiosis in zygote results into haploid spores to form gametophytes, which is the dominant vegetative phase. Example- Volvox, Spirogyra etc.

Diplontic- Diploid sporophytes is dominant, independent, photosynthetic plants. The gametophyte is represented by single to few celled. All seed bearing plants fall under this category.

Haplo-diplontic- Both phases are multicellular and intermediate condition is present. It is present in Bryophytes and Pteridophytes.

CHAPTER: 3 MORPHOLOGY OF FLOWERING PLANTS

ROOT (Underground non-green part)

Arised from **radicle**

Arised from any part other than radicle

Taproot system

Primary root & its branches (network like arrangement) eg., Dicot plants

Fibrous root system

Short lived primary root replaced by large number of roots. (roots arised from base of the stem). Eg., Monocot plants

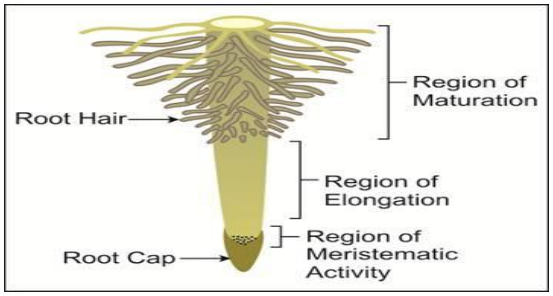
Adventitious root system

eg., Banyan tree, beetle, pepper etc

Regions of root

1. **Root cap** – Thimble-like structure which cover the root tip . It **Protects the root tip**
2. **Region of Meristemmatic activity** – Small, thin walled cells with dense protoplasm. They **divide repeatedly**.
3. **Region of elongation** – Undergo rapid elongation & enlargement. Responsible for growth in length**.**
4. **Root hair** – Fine, delicate ,thread-like structures present on epidermis. They **absorb water & minerals.**

5. **Region of maturation** – Region just above the region of elongation. Root hairs & lateral branches are arised from this region. **Mature tissues perform specific functions**



Modifications of Root (Roots change their shape & structure to perform special functions)

- Modification for **Storage** -eg., Carrot, Beetroot, Radish, Sweet potato , Mango ginger , Asparagus etc.
- Modification for **Climbing** - eg., betle, pepper, etc
- Modification for **Support** – (1) **Prop root** (Pillar like roots from branches) eg., Banyan tree. (2) **Stilt root** (Roots from lower nodes) eg., Maize & Sugarcane.
- Modification for **Respiration** - **Pneumatophores** (Roots grow vertically upwards to get Oxygen). eg., Rhizophora (growing in marshy areas)

STEM

- Aerial , green part which bear branches, leaves, flowers & fruits.
- **Nodes** – Region where leaves are born
- **Internodes** – Portion between two nodes.
- Stem bears **Buds**, Axillary /Terminal
- Underground parts are not always root. Potato, Ginger etc are Unerground Stems which store food. Nodes & Internodes are present in them.

Modification of Stem –(Stem modified to perform special functions)

- Under ground Stem modification for **Storage & Vegetative reproduction** –eg., Potato, Ginger, Yam, Onion, Colochasia, Tamarind etc.
- Sub aerial Stem modification for **Vegetative reproduction** :-
    1. **Runner** eg., Grass, Strawberry, Oxalis etc (have long Internodes. leaves & roots arised from nodes).
    2. **Stolon** –eg., Mint, Jasmine etc (Lateral branch from base of main stem grow aerially for sometime & arch downwards to touch the soil).
    3. **Offset** –eg., Pistia, Eichhornia etc (Short internode. Rosette of leaves & tuft of roots arised from node).

4. **Sucker** – eg., Banana, Pineapple, Chrysanthemum etc (lateral branch from underground &basal part of stem grow horizontally & then come out to grow vertically upward)

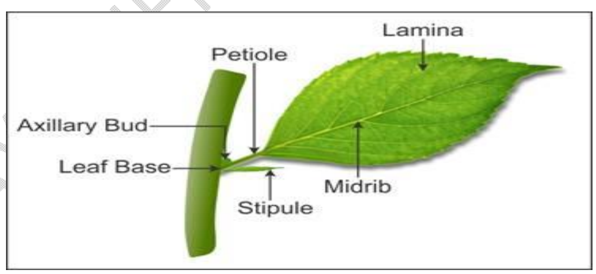
- Modification for **Photosynthesis** – eg., Opuntia (flattened stem) , Euphorbia (fleshy cylindrical stem)
- Modification for **Climbing** – eg., **Tendril** (Slender ,spirally coiled structure develop from axillary buds) in Cucumber, Bittergourd, Pumpkin,Watermelon, Grapevines etc.
- Modification for **Protection** – eg., **Thorns** (Woody, straight&pointed structure develop from Axillary bud) in Citrus, Bougainvilla etc.

LEAF

- Lateral, green flattened structure born on stem
- Develops at node & bear Bud (Axillary bud later develops to branch) in its axil.
- Originate from shoot apical meristem & arranged in an Acropetal order
- Function – Photosynthesis.

Parts of leaf

- **Leaf base** – Attach leaf to stem. It bear two lateral leaf like structures (**Stipule**). **Sheathing leaf base -** Leaf base expands into a sheath covering the stem partially /wholly eg., Monocots. **Pulvinous leaf base** – Swollen leaf base eg., Pea plants.
- **Petiole** Stalk of leaf which hold lamina to light & allow lamina to flutter in the wind.
- **Lamina / Leaf blade** – green expanded part with **Veins** (It provide rigidity to lamina & channels of transport of water, minerals and food) & **Veinlets**. Middle prominent vein is **Midrib**.



Venation (Arrangement of veins on lamina)

Reticulate venation

Veins & Veinlets are arranged in the form of a network. eg., Dicot plants

Parallel venation

Veins are arranged parallel to one another. eg., Monocot plants.

Types of Leaf

Simple leaf

Lamina is entire, or when inscise, inscisions do not touch the midrib. eg., china rose

Compound leaf

Inscisions of the lamina reach up to the midrib. Lamina divided into leaflets.

Pinnately compound leaf

Number of leaflets are arranged on a common axis called **rachis.** eg., Tamarind, curry leaf, neem etc

Palmately compound leaf

Leaflets are attached at a common point ie., at the tip of petiole. eg., Silk cotton, Tapioca

A bud is present in the axil of petiole in both simple & compound leaves, but not in the axil of leaflets of compound leaf.

Phyllotaxy (Arrangement of leaves on stem or branch)

Alternate

Single leaf from each node in alternate manner. eg., china rose,mustard, sunflower etc.

Two leaves from each node & lie opposite to each other. eg., Guava, calotropis ,

More than two leaves from one node & form a whorl. eg., Alstonia, Allamanda etc

Modification of leaf

- **Modification for storage – Scale leaves** – Fleshy leaves of onion & garlic.
- **Modification for climbing – Tendrils** – Spirally coiled structure. eg., Pea, Gloriosa
- **Modification for defence & to reduce transpiration - Spine leaf -** eg., Cactus
- **Modification for photosynthesis – Phyllode** –eg., In Acacia, leaves are small & short lived. So Petiole expand, become green to perform photosynthesis.
- **Modification to catch insects** - eg., Pitcher plant , venus-fly-trap .

INFLORESCENCE (arrangement of flowers on floral axis)

Racemose

Peduncle (main axis) continues to grow (unlimited growth). Flowers borne laterally in an **Acropetal succession. eg.,Crotalaria**

Cymose

Main axis terminates in a flower (limited growth). Flowers borne in a **Basipetal succession**. eg., Jasmine

FLOWER – Reproductive Part in Angiosperm

Flower is a modified shoot – Shoot apical meristem changes to floral meristem. Internodes do not elongate. Axis gets condensed. Apex produce floral whorls laterally at successive nodes instead of leaves. When a shoot tip transforms into a flower, it is always **Solitary**.

Pedicel	Stalk of flower
Thalamus/ Receptacle	Swollen tip of pedicel from which floral whorls arises.
Bisexual flower	Flower has both androecium & gynoecium. eg., Ixora
Unisexual flower	Flower having either androecium /gynoecium eg., Cucumber
Actinomorphic symmetry	Flower can be divide into two equal parts in any radial plane passing through the centre eg., Mustard, Datura, Chilli, Shoe flower etc
Zygomorphic symmetry	Flower can be divided into two equal parts only in one plane eg., Pea Gulmohur, Bean, Cassia etc
Asymmetric	Flower cannot be divided int two equal parts by any vertical plane passing through the centre . eg., Canna
Trimerous flower	Floral whorls are 3 /multiples of 3 in number
Tetramerous	Floral whorls are 4 /multiples of 4 in number
Pentamerous	Floral whorls are 5 /multiples of 5 in number
Bract	Reduced leaf found at the base of the pedicel (flower with bract – Bracteate. Flower without bract – Ebracteate)
Aestivation	Arrangement of sepal / petals in floral bud with respect to other members of same whorl.
Placentation	Arrangement of ovules within the ovary
Epipetalous	Stamens are attached to petals eg., Brinjal
Epiphyllous	Stamens are attached to perianth eg., Lilly

Monoadelphous	Stamens are united to form single bundle eg., Shoe flower
Diadelphous	Stamens are united to form 2 bundles eg., Pea, Crotalaria
Polyadelphous	Stamens are united to form more than 2 bundles eg., Citrus
Staminode	Sterile stamen

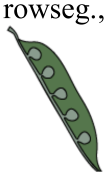
Parts of flower

- **Calyx** - Outer, green whorl. Its members are **Sepals**. It Protect flower in the bud stage. May be **Gamosepalous** (united sepals) or **polysepalous** (free sepals.)
- **Corolla** _ Second whorl. Members are petals (brightly coloured to attract insects for pollination) **gamopetalous** (united petals) .**polypetalous** (petals free). Shape of corolla may be varied.
- **Perianth** – Undifferentiated calyx and corolla. Members are **Tepals**.
- **Androecium** _Male reproductive organ. Composed of **stamens** (consists of filament & anther).Anther is bilobed & each lobe has two chambers (pollen_sacs in which pollen grains are produced). Stamens in a flower may either remain free (**Polyandrous**) or united . Length of the filament in a flower may be varied eg., Salvia & Mustard.
- **Gynoecium** – Female reproductive organ. Basic unit is **carpel.** Carpel consists of 3 parts (Ovary (enlarged basal part), Style (elongated tube) & Stigma (Receptive surface for pollen grain). Ovary bear ovules. Ovules are attached to flattened, cushion like **Placenta**. Ovary may be **Monocarpellary** (one carpel) or **Multicarpellary** (more than 1 carpel). Carpels may be **Apocarpous** (free carpels eg., lotus, rose)or **Syncarpous** (united carpels eg., Mustard & tomato). Later Ovules develop into seeds and Ovary into Fruit.

Aestivation

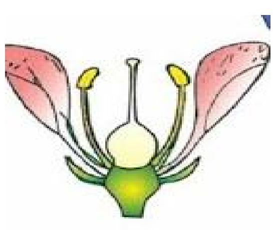
Valvate	**Twisted**	**Imbricate**	**Vexillary**
Sepals /Petals in a whorl just touch one another without overlapping	Regular overlapping eg., Shoe flower, ladies finger, cotton	Irregular overlapping eg., cassia, gulmohur etc	5 petals. 1 large standard petal overlap 2 wing petals which in turn

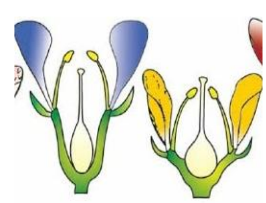
Placentation

Marginal	Axile	Parietal	Freecentral	Basal
Placenta forms a ridge along the ventral suture of the ovary, ovules are borne on this ridge forming two rowseg., Pea 	Ovules on central axis of syncarpous ovary, septa present eg., china rose, tomato, lemon 	Ovules Develop on inner wall of ovary. eg., mustard, Argemone. 	Ovules on central axis, septa absent eg., Dianthus &Primrose 	Single ovule at the base of the ovary eg., Sunflower, Marigold 

Flower

Hypogynous	Epigynous	Perigynous
Gynoecium occupies the highest position, other parts are situated below it. Ovary superior.	Margin of thalamus grows upward enclosing the ovary completely & fused with ovary. other parts arise above the ovary . Inferior ovary. eg., Guava, Cucumber, ray florets	Gynoecium situated in the centre. Other parts are located on the rim of thalamus almost at the same level. Half inferior ovary eg., Pea, Plum, Rose,Peach ,





Fruit

- Ovary is developed into fruit after fertilization
- **Pericarp**- Fruit wall.
- Fleshy fruit – Pericarp is thick & fleshy. Pericarp is differentiated into outer **Epicarp** , middle **Mesocarp** and inner **Endocarp**. In mango, mesocarp is fleshy. In coconut, mesocarp is fibrous.
- In mango & coconut, fruit is known as **Drupe**

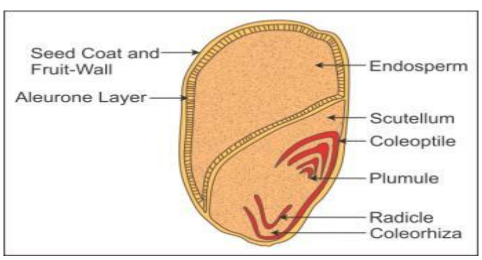
Seed

- Ovule developed into seed after fertilization.
- **Seed coat -** Outermost covering of seed. It has two layers, outer **testa,** & inner **tegmen.**
- **Hilum** – Scar on the seed coat through which seeds were attached to fruits.
- **Micropyle** – Small pore just above the hilum.
- **Embryo** – Zygote developed into embryo. Consists of **embryonal axis & cotyledon**.
- **Cotyledon** first formed leaf. Fleshy & reserve food material (give food to developing seedling)
- **Radicle**- Part of embryo that develops into root
- **Plumule** – Part of embryo that develops into shoot
- **Endosperm** – Nutritive tissue for embryo.
- Dicot seeds contain two cotyledons & monocot seeds contain one cotyledon

Seed

Endospermous / Albuminous	**Non-endospermous / Exalbuminous**
Seeds which store their food in endosperm. eg., castor, rice, coconut ,orchids etc.	Endosperm is not present in mature seeds. Store their food in cotyledons. eg., bean, pea, gram, etc

Monocot seed



- Most of the monocot seeds are endospermic, but orchid is non-endospermic.
- In the seeds of cereals like maize, membraneous seed coat fused with fruit wall.

- **Aleuron layer**- Proteinaceous outer covering of endosperm that separates the embryo
- **Scutellum**- Large & shield shaped cotyledon
- Embryonal axis contain **Plumule & Radicle**
- **Coleoptile** –protective sheath covering of plumule
- **Coleorhiza**- Protective sheath covering of radicle

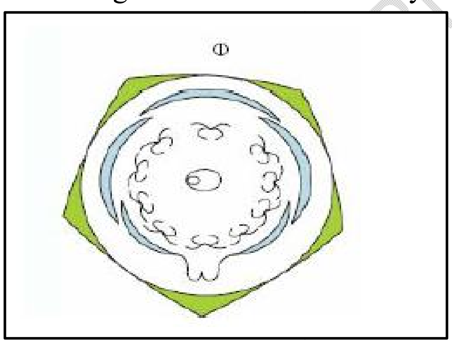
FABACEAE - Old name- Papilionoideae, subfamily of family Leguminosae. Also known as **Pea family**.

Vegetative characters

- Habit – trees, shrubs or herbs. Root nodules present
- Stem- erect / climber
- Leaves – alternate, pinnately compound /simple, pulvinous leaf base, stipulate, reticulate venation

Floral characters

- Inflorescence – Racemose
- Flower – Bisexual, Zygomorphic, Pentamerous, Perigynous
- Calyx – 5 sepals, Gamosepalous, Valvate aestivation
- Corolla – 5 petals, papilionaceous corolla, vexillary aestivation
- Androecium – 10 stamens Diadelphous
- Gynoecium – monocarpellary, unilocular, half inferior ovary, marginal placentation
- Fruit – legume. Seed –one to many seeded.



$$\% \; ⚥ \; K_{(5)} \; C_{1+2+(2)} \; A_{(9)+1} \; \underline{G}_1$$

Economic importance

- **Sources of pulses** – Gram (chana), soyabean, pigeon pea(arhar), pea, greengram, black gram , beans etc.
- **Edible oil**- Soyabean, ground nut
- **Dye**- Indigofera
- **Fibres**- Sunhemp
- **Fodder**- Sesbania, Trifolium
- **Ornamentals**- Lupin, Sweetpea
- **Medicine**- Muliathi, pigeon pea, clitorea(sankhupushpam) etc.

SOLANACEAE - Also known as **Potato family**.

Vegetative characters

- Habit – herbs, shrubs, rearly trees
- Stem – herbaceous, rearly woody, aerial, erect, cylindrical , branched, solid,/hollow, underground stem in potato
- Leaves – simple, alternate, rearly pinnately compound, exstipulate, reticulate venation

Floral characters

- Inflorescence – Solitary or cymose
- Flower – Bisexual, actinomorphic
- Calyx – 5 sepals, gamosepalous, valvate aestivation
- Corolla – 5 petals, gamopetalous, valvate aestivation
- Androecium – 5 stamens, epipetalous
- Gynoecium – bicarpellary, syncarpous, superior ovary, bilocular, swollen placentation with many ovules.
- Fruits – berry / capsules
- Seeds- many, endospermous.

$\oplus$ ⚥ $K_{(5)}\ \widehat{C_{(5)}\ A_5}\ \underline{G}_{(2)}$

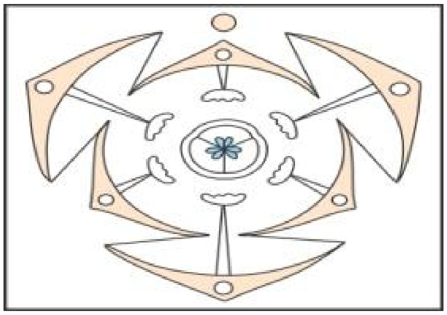
LILIACEAE - Also called as **Lily family**. Monocots

Vegetative characters

- Stem- Perennial herbs , underground bulbs/ corms/ rhizhomes
- Leaves- alternate, exstipulate, parallel venation

Floral characters

- Inflorescence – Cymose
- Flower – Bisexual, Actinomorphic, Trimerous, Hypogynous
- Perianth – 6 tepals (3+3) united, Epiphyllous
- Gynoecium – Tricarpellary, Syncarpous , Trilocular, Superior ovary with Axile placentation
- Fruit – Berry /Capsule. Seed – Endospermous



$Br \oplus \text{⚥} \, \widehat{P_{(3+3)} A_{3+3}} \, \underline{G}_{(3)}$

Economic importance

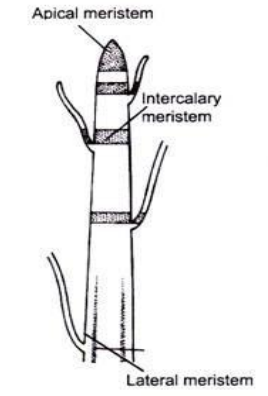
- **Edible** – onion, garlic, asparagus etc.
- **Ornamentals**- Tulip, gloriosa etc
- **Medicine**- Aloe (kattarvazha), Colchicum. Autumnale (produce **Colchicine)**

CHAPTER 4: ANATOMY OF FLOWERING PLANTS

Tissues - Group of cells having common origin and common function. Based on the dividing capacity, they are classified into two **Meristematic Tissues** and **Permanent tissues** **Meristems**- Actively dividing cells. Based on the position, they are divided into 3. Apical, intercalary & lateral meristems.

1. **Apical meristem**
   - Occur at the tip of root & shoot
   - Primary meristem (produce primary tissues)
   - Appear early in the life of a plant
   - Function – Growth in length.
   - **Axillary buds -** Left out cells of shoot apical meristem (during the formation of leaf & elongation of stem). They are present in the axils of leaves & are capable of forming a branch / Flower.
2. **Intercalary meristem**
   - Occurs between permanent tissues (mature tissues)
   - Occur in grasses (nodes of monocot plants) and regenerate parts removed by the grazing herbivores
   - Primary meristem (produce primary tissues)
   - Appear early in life of a plant.
3. **Lateral meristem**
   - Occurs in the mature regions of root and shoot.
   - Cylindrical meristems
   - Secondary meristem (produce secondary tissues)

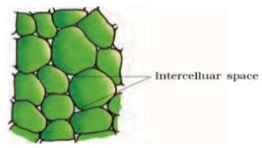
- Appear later in the life of plant than primary meristem.
- Function –Secondary thickening (increase in girth / Produce woody axis)
- eg., Vascular cambium & Cork cambium.



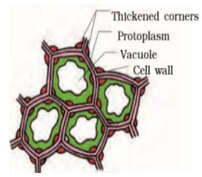
Permanent tissues – Structurally & functionally specialized cells lose the ability to divide. Permanent tissues are classified into two. **Simple Tissues** (made up of only one type of cells) and **Complex Tissues** (Made of more than one type of cells & these work together as a unit).

Simple Tissue

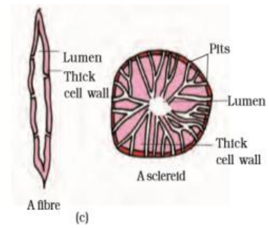
1. **Parenchyma**
   - Generally isodiametric in shape. They may be spherical, oval, round, polygonal or elongated in shape.
   - Thin cellulosic cell wall
   - They may either be closely packed or have small intercellular spaces.
   - Perform various functions like photosynthesis, storage & secretion
2. **Collenchyma**
   - Cells thickened at the corners due to the deposition of **cellulose, hemicelluloses & pectin**.
   - Oval, spherical or polygonal in shape
   - Intercellular space absent
   - Cells assimilate food when they contain chloroplast
   - Provide mechanical support to growing parts of the plant such as young stem & petiole of a leaf
3. **Sclerenchyma**
   - Cell walls are thickened due to the deposition of **lignin**
   - Dead cells without protoplasts
   - On the basis of variation in form, structure, origin & development sclerenchyma may be either fibres or sclereids.
   - **Fibres**- Thick walled, elongated & pointed cells generally occurring in groups
   - **Sclereids** – Spherical, oval or cylindrical ,highly thickened dead cells with very narrow cavities . Found in the fruit walls of nut, pulp of fruits (like guava, pear, & sapota), Seed coat of legumes and leaves of tea.



Parenchyma



Collenchyma



Sclerenchyma – fibre & sclereid

<u>Complex Tissues</u>

1. **<u>Xylem</u>**
- Conducting tissue for water & minerals (from root to stem & leaves)
- Provide mechanical strength to plant parts.
- Composed of 4 types of cells
  - (a) **Tracheids** -Elongated /tube like cells. Thick & lignified walls (Inner layers of cell walls have thickenings) . Tapering ends. Dead & without protoplasm.
  - (b) **Vessels** – Long Cylindrical tube-like structure made up of many cells called vessel members (each with lignified walls & large central cavity). Dead cells without protoplasm. Vessel members are interconnected through Perforations in their common walls.
  - (c) **Xylem fibres** – Sclerenchyma fibres .Dead cells. Highly thickened walls. Obliterate central lumen. Septate /Aseptate.
  - (d) **Xylem parenchyma** - Living thin walled cells with cellulosic cell wall. Store food materials in the form of starch / fat and other substances like tannins. Radial conduction occur through Ray parenchymatous cells.
- Gymnosperms lack Xylem vessels (vessel is a characteristic feature of Angiosperm).
- In flowering plants (Angiosperms), Tracheids & vessels are main transporting elements.
- **Protoxylem** – First formed primary xylem. Small vessels
- **Metaxylem** – Later formed primary xylem. Large vessels
- **Endarch xylem** – Protoxlem lies towards the centre & Metaxylem towards Periphery eg., Stem.
- **Exarch xylem** – Protoxylem lies towards periphery & metaxylem towards centre eg., Root.

2. **<u>Phloem</u>**
- Transport food materials (usually from leaves to other parts)
- Composed of 4 type of cells.
  - (1) **Sieve tube elements** – Living ,long tube- like structures. Arranged longitudinally. Associated with companion cells. End walls are perforated

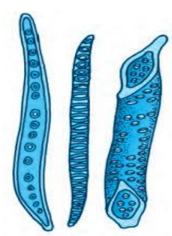
in a sieve like manner & form **sieve plates**. Mature sieve element possesses peripheral cytoplasm & large vacuole. Nucleus absent. Functions of sieve tubes are controlled by nucleus of companion cells.

(2) **Companion cells** – Specialised parenchymatous cells. Connected with sieve tube elements by **Pit fields** present between their common wall. Dense cytoplasm & nucleus present. Helps in maintaining the pressure gradient in the sieve tubes.

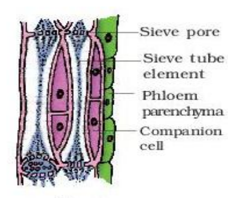
(3) **Phloem parenchyma -** Living parenchymatous cells. Elongated cylindrical, with dense cytoplasm & nucleus. Cellulosic cell wall. Cells are connected with each other through plasmodesmata. Store food & other substances like resins, latex & mucilage. Absent in Monocots.

(4) **Phloem fibres (bast fibres)** – Sclerenchymatous fibres. Absent in primary phloem .Present in secondary phloem. Dead, Lignified, elongated , branched cells with pointed (needle like) end walls. Provide mechanical strength. Phloem fibres of jute, flax & hemp are used commercially.

- Gymnosperms have **albuminous cells & sieve cells (** Sieve tubes & companion cells are absent in gymnosperm).
- **Protophloem** – First formed primary phloem with narrow sieve tubes.
- **Metaphloem** – Later formed Primary phloem with bigger sieve tubes.



Xylem- trachieds & vessels

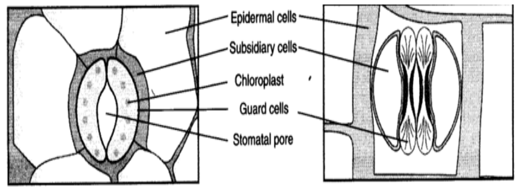


Phloem

Epidermal Tissue System

- Outermost covering of the whole plant body .It consists of Epidermis, Stomata, Trichome , hair & cuticle.
- **Epidermis** – Outermost layer. Elongated compactly arranged cells , forms a continuous layer. Single layered parenchymatous cells with small amount of cytoplasm & large vacuole. Function :- Protection
- **Cuticle** – Waxy thick layer which cover epidermis. It prevents the loss of water. Absent in roots.
- **Stomata** – Pores present in epidermis of leaves & young stems. Stoma /Stomatal pore is surrounded by **Guard cells** (in dicot **bean shaped** guard cells & in monocots **dumb-bell shaped** guard cells are present) .Outer walls of guard cells are thin & the inner walls are highly thickened. Guard cells possess chloroplast & it regulate opening and closing of stomata. Guard cells are surrounded by **Subsidiary cells** (specialised epidermal cells) which are specialised in shape and size. Stomatal pore, guard cells & subsidiary cells together known as **Stomatal apparatus.** Function – Removal of excess water through transpiration & Exchange of gases.

Dicot and Monocot stomata.



- **Root hair** – Unicellular elongations of epidermal cells. Absorb water & minerals from the soil.
- **Trichomes / Stem hair** – Multicellular, branched / unbranched & soft / stiff. May be secretory. Prevent water loss due to transpiration.

Ground Tissue system

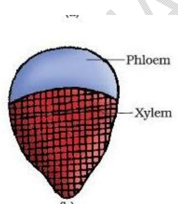
- All tissues except epidermis & vascular bundles.
- Consists of simple tissues
- Cortex, pericycle, medullary ray , pith & mesophyll in leaf constitute ground tissue system.

Vascular Tissue System (Xylem & Phloem together constitute **Vascular bundles.)**

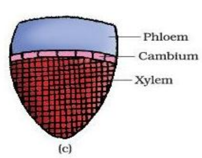
Conjoint vascular bundle :- Xylem & Phloem are in the same bundle on the same radius. Phloem located on the outer side of Xylem eg., Stem.

- **Open vascular bundle** – Cambium present in between Xylem & Phloem (So able to form secondary xylem & phloem) eg., Dicot stem.
- **Closed vascular bundle** – Cambium absent (do not form secondary xylem & phloem) eg., Monocot stem.

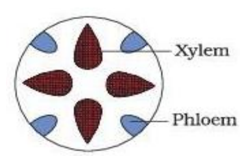
Radial vascular bundle :- Xylem & Phloem occur in separate bundles on different radius. eg., Root.



Conjoint closed.



Conjoint open.



Radial.

Dicot Root

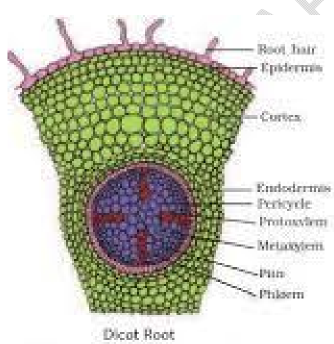
- Ouermost layer is **Epiblema** (Epidermis) Unicellular **root hairs** arise from epidermal cells.
- **Cortex** – Several layers of thin walled parenchymatous cells with intercellular space below the epidermis.

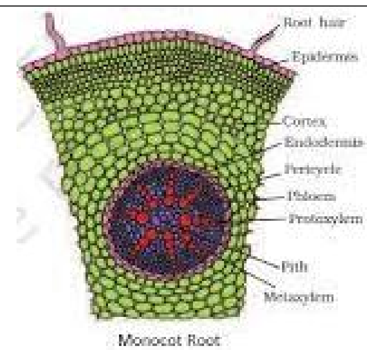
- **Endodermis** – Innermost layer of cortex. Single layer of barrel- shaped cells without intercellular space. Waxy material **Suberin** is deposited on the walls of endodermis (**Casparian thickening)** .So endodermis is impermeable to water.
- **Pericycle** – Few layers of thick walled parenchymatous cells , next to endodermis. Initiation of lateral roots & vascular cambium takes place in these cells.
- **Pith** – Small / inconspicuous
- **Conjunctive tissue** – Parenchymatous cells between the xylem & phloem.
- **Radial vascular bundle** – 2-4 xylem & phloem bundles. **Exarch xylem**.
- **Stele** – All tissues on the innerside of the endodermis such as pericycle, vascular bundles & pith.

Monocot Root -It has outer Epidermis, Cortex, Endodermis, Pericycle, Radial vascular bundles , conjunctive tissue & pith similar to dicot root

Difference between Dicot & Monocot root

Dicot root	Monocot root
In the cortex Air cavity absent.	Air cavity present in the cortex
2-4 Xylem & Phloem bundles	More than six (polyarch) xylem & phloem bundles.
Small pith	Large & well developed pith
Polygonal shaped xylem	Round shaped xylem
Undergo secondary growth	Do not undergo secondary growth



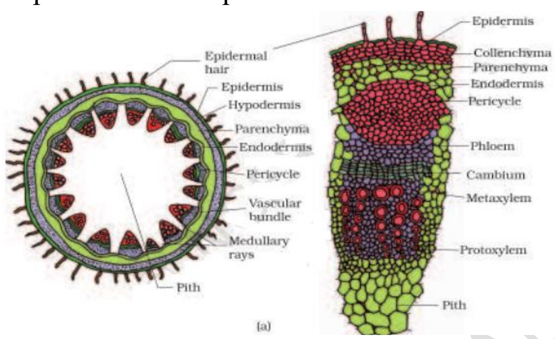


Dicot stem

- **Epidermis** – Outermost protective layer ,covered with a thin layer of **cuticle** , may bear **Trichomes & few stomata**.
- **Cortex** – Several layers between epidermis & pericycle. It consists of 3 sub-zones.

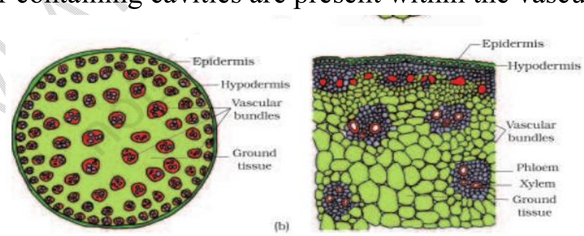
1. **Hypodermis** – Few layers of collenchymatous cells just below the epidermis, which provide mechanical strength to young stem.
2. Rounded thin walled **parenchymatous cortical cells** with intercellular space.
3. **Endodermis** – Innermost layer of cortex. Cells are rich in starch grains , So the layer is **Starch sheath**.

- **Pericycle** – Innerside of the endodermis and above the phloem in the form of semi – lunar patches of sclerenchyma (**Bundle cap)**.
- **Medullary ray** – Few layers of radially placed parenchymatous cells in between vascular bundles.
- **Conjoint, open vascular bundle with endarch xylem**.
- **Pith** – Large number of rounded parenchymatous cells with large intercellular spaces, occupies the central portion of the stem.



Monocot Stem –

- It has Epidermis & Sclrenchymatous Hypodermis.
- Numerous vascular bundles (Conjoint, closed, endarch xylem).
- Peripheral vascular bundles are smaller than centrally located ones.
- Phloem parenchyma absent.
- Water containing cavities are present within the vascular bundle.



Difference between Dicot & Monocot stem

Dicot stem	Monocot stem
Collenchymatous hypodermis	Sclerenchymatous hypodermis
Differentiated cortex	Undifferentiated cortex
Bundle cap present	Bundle sheath present

Limited number of vascular bundles	Numerous Vascular bundles
Vascular bundles arranged in the form of a ring	Scattered vascular bundles
Open vascular bundle (cambium present)	Closed vascular bundles (Cambium absent)
Well developed pith	Pith absent
Undergo secondary growth	Do not undergo secondary growth
Protoxylem lacunae (water containing cavity) absent	Protoxylem lacunae (water containing cavity) present

Difference between Root & Stem

Stem	Root
Conjoint vascular bundle	Radial vascular bundle
Endarch xylem	Exarch xylem
Multicellular hair (Trichome)	Unicellular root hair
Cuticle present	Cuticle absent

Dorsiventral (Dicotyledonous) Leaf

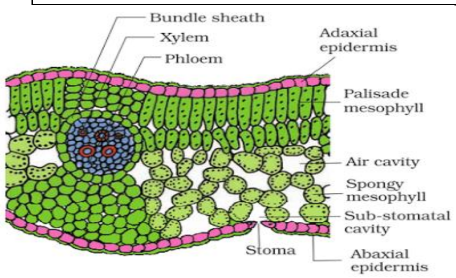
- 3 main parts. Epidermis, Mesophyll & Vascular bundle.
- **Epidermis** -Cover both upper (adaxial) & lower (abaxial) surface.
- **Cuticle** – Covers the upper & lower epidermis.
- **Lower epidermis** bears more stomata.
- **Mesophyll** –Tissue (parenchymatous cells) between the upper & lower epidermis. It possess chloroplast & carry out photosynthesis. It has 2 types of cells.
  1) **Palisade pa*renchyma** – Elongated cells placed below the upper epidermis, arranged vertically & parallel to each other.
  2) **Spongy parenchyma** – Oval /round & loosely arranged parenchymatous cells below the palisade parenchyma & extends to lower epidermis. Intercellular spaces & air cavities are present.
- **Vascular bundles** – Present in the veins & midrib. Vascular bundles are surrounded by a layer of thick walled **bundle sheath cells.**

Isobilateral (Monocotyledonous) Leaf

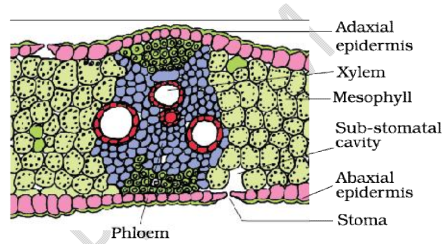
- 3 main parts. Epidermis, Mesophyll & Vascular bundle.
- Stomata are equally distributed on both upper & lower epidermis
- Mesophyll is not differentiated into palisade & spongy parenchyma
- **Bulliform cells** –Large, empty, colourless cells occur in the upper epidermis of many grasses. When they absorb water & are turgid, leaf surface is exposed. When they are flaccid due to water stress, they make the leaves curl inwards to minimize water loss.

Anatomical difference between dicot & monocot leaf

Dicot leaf	Monocot leaf
Mesophyll is differentiated into palisade & spongy parenchyma	Mesophyll is not differentiated into palisade & spongy parenchyma
Bulliform cells absent	Bulliform cells present
lower epidermis has more number of stomata	Equal distribution of stomata on both upper & lower epidermis.
Guard cells of stomata are bean shaped	Guard cells are dumbbell shaped.



Dicot leaf



Monocot leaf

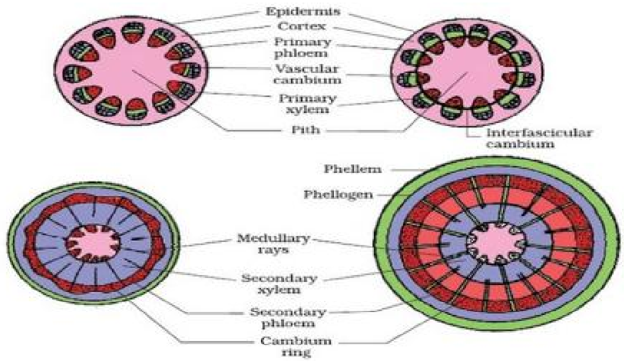
Secondary Growth

- Increase in thickness exhibited by most of the dicot plants.
- Tissue involved in secondary growth – lateral meristems (Vascular cambium & Cork cambium)
- **Vascular cambium** –Meristemmatic layer responsible for cutting off vascular tissues.
- **Cork cambium** – Meristemmatic layer responsible for formation of periderm.
- **Stele**- central part of root & stem consisting of pith, vascular bundles, medullary rays & pericycle.

Stelar Secondary Thickening (by the activity of vascular cambium)

- **Intrafascicular cambium** –cambium present between primary xylem & primary phloem
- Cells of medullary rays, adjoining intrafascicular cambium become meristemmatic to form **Interfascicular cambium.**
- Intra fascicular cambium & interfascicular cambium join together to form **Vascular cambium.**
- Vascular cambium cut off new cells towards inner & outersides. Inner cells mature into **secondary xylem** & outer cells mature into **secondary phloem.**
- Cambium is more active towards innerside. So the amount of secondary xylem is more than the secondary phloem.
- Primary & secondary phloems get gradually crushed due to the continued formation & accumulation of secondary xylem.

- **Secondary medullary rays** – At some places , cambium forms a narrow band of parenchyma which passes through secondary xylem & phloem in the radial directions.



Spring wood / Early wood	Autumn wood / Late wood
Xylem/ Wood formed during spring season	Xylem/ Wood formed during winter season
Cambium is more active & produce large number of xylem having vessels with wider cavities.	Cambium is less active & produce fewer xylem that have narrow vessels.
Lighter in colour	Dark in colour
Lower density	Higher density

- **Annual ring-** The alternation of spring wood & autumn wood in a concentric circle on the trunk. Annual rings in a cut stem give an estimate of the age of tree.

Heart wood

- Older,harder,dead central wood (xylem) of trees
- Secondary xylem is dark brown in colour due to the deposition of resins, tannins, oils, gums, aromatic substances & essential oils.
- Deposition of organic compounds make it hard, durable & resistant to the attack of micro organisms &insects.
- Dead elements with lignified walls.
- Give mechanical support to stem

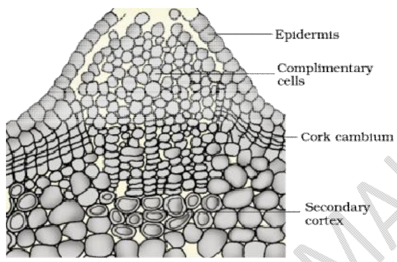
Sap wood

- soft outer layers of recently formed secondary xylem between heart wood & bark
- Lighter in colour
- Involved in the conduction of water & minerals.

Extrastelar Secondary Thickening (by the activity of cork cambium)

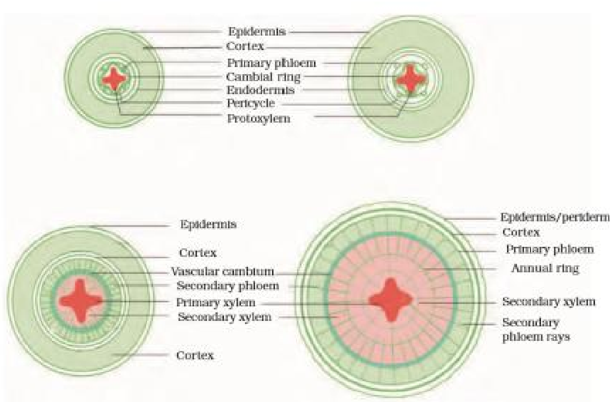
- Due to the activity of vascular cambium, outer cortical & epidermal cells get broken and need to be replaced.

- Some cortical cells become meristemmatic to form **Cork cambium (Phellogen)** . Phellogen is a couple of layers thick. Made of narrow ,thinwalled, rectangular cells.
- Cork cambium cut off cells on both sides. Outer cells differentiates into **Cork (Phellum**) & inner cells differentiates into **Secondary cortex (Phelloderm**).
- Phellogen, phellum & phelloderm are collectively known as **Periderm.**
- Cork is impermeable to water due to suberin deposition in the cell walls.
- Ceils of secondary cortex are parenchymatous.
- **Bark-** All tissues exterior to vascular cambium (Periderm & secondary phloem)**.**
- **Early/ soft bark** – Bark formed early in the season.
- **Late/ hard bark-** Bark formed towards the end of the season.
- **Complementary cells-** loosely arranged parenchymatous cells, which are cuts off by phellogen towards outerside instead of cork cell at certain regions.
- **Lenticels**- Lens shaped opening found on the epidermis of woody trees, through which gas exchange takes place.



Secondary Thickening In Root

- Vascular cambium is completely secondary in origin.
- Tissue located just below the phloem bundles & portion of pericycle just above the protoxylem become meristemmatic. They join together to form wavy vascular cambium.
- Vascular cambium cut cells towards innerside & outerside. Inner cells mature into secondary xylem & outer cells mature into secondary phloem.
- Cambium is more active towards innerside. So more secondary xylem is formed.
- Due to the continuous activity, wavy vascular cambium becomes circular.
- Primary & secondary phloem get gradually crushed.



CHAPTER 5: CELL-THE UNIT OF LIFE

- Cell is the structural and functional unit of life
- The study of structure of cell and its organelles is called *cytology*.
- Cell was discovered by Robert Hooke.

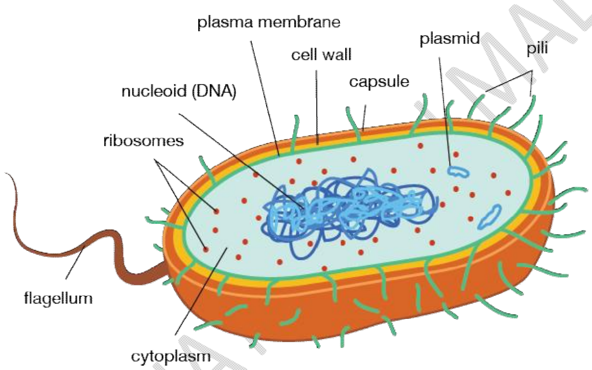
CELL THEORY

- *M.J Schlieden* said; the body of all plants are made up of cells.
- *Theoder Shwann* said; the body of all animals are made up of cells
- *Rudolph Virschow* said; new cells are formed from pre-existing cells (*omniscellula -e cellula)* these three constitute the cell theory.

PROKARYOTIC CELLS-Eg: Bacteria, Cyanobacteria, Mycoplasma (PPLO).
Bacteria can be divided into 2 groups based on their cell envelope differences and response to gram staining methods

Gram staining

Christian gram developed a technique of staining bacteria called gram staining.
Gram positive: The bacteria which take up and retain stain after the washing.
Gram negative: They do not retain stain after washing.
Addition to cell wall in some bacteria there is another layer –**glycocalyx**-It may be a **slime layer** (loose sheath) or **capsule.** (tough outer coat)



Mesosomes:- They are invaginations of palsma membrane. They help in respiration and secretion.
Ribosomes: The only cell organelle in prokaryotic cell ,70S ribosomes are seen in bacteria
Plasmids: They are extra chromosomal circular DNA present in bacteria
Flagella: they help in locomotion. Flagellum has three parts

1. **filament** **2. hook** **3. basal body**

some outgrowths are also seen on the body of bacteria. They are **pili** and **fimbriae**. Pili are longer the fimbria
Pili are elongated tubular structures. While fimbriae are bristle like, which help to attach two bacterial cells together during reproduction. Some reserve food materials in form of inclusion bodies are also present in bacteria

EUKARYOTIC CELLS

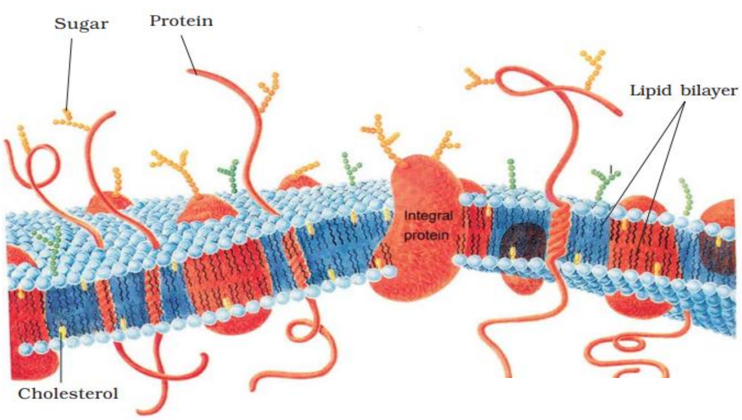
1.Cell membrane

Singer and Nicholson proposed **fluid mosiac model** of plasma membrane.

According to them cell membrane is made up of **lipid bilayer** and **protein** According to Fluid Mosaic Model, Phosphoglycerides are in form two layers-bilayer. Into this bilayer proteins are arranged in a Mosaic (scattered) manner. Some proteins are seen completely inside the bilayer-**Intrinsic (Integral) proteins** and some outside the bilayer-**Extrinsic proteins** and some are partially in and out.

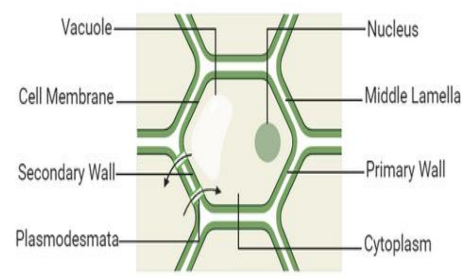
Function:

- Cell membrane protect the cells, helping transport of materials across it-passive transport (without energy), active transport(with energy) and osmosis.
- Due to the fluid nature, plasma membrane can help in cell growth, formation of inter cellular junctions,secretion, endocytosis, cell division etc



2. CELL WALL

- It forms the outer covering for the plasma membrane of fungi and plants
- It is a non living rigid structure
- It has primary wall, secondary wall and middle lamella
- **Middle lamella** is a layer mainly of **calcium pectate** which holds the neighbouring cells together
- The adjacent cells are connected through fine strands of cytoplasm through fine pores called **plasmodesmata**



3.ENDOMEMBRANE SYSTEM

It is a group of membranous organelles having co ordinate function.
They include

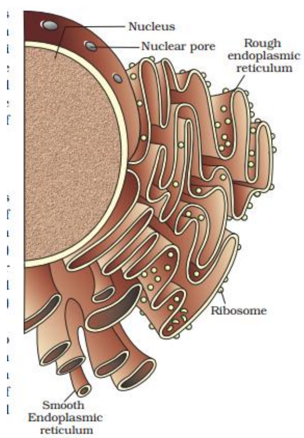
1. Endoplasmic reticulum
2. Golgi bodies
3. Lysosomes
4. Vacuoles

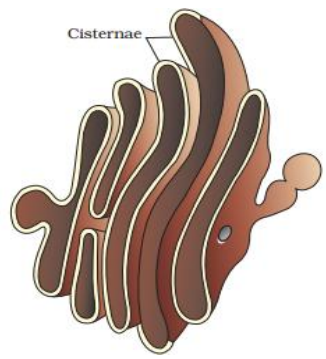
i).ENDOPLASMIC RETICULUM

- Two types of ER are there **Rough ER and smooth ER.**
- In rough ER the ribosomes are attached onthe surface of ER.
  Protein synthesis and secretion are the functions of RER
- In smooth ER, ribosomes are absent on it.
  The function is lipid synthesis.

ii). GOLGI APPARATUS

- First observed by Camillo Golgi.
- Golgi bodies are made up of Cisternae,Tubules and Vesicles
  Functions:
- Packaging of materials
- It is the important site of formation of glycoproteins and Glycolipid





Endoplasmic reticulum **Golgi bodies**

iii).LYSOSOME

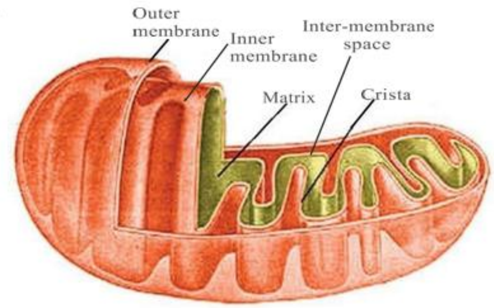
- Other wise called as suicidal bags.they contain hydrolytic enzymes
- Function: Intra cellular and extra cellular digestion

iv).VACOULES

- They are membrane bound space in cytoplasmit contain water,sap etc
- Its membrane is called tonoplast, a single layer membrane

Functions: **Contractile vacuole** helps in excretion(E
Food vacuoles are formed by engulfing the food parti
Protists)

4.MITOCHONDRIA



- Discovered by Kolliker
- Responsible for respiration
- Otherwise called **powerhouses of cell**; because they produce, store and supply energy
- They are double layered, outer and inner membrane in between outer and inner membrane is a space,

  peri-mitochondrial space
- Inner membrane show several infoldings called **cristae**
- On cristae and inner side of the inner membrane tennis racquet like structures seen called as**oxysomes**
- There is a fluid inside the mitochondria called *matrix*
- They are semi autonomous; they contain DNA, RNA and 70S ribosomes.

5. PLASTIDS

Classification: Plastids are grouped into three

1.Chloroplast (green plastids)

2.Chromoplast (are coloured other than green)

3.Leucoplast (are colourless plastids)

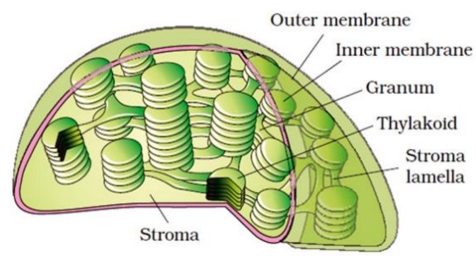
Leucoplasts are divided into 3

Amyloplast [store starch]

Elaioplast [store lipid and oil]

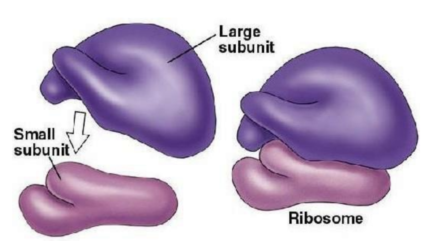
Aleuroplast [store protein]

Chloroplast



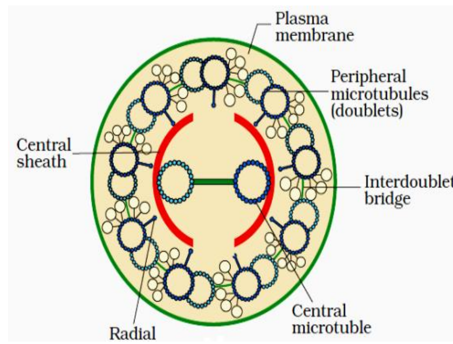
- Double membraneous ; outer and inner membrane
- A space in between outer and inner membrane called **peri plastidal space**
- Fluid inside chloroplast called **stroma**
- Membraneous structures inside it termed as lamella Or **thylakoids**
- Thylakoids seen as stack; then this stack is known as **grana.**
- Some thylakoids connect adjacent grana; termed as **stroma lamella**
- They are semiautonomous ;they contain DNA and 70 S ribosomes.

6. RIBOSOME



- Non-membrane covered structures.
- First observed by **George Palade**
- Seen in both prokaryotic and eukaryotic cell.
- Each made of a **large sub-unit** and **small sub unit**.

- Sub units are made up of ribonucleoproteins **(RNA + proteins).**
- In eukaryotic cells ribosomes seen in cytoplasm are **<u>80S type</u>** and those in mitochondria and chloroplasts – **<u>70S type</u>**.
- **'S'**-is **<u>Svedberg unit</u>** – <u>sedimentation co -efficient</u> – indirectly related to density and size.
- 80S = 60S + 40S
- 70S = 50S + 30S



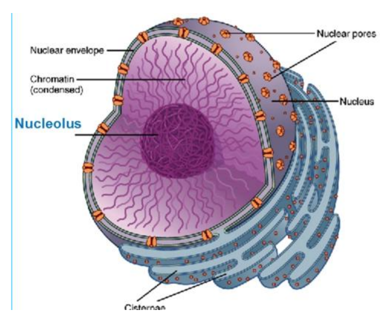
7. <u>CILIA AND FLAGELLA</u>

- Cilia and flagella are hair like outgrowths of cell membrane.
- Cilia are small and more in number while flagella are longer less in number Both help in **locomotion**
- Both flagellum and cilia has a central core called **axoneme** this axoneme is made up of **microtubules**
- Microtubules are in **9+2 condition**
- 9 peripheral doublet tubules and two central singlet tubules From peripheral to central radial spokes are seen

8. <u>CENTROSOME AND CENTRIOLES</u>

- Centrosome is an organ which contain two cylindrical centrioles
- Both centrioles in a centrosome is perpendicular to each other
- Centrioles are made up of nine triplet tubulins
- Central part is proteinaceous
- Spokes are there in between peripheral tubulins and spoke
- Centrioles form the basal body of cilia ,flagella and spindle fibers

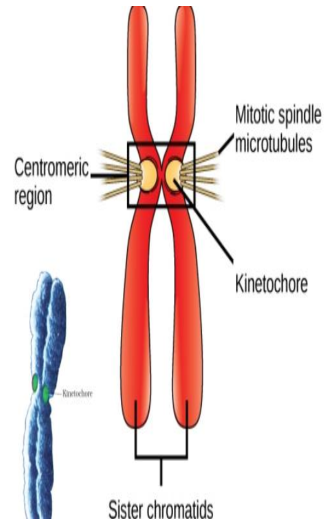
9. <u>NUCLEUS</u>



- It was first described by **Robert Brown**
- Each nucleus has an envelope; it is double membraneous
- [**outer and inner membrane**]in between outer and
- inner membrane there is space called **perinuclear space**
- Some pores are there for the nuclear envelope called **Nuclear Pore**.
- Nucleus is filled with a fluid called **Nucleoplasm**
- Nucleus show a spherical structure called **Nucleolus.**
- Chromatin threads seen inside the nucleus. They later form chromosomes during cell division
- Chromatin contain DNA,RNA, histone proteins and non histone proteins.

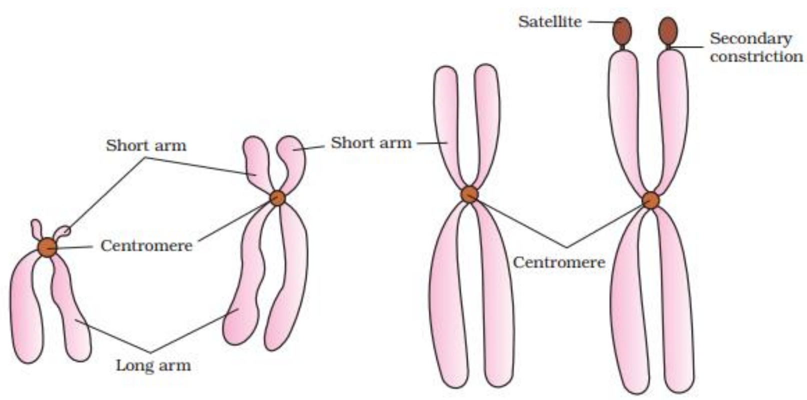
Chromosome

- Every chromosome has a primary constriction called **centromer**
- On either side of the centromere there is disc shaped structures called
  kinetochore



Types of chromosome

1. **Metacentric**: Centromere is seen at the centre of chromosome
2. **Sub metacentric**: Centromere is seen nearer to the centre
3. **Acrocentric**: Centromere towards apex
4. **Telocentric**: Centromere is terminal in position



Types of chromosomes based on the position of centromere

satellite chromosome: in some chromosomes a secondary constriction is seen. This gives the appearance ofa small fragment . It is the satellite.

10. Micrbodies: The membrane bound small vesicles present in animal and plant cell is called microbodies.They contain various enzymes.

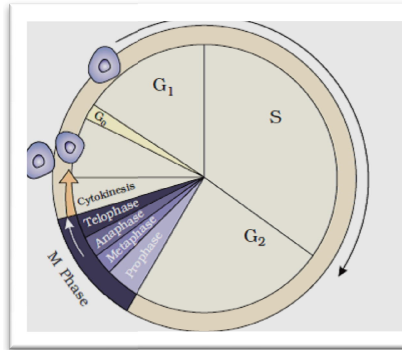
11. Cytoskeleton : An elaborate network of filamentous , proteinaceous structures present in the ytoplasm is collectively called as the cytoskeleton. Cytoskeletal structures are **Microfilaments** and **Microtubules.**

CHAPTER 6: CELL CYCLE AND CELL DIVISION

Cell cycle: The sequence of events by which a cell duplicates its genome, synthesis the other constituents of the cell and eventually divides into two daughter cells.

Phases of cell cycle :

1. Interphase :



a) G1 Phase*:* Cell metabolically active and grows continuously.

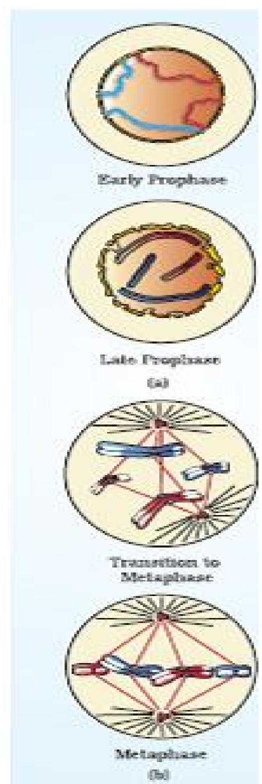
b) S Phase: DNA synthesis occurs, DNA content increases from 2C to 4C.but the number of chromosomes remains some (2n).

c) G2 Phase: Proteins are synthesized in preparation for mitosis while cell growth continues.

2. M Phase (Mitosis Phase): Starts with nuclear division, corresponding to separation of daughter chromosomes (karyokinesis) and usually ends with division of cytoplasm (cytokinesis).

Quiescent stage (G0): Cells that do not divide and exit G1 phase to enter an inactive stage called G0. Cells at this stage remain metabolically active but do not proliferate.

MITOSIS



1. Prophase :

- Chromatin network condenses to form chromosomes
- Each chromosomes consisting of 2 chromatids attached at centromere
- Microtubules are assembled into mitotic spindle.
- Nucleolus and nuclear envelope starts to disappear.

2. Metaphase :

- Spindle fibres attached to kinetochores (small disc-shaped structure attached surface of centromers) of chromosomes.
- Chromosomes line up at the equator of the spindle to form **metaphase plate.**

3. Anaphase :

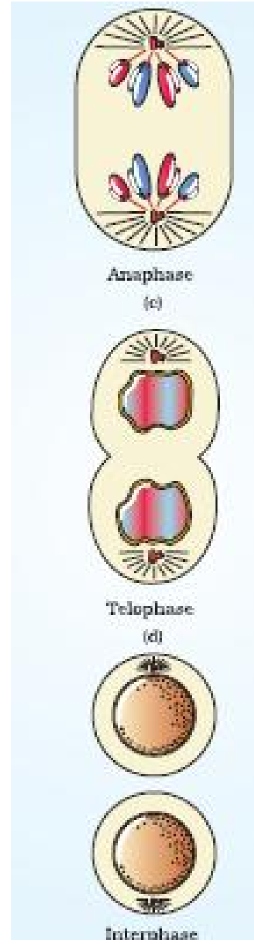
- Centromeres split and chromatids separate.
- Chromatids move to opposite poles.

4. Telophase :

- Chromosomes cluster at opposite poles.
- Nuclear envelope assembles around chromosome cluster.
- Nucleolus, Golgi complex, ER reform

Cytokinesis : Is the division of protoplast of a cell into two daughter cells after Karyokinesis (nuclear division).

- **Animal cytokinesis** : Appearance of **cleavage furrow** in plasma membrane which deepens and joins in the centre dividing cell cytoplasm into two.
- **Plant cytokinesis** : Formation of new cell wall begins with the formation of a simple precursor − **cell plate** which represents the middle lamella between the walls of two adjacent cells.



Significance of Mitosis :

- Growth − addition of cells.
- Maintenance of surface/volume ratio.
- Maintenance of chromosome number.
- Regeneration,
- Repair and wound healing.
- Reproduction in unicellular organism.

MEIOSIS

- Specialized kind of cell division that **reduces the chromosome number by half,** resulting in formation of 4 haploid daughter cells.
- Occurs during gametogenesis in plants and animals.It takes place in **reproductive cells**
- Involves two cycles of nuclear and cell division called Meiosis I and Meiosis II.
- Interphase occurs prior to meiosis which is similar to interphase of mitosis except the 4 haploid daughter cells are formed.

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

Meiosis I

I. **Prophase I** : Subdivided into 5 phases.

a) Leptotene :

- Chromatin network condensed to form single strandedand thread like chromosomes.

b) Zygotene :

- Homologous chromosomes start pairing and this process of association is called **synapsis.**
- Chromosomal synapsis is accompanied by formation of **synaptonemal complex.**
- Chromosome pairs of zygotene is called **bivalent**

c) Pachytene :

- Each chromosomes split longitudinally in to 2 sister chromatids. The bivalent become **tetrad** with 4 chromatids.
- **Recombination nodules** appear, these are the site at which crossing over takes place
- **Crossing over** occurs between non-sister chromatids of homologous chromosomes.

d) Diplotene :

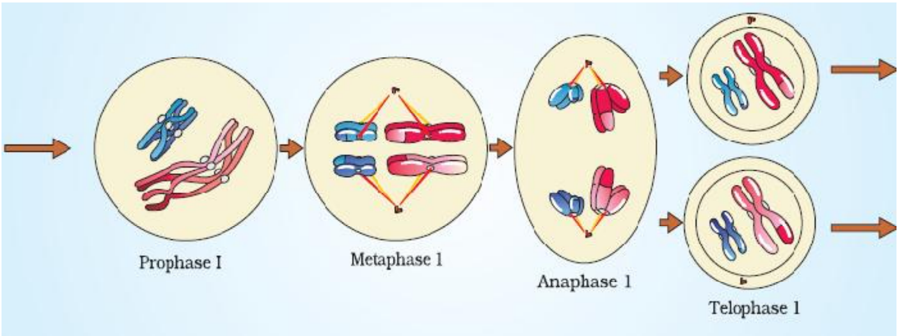
- Dissolution of synaptonemal complex occurs and the recombined chromosomes separate from each other except at the sites of crossing over. These X-shaped structures are called **chaismata**.

e) Diakinesis :

- Terminalisation of chaismata.
- Chromosomes are fully condensed and meiotic spindles assembled.
- Nucleolus and nuclear envelope disappears.

II Metaphase I :

- Bivalent chromosomes align on the equatorial plate.
- Microtubules from opposite poles of the spindle attach to the pair of homologous chromosomes.



III Anaphase I:

- Homologous chromosomes separate while chromatids remain associated at their centromeres.
- The number of chromosomes move towards opposite poles is reduced to half

IV Telophase I :

- Nuclear membrane and nucleolus reappear.
- Cytokinesis follows 2 haploid daughter cells (dyad of cells).

Interkinesis : Stage between two meiotic divisions. (Meiosis I and meiosis II)

Meiosis II

It is similar to Mitosis and is also called **equational division**

I Prophase II

- Nuclear membrane disappears.
- Chromosomes become compact.

II Metaphase II

- Chromosomes align at the equator.
- Microtubules from opposite poles of spindle get attached to kinetochores of sister chromatids.

III Anaphase II

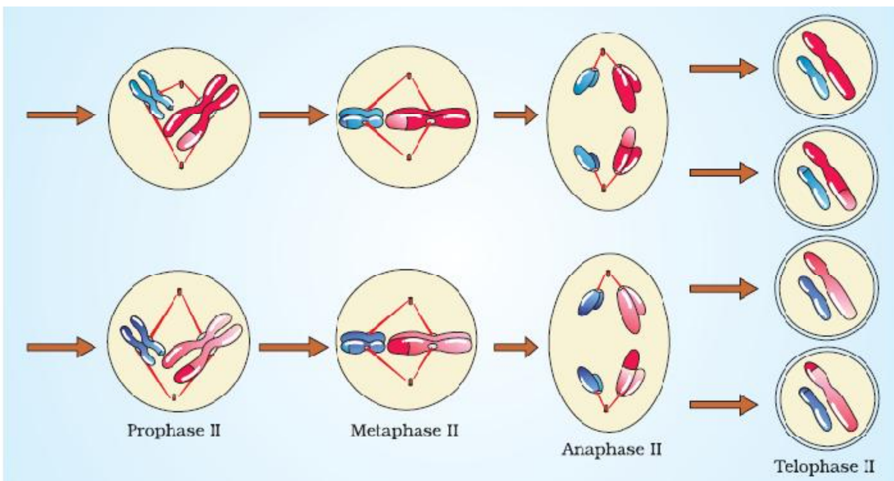
- Simultaneous splitting of the centromere of each chromosome, allowing them to move towards opposite poles of the cell.

IV Telophase II

- The chromosomes in the respective poles uncoil and form the chromatin network
- Two groups of chromosomes get enclosed by a nuclear envelope.
- Cytokinesis follows resulting in the formation of tetrad of cells i.e., 4 haploid cells.

Significance of Meiosis

- Formation of gametes: In sexually reproducing organisms.
- Genetic variability
- Maintenance of chromosomal number: By reducing the chromosome number in gametes.
- Chromosomal number is restored by fertilisation of gametes.



CHAPTER : 7 TRANSPORT IN PLANTS

Transport of substances over along distance is through xylem and phloem. it is called *translocation.* Transport of substances in xylem is unidirectional that means from root to stem.

Means of transprot

Diffusion

- Diffusion is a passive process, i.e here no energy is used.

- Diffusion is the movement of substances from region of higher concentration to the region of lower concentration.

A pressure formed in the substances due to the diffusion is called diffusion pressure.(D.P)

Eg.spreading of a drop of ink in water

Diffusion rates are affected by

a) The gradient of concentration

b) The permeability of the membrane.

c) Temperature

d) Pressure

Facilitated diffusion

The diffusion take place with the help of proteins is called facilitated diffusion.

Reason for facilitated diffusion.

Substances with hydrophilic moiety, find difficult to pass through the membrane.

Their movement has to be facilitated.

Such substances are moved by the help of proteins present tin the membrane.

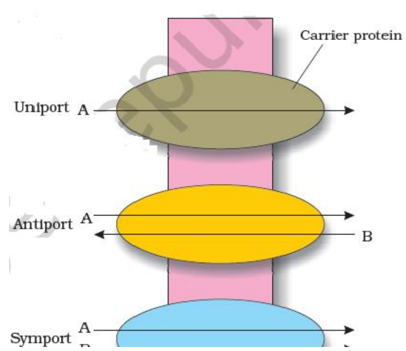
The diffusion rate depends on the size of substances. *The smaller substances move faster.*

The diffusion of substance across the membrane also depends on solubility of it in lipids.

In facilitated diffusion there is no expenditure of energy. Facilitated diffusion is very specific[selective.]

Porins:-

- ✓ They are the proteins that form huge pores in the outer membranes of the plastids, mitochondria and some bacteria.
- ✓ *Aquaporins* are the water channels made up of eight different types of aquaporins.



Passive symport and antiports

Uniport	only one molecule is transported through protein
Antiport	Two molecules move in opposite directions
Symport	Two molecules move in same direction

Active transport

This type of transport uses energy. It is carried out by membrane proteins. It takes place against the concentration gradient.

Comparison of different transport

Property	Simple diffusion	Facilitated diffusion	Active transport
Requires special membrane proteins	No	Yes	Yes
Highly selective	No	Yes	Yes
Transport saturates	No	Yes	Yes
Uphill transport	No	No	Yes
Require ATP	No	No	Yes

Water potential

This is the chemical potential of water. It is denoted by the symbol $\psi_{w.}$

Ψ_w

The water potential of pure water is the maximum, it is 0.

If solute is added it is decreased to negative value.

Solute potential (ψ_s). and pressure potential (ψ_p). are thetwo components of $\psi_{w.}$

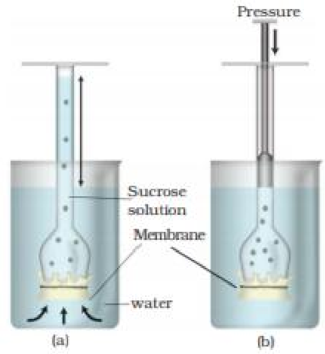
$$\psi_{w.} = \psi_s + \psi_p$$

ψ_s will be negative

OSMOSIS

- Osmosis is the simple diffusion across a semi permeable membrane.
- Here water move from a region of high water potential to a region of lower water potential.
- As a result of osmosis a pressure is exerted, is called *osmotic pressure*.
- If we give a pressure against the osmotic pressure the process of osmosis will stop.
- If we increase such pressure again; the osmosis takes place in reverse direction.

- This is called *reverse osmosis*.
- The reverse osmosis is used for the purification of water.



Osmosis are of two types.; **endosmosis and exosmosis**.

Difference between endosmosis and exosmosis

Endosmosis	Exosmosis
endosmosis takes place , when a cell is placed in hypotonic solution	exosmosis takes place , when a cell is placed inhypertonic solution
During endosmosis water move into the cell	During exosmosis water move out of the cell
After endosmosis cell become Turgid	During exosmosis cell become flaccid

Hypotonic solution means the solution with comparatively less concentration

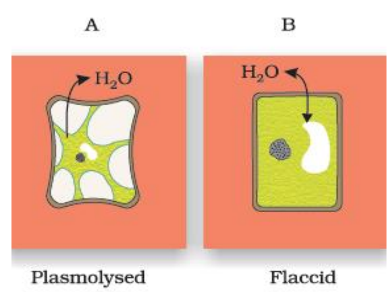
Hypertonic solution

Plasmolysis

When water move out of the cell the cell (by exosmosis) membrane shrinks and detaches from the cell wall. This process is called plasmolysis.

Water lost from cytoplasm first and then from vacuole during plasmolysis.

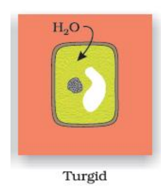
By endosmosis the cytoplasm exerts a pressure against the cell wall, is called turgor pressure.



Imbibition

Here water is absorbed by the solids colloids and result in the increase in volume.

Eg. Absorb water by dry seeds, dry wood.



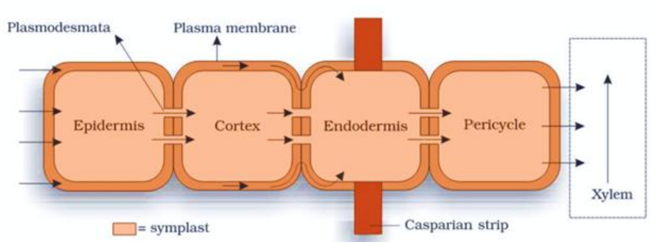
The prerequisite for the imbibition are:

1. water potential gradient between the absorbent and the liquid imbibed
2. affinity between the adsorbent and liquid

water absorption

water from soil is absorbed by the root hair. Then from there it is moved deeper through two pathway.

a) apoplast pathway
b) symplast pathway



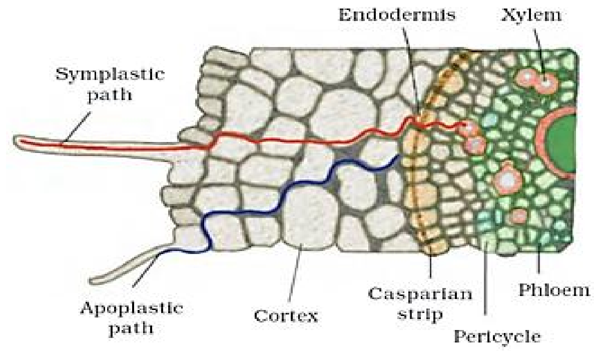
Apoplast: here water moves through inter cellular spaces and cell wall.

Symplast: here water move by crossing the cell membrane, and through the plasmodesmata.

Water movement in roots

- Root hair to cortex
- cortex to endodermis (apoplast way)
- Then to xylem

Endodermis,is impervious to water because of casparian strip.(they are the band of suberisedmatrix in endodermal cells)



Mycorrhiza

- ✓ is a symbiotic association of a fungus with a root system.
- ✓ Thefungus increase the surface areato absorb mineral ions and water from the soil.
- ✓ The roots provide sugars and N-containing compounds to the fungus

Water movement up a plant

Can be explained by various theories.

1. Root pressure theory

Root pressure is the pressure developed inside the root due to the accumulation of water. This pressure helps in the upward movement.

Guttation

- Ii is the process take place by the phenomenon of root pressure.
- Guttation is the water loss from plants in the form of liquid. It takes place at the openings of veins of leaf blade and leaf tip.
- It occurs in herbs, and takes place in night.

2. Transpiration pull theory

Transpiration is a water loss process in plants. Transpiration takes place through stomata and cuticle. Transpired water is in the form of vapour.

When transpiration take place in leaves a pull is occurred, that pull affects at the root xylem. So that pull result in the absorption of water and upward movement of water.

It is because of the presence of continuous column of water in the xylem from leaf to root.

The continuous column of water is maintained by the two special properties of water; cohesion and adhesion

Cohesion

is the affinity between similar molecules. Here water molecules show affinity between them.

Adhesion

is the affinity between the dissimilar molecules. Here the affinity is, between the water molecule and inner wall of xylem.

Transpiration – merits

1. creates transpiration pull
2. helps in the absorption and upward movement of water
3. helps in the absorption and upward movement of minerals
4. cools leaf surfaces
5. maintains the structure and shape of plants by keeping cells turgid.

Transpiration – demerits

1. leads to wilting and death of plant

Uptake of mineral ions

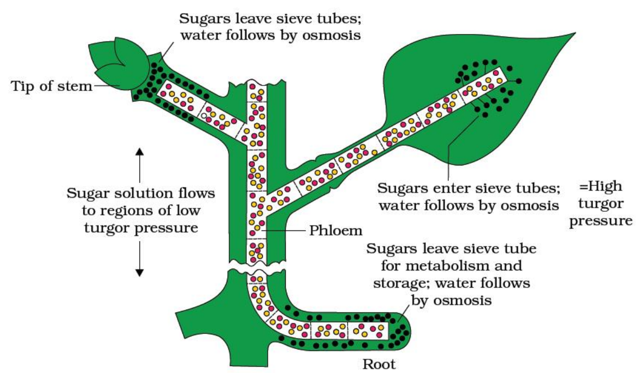
Minerals are absorbed and transported by both active and passive mode.

Phloem transport

- The synthesisedfood from leaves is transported to different regions of the plant through the phloem.
- Sometimes it is stored at some parts. That part is called sink.
- Form sink the food again move to different parts when it is required. So a sinkto source transport is seen this time. So the phloem transport is a bidirectional one.
- But the xylem transport is unidirectional.

Pressure flow hypothesis

- ✓ The glucose formed in the leaves then converted into sucrose and reach at companion cell, and then into sieve tubes by active transport.
- ✓ This produce a hypertonic condition inside the phloem.
- ✓ So water in the adjacent xylem move into the phloem by osmosis.
- ✓ Then the phloem sap will move to lower pressure area.

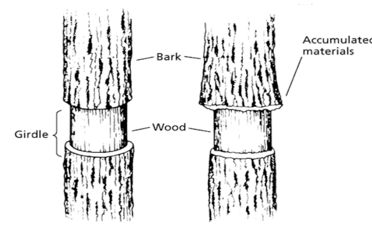


Girdling Experiment

The experiment is used to identify the tissues through which food is transported.

On the trunk of a tree a ring of bark up to a depth of the phloem layer, is removed.

In the absence of downward movement of food,the portion of the bark above the ring becomes swollen after few weeks.



CHAPTER 8: MINERAL NUTRITION

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 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.

1. Element must be absolutely necessary for the normal growth and reproduction to complete their life cycle.
2. The requirement of element must be specific and not replaceable.
3. Element must be directly involved in the metabolism of plants.

Macro and Micro nutrients- On the basis of diverse functions, essential elements are divided into following categories-

- Macronutrients are present in plants 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.

Role of Macro and Micro nutrients-

1. Essential elements participate in various metabolic processes in plants such as permeability of cell membrane, maintenance of osmotic potential, ETS. Etc.
2. Act as major constituents of macromolecules and co-enzymes.

Various forms and function of essential nutrients-

1. **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.
2. **Phosphorus-** Absorbed by plants from soil in the form of phosphate ions. It is the constituent of cell membrane. All nucleic acids and nucleotides require phosphorus.
3. **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.
4. **Calcium –** absorbed by plants from soil in form of Calcium ions (Ca^{2+}). Used in synthesis of cell wall. It activates certain enzymes.
5. **Magnesium-** absorbed by plants in form of Mg^{2+} ions. It activates the enzymes for respiration, photosynthesis, and involved in synthesis of DNA and RNA. It is constituent of chlorophyll.
6. **Sulphur-** plants obtain sulphur in form of sulphate (SO_4^{2-}). Present in amino acids (cysteine, methionine) and is main constituent of coenzymes and vitamins.
7. **Iron-** obtained in the form of ferric iron (Fe^{3+}). It is important constituent of protein involved in transport system.
8. **Manganese-**absorbed in form of Mn^{2+} ions. Main function is splitting of water to liberate Hydrogen and Oxygen during photosynthesis.
9. **Zinc-**obtained as Zn^{2+} ions. Activate enzymes like carboxylases. Needed in formation of Auxin.
10. **Copper –**absorbed as cupric ions(Cu^{2+}). Involved in various metabolic activities and redox reactions.
11. **Boron-**absorbed as BO_3^{3-} or $B_4O_7^{2-}$ ions. Required for uptake of calcium, cell elongation and pollen germination.
12. **Chlorine –** it is absorbed in form of Cl^- ions. Determine the solute concentration and splitting of water during photosynthesis.

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) show 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.

Kinds of deficiency syndrome are as follows-

Deficiency Disease	**Deficient elements**
Chlorosis	N, K, Mg, S, Fe, MN, Zn, Mo

– It is the loss of chlorophyll leading to yellowing of leaves	
Necrosis -Death of tissue (leaf).	Ca, Mg, Cu, K.
Stunted plant growth	Fe, K.
Premature fall of leaves and buds.	P, Mg, Cu
Inhibition of cell division	Low level of N, K, S, Mo.

- 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**
- It takes place in two phases. In first phase, rapid intake of ions occurs 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 harbours nitrogen fixing bacteria and other microbes, holds water and supplies air to roots. Deficiency of essential elements affects the crop yield. So, fertilisers are used to supplement these elements.

Metabolism of Nitrogen

- Nitrogen is the most prevalent element 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 lightening 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.
- 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 *Nitrobactor*. These processes are called **nitrification.**

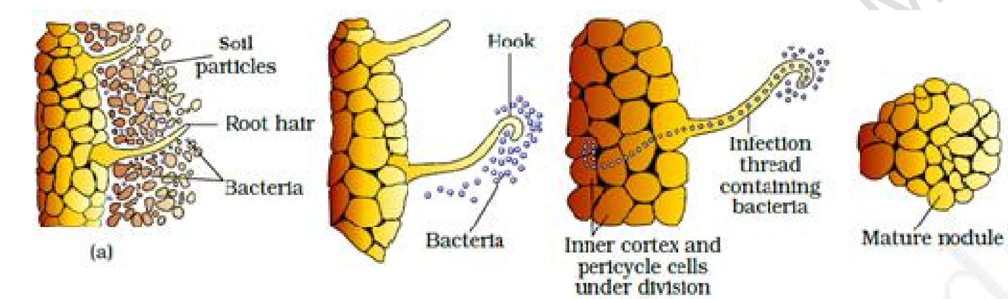
- Nitrates formed is absorbed by plants and transported to leaves. Nitrates is converted into free nitrogen by the process called **denitrificaion** by bacteria *Pseudomonas* and *Thiobacillus*.

- Reduction of nitrogen to ammonia by living organism is called **Biological Nitrogen Fixation**. The enzyme **nitrogenase** is present in prokaryotic organism called nitrogen fixer.

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

- Nitrogen fixing microbes may be symbiotic (Rhizobium) or free living (Nostoc, Azotobacter, Anabaena).
- 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 leg-haemoglobin.

Nodule formation involves sequence of interaction between root and Rhizobium as follows-



Nodule formation involves a sequence of multiple interactions between Rhizobium and roots of the host plant. Main stages in the nodule formation are:

(i) Rhizobia multiply and colonise the surrounding of roots and get attached to epidermal and root hair cells

(ii)The root hair curl and the bacteria invade the root hair.

(iii)An infection thread is produced carrying the bacteria into the inner cortex of the root

(iv)The bacteria get modified into rod-shaped bacteroids and cause inner cortical and pericycle cells to divide. Division and growth of cortical and peri cycle cells lead to nodule formation.

(v) The nodule thus formed, establishes a direct vascular connection with the host for exchange of nutrients

(vi)The nodule contains all the necessary biochemical components, such as the enzyme nitrogenase and leghaemoglobin. The enzyme nitrogenase catalyses the conversion of atmospheric nitrogen to ammonia, the first stable product of nitrogen fixation.

The reaction is as follows-

$$N_2 + 8e^- + 8H^+ + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16P_1$$

- 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 (18ATP) for each NH3 produced.0

Fate of ammonia- at physiological pH, ammonia is converted into ammonium ions (NH_4^+).It is toxic for plants in larger concentration and ammonium ion is converted into amino acids by two methods-

1. **Reductive amination**– in this process ammonia reacts with α-ketoglutaric acid to form glutamic acid.
2. **Transamination**– it involves the transfer of amino group from amino acids to keto group of keto acid. Glutamic acid is the main amino acid from which transfer of NH3 takes place and other amino acids are formed by transamination. The enzyme **transaminase** catalyses all such reactions.

Two important amides asparagine and glutamine found in plants as structural part of proteins. They are formed from aspartic acid and glutamic acid by addition of another amino group to it

CHAPTER 9: PHOTOSYNTHESIS IN HIGHER PLANTS

Half leaf experiment

- Here a part of a leaf is enclosed in a test tube containing some KOH soaked cotton (That absorbs CO_2),
- while the other half is exposed to air.
- The setup is then placed in light for some time.
- Starch is formed at exposed part while the part inside the test tube does not produce starch.
- This is because of absence of starch.

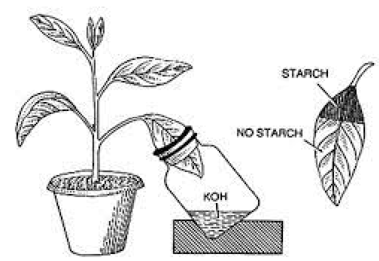


Fig 5.27. Moll's experiment.

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

Early experiments relate with photosynthesis

	Scientist	Inference of Experiment
1	Joseph preistely	Found that air is restored by mint plant inside the bell jar of his experiment [by using candle, mint plant and mice]
2	Jan Ingenhouesz	Found air restored in light only after repeating Preistly's experiment

3.	Julius Von sachs	Found glucose is produced in some green bodies[chloroplasts] during the process of photosynthesis
4.	T.W Engelmann	Found that the places where aerobic bacteria is concentrated during his cladophora experiment

- Photosynthesis is an oxidation reduction reaction; because here CO_2 is reduced and H_2O getsoxidised
- In photosynthesis Glucose is the main product and $O_2$is bye product
- here solar energy converted into chemical energy
- photosynthesis completes in two phases; light reaction and Dark reaction

Difference between light reaction and dark reaction

LIGHT REACTION	DARK REACTION
1. Takes place in grana 2. ATP and NADPH are formed 3. Light dependent phase	1. Takes place in stroma 2. Glucose is formed 3. Light independent phase

Photosynthetic pigments

- They are of different colours
- They absorb light, of specific wavelengths.
- They are present in grana.
- *Chlorophyll a* is the major pigment responsible for trapping light,
- *Chlorophyll b*, xanthophylls and carotenoids, absorb light and transfer the energy to *chlorophyll a*.
- The pigments other than *chlorophyll a* iscalled accessory pigments.

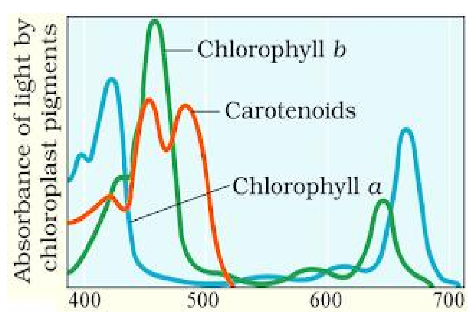
Photosynthetic pigments

Chlorophyll a
(bright or blue green
*)***chlorophyll b**
(yellow green)
xanthophylls
(yellow)

The accessory pigments protect the *chlorophyll a* from photo oxidation

Action spectrum and absorption spectrum

Absorption spectrum: It is the graph showing the absorption of different wavelength of light by pigments. More absorption takes place blue and red light



Action spectrum: graph showing the rate of photosynthesis in different wavelength of light . More photosynthesis takes place blue and red light.

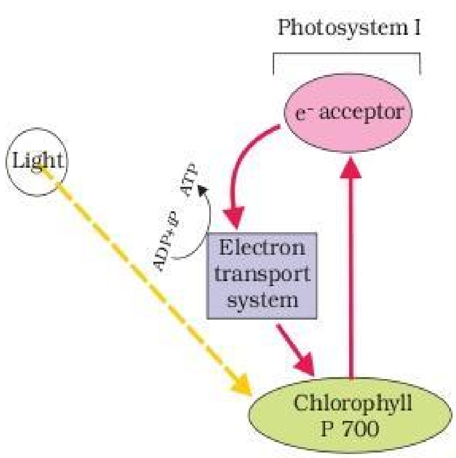
Light harvesting complexes(LHC)

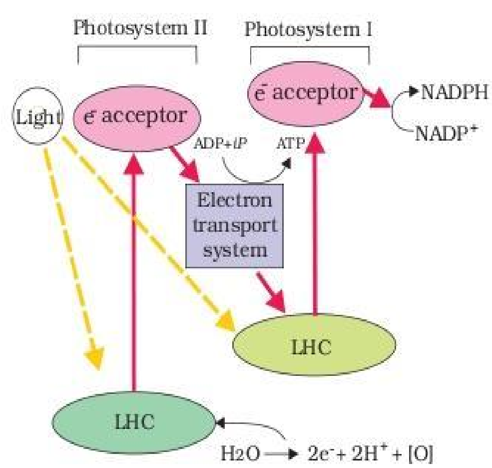
- The LHC are made up of hundreds of pigment molecules bound to proteins.
- These pigments absorb light and transfer energy to *chlorophyll a* ;[the reaction centre].
- The other pigments(except chlorophyll a) are called antenna pigments or accessory pigments.

➢ The LHC is the part of Photosystems.
➢ Two photosystems are there. Photosystem I and Photosystem II (PS I and PS II)
➢ Both PS I and PS II show the reaction centre of *chlorophyll a.*
➢ The reaction centre of PS I absorb 700 nm wavelength of light
➢ The reaction centre of PS II absorb 680 nm wavelength of light

Difference between cyclic photophosphorylation and noncyclic photophosphorylation

Cyclic photophosphorylation	Noncyclic photophosphorylation
Only photosystem I is involved	Both photosystem I and photosystem II are involved
Electrons travel in cyclic manner	Electrons travel in non cyclic manner
Only ATP is synthesized	ATP and NADPH are synthesised
No photolysis of water	Photolysis of water occur
No oxygen evolution	Oxygen evolution takes place
It is predominant in bacteria	Predominant in green plants





Cyclic photophosphorylation Noncyclic photophosphorylation

Non cyclic is also called Z scheme, because of the shape of movement of electron

Phosphorylation

It is the production of ATP from ADP.

i.e addition of inorganic phosphate with ADP and the formation of ATP

Photolysis

It is the splitting of water

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

How ATP is synthesised in grana?

- ✓ It can be explained by ChemiosmoticHypothesis .
- ✓ ATP synthesis takes place due to proton gradient across a membrane.
- ✓ Inside the thylakoid lumen H^+ ions are accumulated.
- ✓ Then they move to stroma ; across the membrane.
- ✓ Then the phosphorylation takes place.

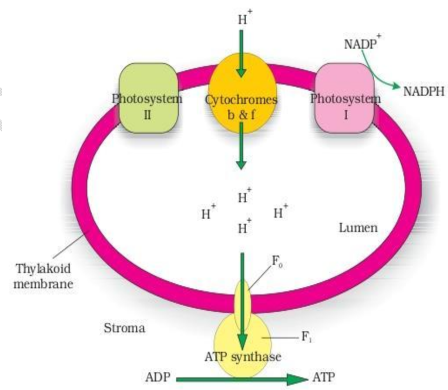


Figure 13.7 ATP synthesis through chemiosmosis

The concentration of H^+ ions are increased inside the lumen of thylakoid by following ways....

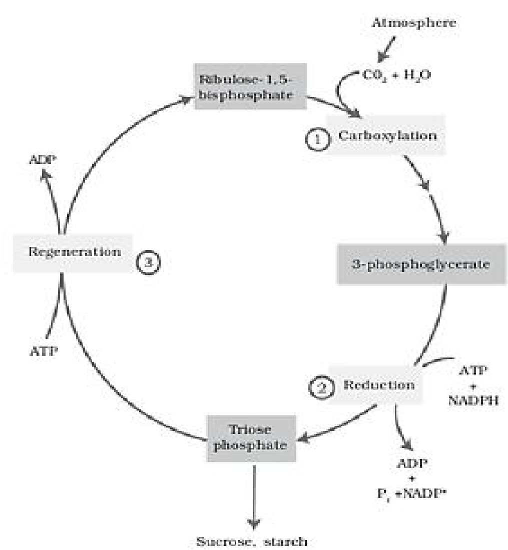
(a) Hydrogen ions that are produced by the splitting of water accumulate within the lumen of the thylakoids.

(b) As electrons move through the photosystems, protons are transported to lumen from stroma.

(c) The H^+ ions are taken from stroma for reduction of NADP .(H^+ ions decreases in stroma)

DARK REACTION

- The ATP and NADPH produced in light reaction are used here and the synthesis of glucose takes place
- This is the biosynthetic phase of photosynthesis.
- This process does not directly depend on the presence of light.



Calvin cycle

Three steps of Calvin cycle are: *carboxylation, reduction and regeneration*.

1. Carboxylation

- RuBP (5 carbon compound) accept CO_2 and

two molecules of 3-PGA are formed.

- It is catalysed by the enzyme RuBP carboxylase Oxygenase. (RuBisCO).

2. Reduction– These are a series of reactions that lead to the formation of glucose.

This steputilise 2 molecules of ATP for phosphorylation and two molecules of NADPH.

3. Regeneration– Regeneration of the RuBP (CO_2 acceptor molecule) . The regeneration steps require one ATP.

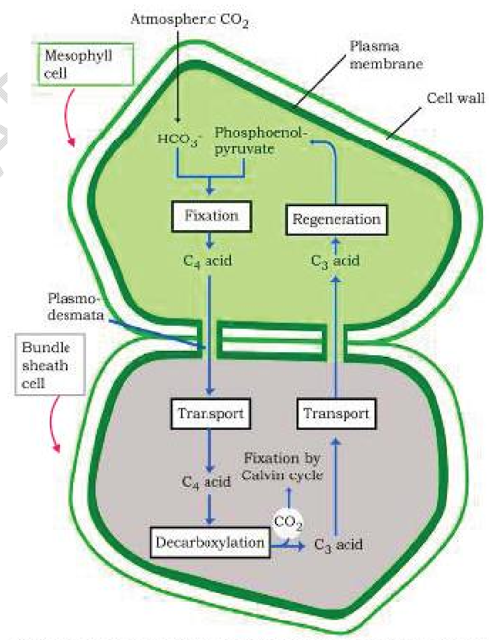
To make one molecule of glucose 6 turns of the cycle are required.

So in Calvin cycle 18 ATP and 12 NADPH are required for the synthesis of 1 glucose molecule.

Hatch and Slack Pathway (C_4 Cycle)

Plants that are adapted to dry tropical regions have the C_4 pathway to fix CO_2

- The pathway completes in mesophyll and bundle sheath cells.
- Pathway is traced out by Hatch and Slack



Diagrammatic representation of the Hatch and Slack Pathway

PHOTORESPIRATION

If the O_2 concentration is more than that of $CO_2$the RuBP combines with O_2 to form 1 molecule of 3PGA and one molecule phosphoglycolate.[It is common in C_3 plants].

In the photorespiration there is no synthesis of ATP or NADPH. Therefore, photorespiration is a wasteful process.

In C4 plants photorespiration does not occur. Because the RuBisCO s seen in bundlesheath cells; there is enough supply of CO_2.

Difference between C_3 cycle and C_4 cycle

C_3 cycle	C_4 cycle
Traced out by Melvin Calvin	Traced out by Hatch and Slack
Co_2 acceptor is RuBp	Co_2 acceptor is PEP
First stable compound is 3-PGA	First stable compound is OAA
RuBisCo is the carboxylation enzyme	PEP Case is the carboxylation enzyme
Leaves have no Kranz anatomy	Leaves show Kranz anatomy
Bundle sheath cells do not show chloroplasts	Bundle sheath cells show chloroplasts
Only mesophyll cells involved	Both mesophyll and Bundle sheath cells involved
Optimum temperature is low	Optimum temperature is high
Photorespiration is high	No Photorespiration
Co_2 compensation point is high	Co_2 compensation point is low
Eg.wheat, rice, cotton	Eg.sugarcane,sorghum,amaranthus
Less efficient	High efficient

Factors affecting photosynthesis

Internal factors	External factors
leaf number, leaf size, leaf age and orientation of leaves, orientation of mesophyll cells,orientation of chloroplasts	sunlight, temperature, CO_2 concentration and water,

1. Light: light affect in various ways

a) light quality: photosynthesis is maximum in red and blue light

b) light intensity: photosynthesis is maximum in intense light than dim light.

c) duration: photosynthesis is maximum in intermittent light than continuous light.

2. Carbon dioxide Concentration

The concentration of CO2 is very low in the atmosphere (between 0.03 and 0.04 per cent). Increase in concentration up to 0.05 per cent can cause an increase photosynthesis; beyond this the levels can become damaging.

3. Temperature

The dark reactions being enzymatic are temperature controlled, the C4 plants respond to higher temperatures and show higher rate of photosynthesis while C3 plants have a much lower temperature optimum.

4.Water

Water is necessary for photosynthesis.

Water stress causes the stomata to close hence reducing the CO_2 availability.

Blackman's Law of Limiting Factors

This states that- If a chemical process is affected by more than one factor, then its rate will be determined by the factor which is nearest to its minimal value.

CHAPTER: 10 RESPIRATION IN PLANTS

Respiration

- During the process of respiration, glucose is oxidised, oxygen is utilised and carbon dioxide, water and energy are released as products
- $C_6H_{12}O_6 + 6O_2$® $6CO_2 + 6H_2O$ + *Energy (glucose)*
- This combustion reaction requires oxygen (aerobes). But some cells or many not available (aneorbes). Some of these organisms are facultative anaerobes while in others the requirement for anaerobic condition is obligate.
- In any case, all living organisms retain the enzymatic machinery to partially oxidise glucose without the help of oxygen. This breakdown of glucose to pyruvic acid is called **glycolysis**.

Glycolysis (glycos: sugar, lysis: splitting)

- The scheme of glycolysis was given by Gustav Embden, Otto Meyerhof, and J. Parnas.
- It is often referred as EMP pathway.
- It occurs in the cytoplasm of the cell and is present in all living organisms.

- In glycolysis glucose undergoes partial oxidation to form two molecules of **pyruic acid.**
- In plants, this glucose is derived from sucrose, which is the end product of photosynthesis, or from storage carbohydrates. Sucrose is converted into glucose and fructose by the enzyme, invertase and these two monosaccharide readily enter the glycolytic pathway.

Steps

(1) Glucose and fructose are phosphorylated to give rise to glucose-6- phosphate by the enzyme hexokinase.

ATP is utilised in this step.

$$\text{Glucose} \xrightarrow[\text{Hexokinase}]{\text{ATP} \;\to\; \text{ADP}} \underset{(6C)}{\text{Glucose - 6 , phosphate}}$$

(2) This glucose - 6- phosphate then isomerises to produce fructose- 6 - phosphate

$$\underset{(6C)}{\text{Glucos - 6 - Phosphate}} \longrightarrow \underset{(6C)}{\text{Fructose - 6 - phosphate}}$$

(3) The fructose - 6 - phosphate converted to fructose 1, 6, bisphosphate. ATP molecule is utilized in this step.

$$\underset{(6C)}{\text{Fructose - 6 - phosphate}} \xrightarrow{\text{ATP} \;\to\; \text{ADP}} \underset{(6C)}{\text{Fructose 1,6 biphosphate}}$$

(4) The fructose 1, 6 bisphosphate is split into dihydroxyacetone phosphate and 3-phosphoglycer aldehyde (PGAL)

Fructose 1, 6 bisphosphate

↓ *Dihydroxyaceton phosphate*

↓ *3 Phosphr Glyceraldehyde*

(5) Glyceraldehyde - 3- phosphate is converted to 1,3 bisphosphoglyceric acid (BPGA). In this step NADH + H^+ is formed from NAD^+. Two redox equivalents are removed (in the form of 2 hydrogen atoms) from PGAL and transferred to a molecule of NAD^+

$$\underset{(3C)}{PGAL} \xrightarrow{NAD^+ \;\to\; NADH + H^+} \underset{(3C)}{1,3\ bisphosphoglyceric\ acid}$$

(6) 1,3 bisphosphoglyceric acid is converted to 3 phosphoglyceric acid. One molecule of ATP is formed in this step.

$$\underset{(3C)}{1,3\ bisphosphoglyceric\ acid} \xrightarrow{ADP \;\to\; ATP} \underset{(3C)}{3\text{-}\ phosphoglyceric\ acid}$$

(7) 3 - phosphoglyceric acid is converted to 2- phosphoglycerete.

$$\underset{(3C)}{3\ phosphoglyceric\ acid} \longrightarrow \underset{(3C)}{2\ phospho\ glycerate}$$

(8) 2 phosphoglycerate converted to phosphoenol pyruvate by the elimination of water molecule.

$$2\ Phosphoglycerate \xrightarrow{H_2O} Phosphoenol\ pyruvate$$

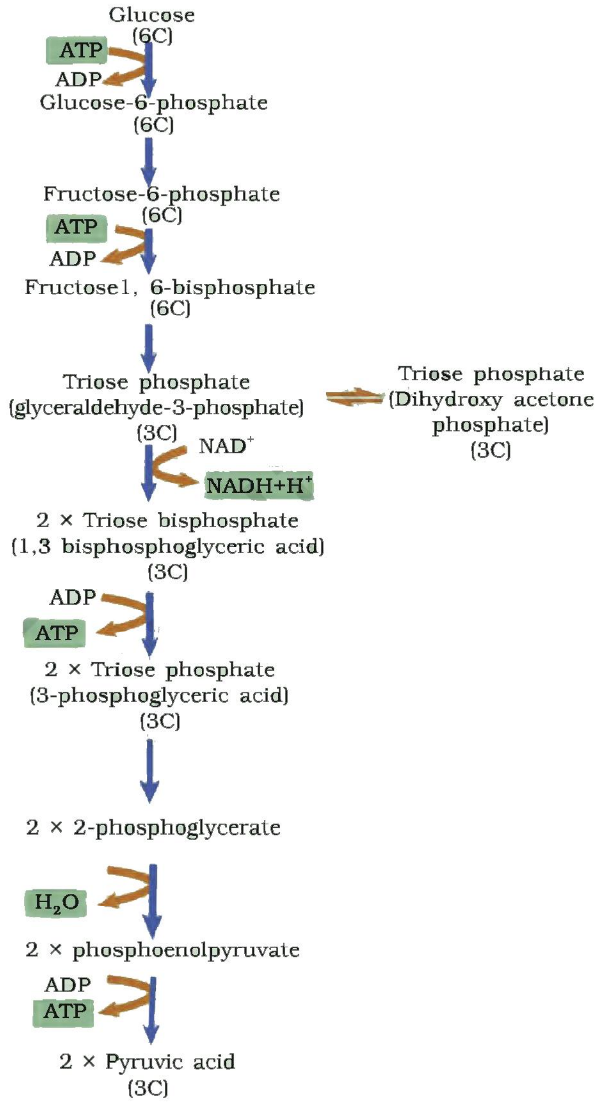
(9) Phosphoenol pyruvate is converted to pyruvate. ATP molecule is formed in this step.

$$Phosphoenol\ pyruvate \xrightarrow{ADP \;\to\; ATP} Pyruvic\ acid$$

(10) ATP is utilised at 2 steps first in the conversion of glucose into glucose-6 phophale and second in the conversion of fructose 6 phosphate to fructose 1,6 bisphospate.

(11) When PGAL is converted to 1,3 biphosphoglycerate (BPGA), NADH + H$^+$ is formed from NAD$^+$.

(12) Conversion of 1,3 bisphosphoglycerate to 3 phosphoglycerate and phosphoenol pyruvate to pyruvate yield energy and is coupled with the formations of ATP.



Steps of glycolysis

- There are 3 major ways in which different cells handle pyruvic acid produced by glycolysis. These are lactic acid fermentation, alcoholic fermentation and aerobic respiration.
- Fermentation is anaerobic respiration, whereas organisms adopt Krebs cycle which is also called as aerobic respiration.

Fermentation

There are 3 major ways in which different cells handle pyruvic acid produced by glycolysis

(i) Alcoholic fermentation

(ii) Lactic acid fermentation

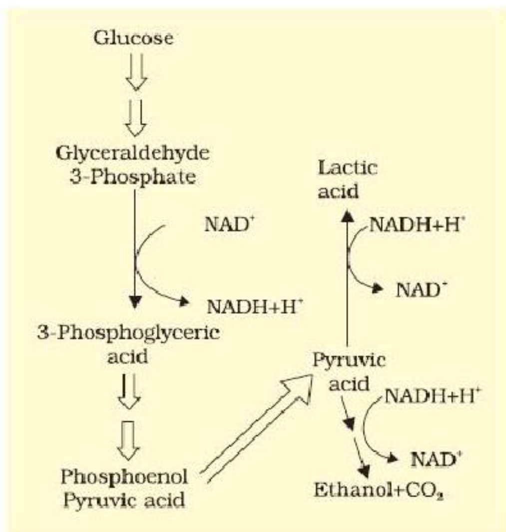
(iii) Aerobic respiration

(i) Alcoholic fermentation

- The incomplete oxidation of glucose is achieved under anaerobic conditions by set of reactions where pyruvic acid is converted to CO_2 and ethanol.
    - Eg:- yeast
- The enzyme pyruvic acid decarboxylase and alcohol dehydrogenase catalyse these reactions.
- NADH + H^+ is reoxidised into NAD^+

(ii) Lactic acid fermentation

- Pyruvic acid converted into lactic acid
- It takes place in the muscle in anaerobic conditions.
- The reaction catalysed by lactate dehydrogenase.
- NADH + H+ is reoxidised into NAD+



Major pathways of anaerobic respiration

(iii) Aerobic respiration

- In eukaryotes it takes place within the mitochondria
- It leads to the complete oxidation of organic substances in the presence of oxygen, and releases CO_2, water and a large amount of energy present in the substrate.

Aerobic Respiration

The mechanism of aerobic respiration can be studies under following steps.

(i) Glycolysis

(ii) Oxidative decarboxylation

(iii) Kreb's cycle(TCA - cycle)

(iv) Oxidative phosphorylation

Oxidative decarboxylation

- Pyruvate is transported from the cytoplasm into the mitochondria. (pyruvate is the final product of glycolysis)
- Pyruvic acid is converted into a acetyl CoA in presence of **pyruvate dehydrogenase.**

$$Pyruvic\ acid + CoA + NAD^+ \xrightarrow{Mg^{2+}} Acetyl\ CoA + CO_2 + NADH + H^+$$

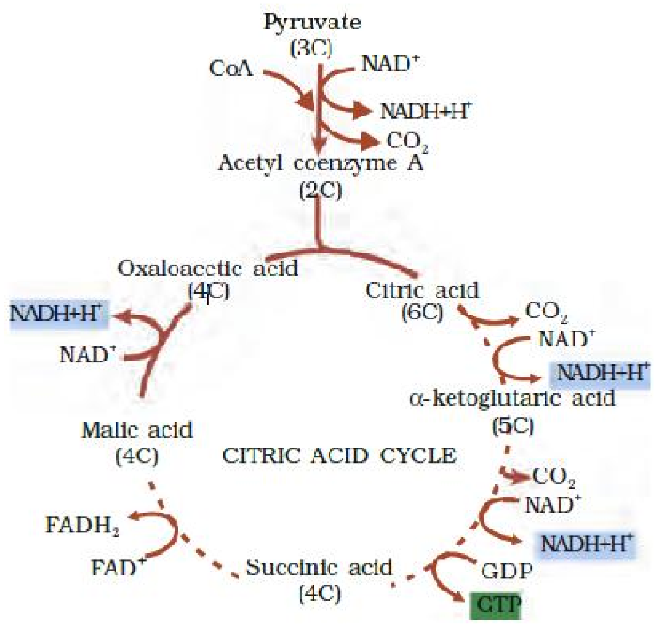
- During this process 2 molecules of NADH are produced from 2 molecules of pyrivic acids (produced, from one glucose molecule during glycolysis)
- The crucial events in aerobic respiration are:

(i) The complete oxidation of pyruvate by the stepwise removal of all the hydrogen atoms, leaving 3 molecules of CO_2.

(ii) The transport of the electrons removed as part of the hydrogen atoms to molecular O_2 with simultaneous synthesis of ATP.

Tricarboxylic acid cycle (Krebs cycle or citric acid cycle)

- It starts with the condensation of acetyl group with oxaloacetic acid (OAA) and water to yield citric acid. The reaction is catalysed by citrate synthase and the molecule of CoA is released.
- Citrate is then isomerised to isocitrate.
- It is followed by 2 successive steps of decarboxylation, leading to the formation of µ-
- ketoglutaric acid and then succinyl CoA.
- In the remaining steps the succinyl CoA oxidized into oxalo acetic acid (OAA).
- During conversion of succinyl CoA to succunic acid there is synthesis of one GTP molecule.
- In a coupled reaction GTP converted to GDP with simultaneous synthesis of ATP from ADP



The Citric acid cycle

- During Krebs cycle there production of 2 molecule of CO_2, 3 ($NADH+H^+$), 1 $FADH_2$ and 1 GTP.
- There are 3 points in the TCA cycle

(i) NAD^+ is reduced to $NADH + H^+$

(ii) FAD^+ is reduced to $FADH_2$

(iii) The continued oxidation of acetyl CoA requires continued replenishment of oxaloacetic acid & regeneration of NAD^+ and FAD^+ from NADH and $FADH_2$ respectively.

The summary equation for thus phase of respiration as follows

$$Pyruvicacid + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pi \xrightarrow{Mitochondrial\ Matrix} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

During the whole process of oxidation of glucose produce"

CO_2

10 ($NADH + H^+$)

2 $FADH_2$

2 GTP (2ATP)

Electron Transport system and oxidation phosphorylation

Electron transport system (ETS) is the metabolic pathway through which the electron passes from one carrier to another. It is located in the inner mitochondrial membrane.

ETS comprises of the following

Complex I - NADH dehydrogenase

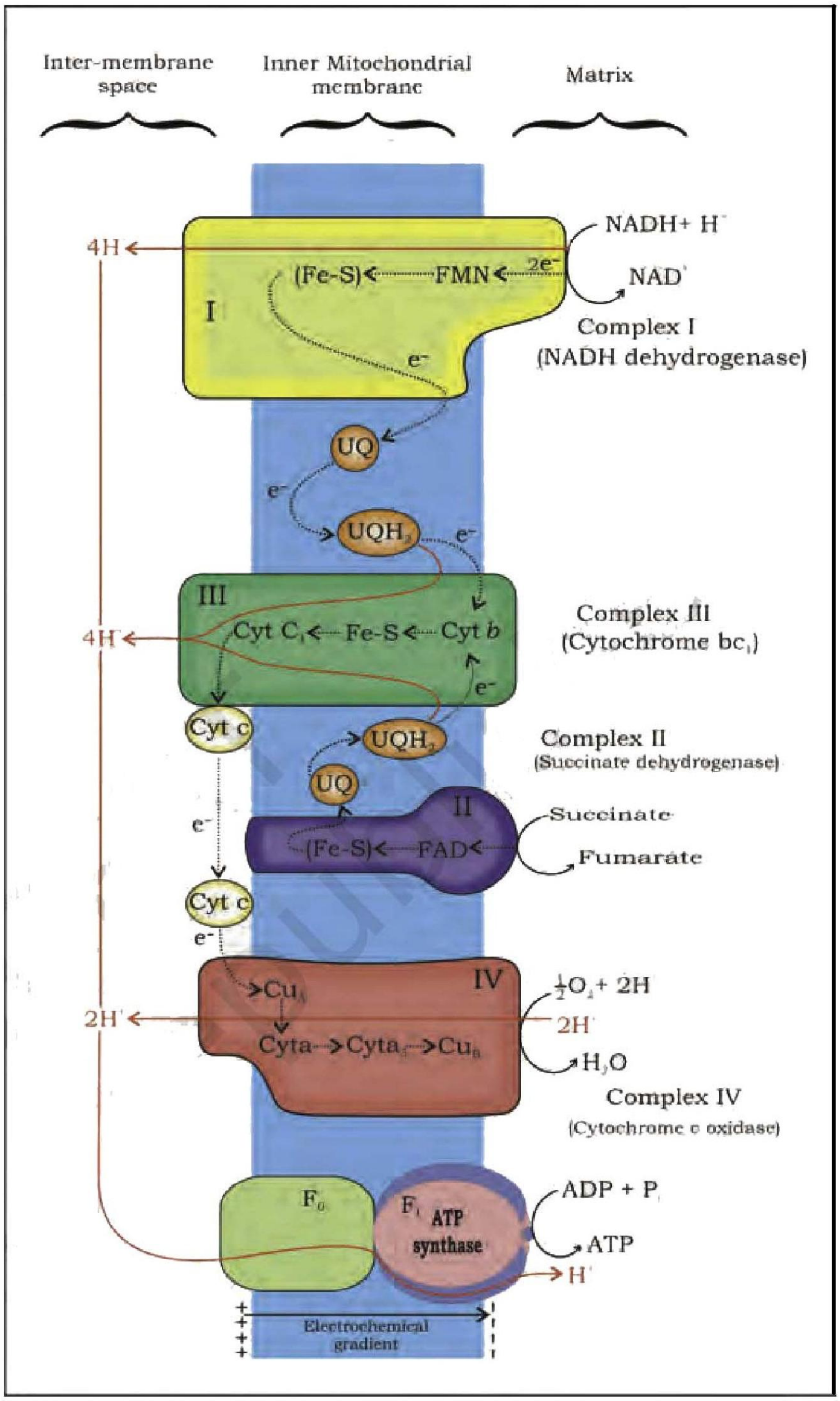
Complex II - Succinate dehydrogenase

Complex III - Cytochrome b - c_1

Complex IV - Cytochrome c oxidase

Complex V - ATP synthase

- NADH + H^+ produced in the citric acid cycle is oxidized by NADH dehydrogenase and electrons are then transferred to ubiquinone located in the inner membrane.
- Succinete is oxidized by succinate dehydrogenase and transferred electrons $FADH_2$ and then to ubiquinone.
- The reduced ubiquinore is then oxidized with transfer of electrons to cytochrome b - c_1 complex.
- Cytochrome c is a small protein attached to the outer surface of the inner membrane and acts as a mobile carrier for transfer electrons from complex III and complex IV.
- When electrons transferred from one carrier to another via complex I to IV in the electron transport chain, they are coupled to ATP synthase for the synthesis of ATP from ADP and Pi
- One molecule of NADH + H^+ gives rise to 3 ATP.
- One molecule of $FADH_2$ gives rise to 2 ATP
- Oxygen plays a vital role in removing electrons and hydrogen ion finally production of H_2O. Oxygen acts as the final hydrogen accepter.
- In photophosphorylation the light energy that is utilised for the production of proton gradient required for phosphorylation. In respiration it the energy of oxidation - reduction utilised for the same process. So it is called oxidative phosphorylation.



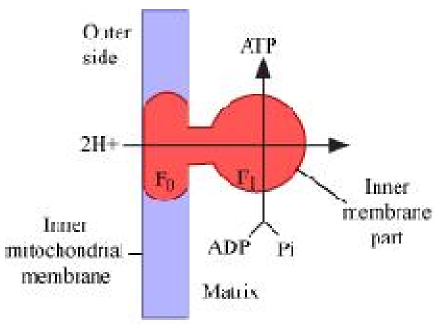
Electron Transport System (ETS)

<u>Mechanism of membrane linked ATP synthesis</u>

Explained by chemiosmotic hypothesis

- The energy released during the electron transport system is utilised in synthesising ATP with the help of ATP synthase (complex v).
- This complex consists of 2 major components, F_1 and F_0.

- The F_1 headpiece is a peripheral membrane protein complex and contains the site for synthesis of ATP from ADP and inorganic phosphate.
- F_0 is an integral membrane protein complex that forms the channel through which protons cross the inner membrane.
- The passage of protons through the channel is coupled to the catalytic site of the F_1 component for the production of ATP.
- For each ATP produced, $3H^+$ passes through F_0 from the intermembrane space to the matrix down the electro chemical proton gradient.



Diagramatic presentation of ATP synthesis in mitochondria

The Respiratory Balance sheet

Total ATP production

There can be a net gain of 36 ATP molecule during aerobic respiration of one molecule of glucose.

- Glycolysis 2 ATP + $2NADH_2$ (6ATP) = 8ATP
- Oxidative decarboxylation 2 $NADH_2$ (6ATP) = 6ATP
- Krebs cycle 2GTP (2ATP) + $6NADH_2$
  - (18ATP) + 2 $FADH_2$ (4ATP) = 24 ATP
- Energy production during acrobic respiration = 38 ATP

Fermentation	Aerobic respiration
It account for only a partial breakdown of glucose	It is completely degraded to CO_2 and H_2O
There is a net gein of only 2 molecule of ATP for each molecule of glycose degraded to phyruvic acid	Many molecules of ATP are generated
NADH is oxidised to NAD^+ rather slowly	NADH is oxidised to NAD^+ vigorous

AMPHIBOLIC PATHWAY

The respiration pathway is involved in both anabolism and catabolism. So the respiratory pathway is an amphibolic pathway.

Respiratory Quotient (RQ)

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.

$$RQ = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ Consumed}}$$

The respiratory quotient depends upon the type of respiratory substrate used during respiration.

Carbohydrates RQ will be 1

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

$$RQ = \frac{6CO_2}{6O_2} = 1.0$$

Fats RQ is less than 1

$$2\ (C_{51}H_{98}O_6) + 145O_2 \rightarrow 102CO_2 + 98H_2O + Energy$$

$$RQ = \frac{102\ CO_2}{145\ O_2} = 0.7$$

When proteins are respiratory substrates the ratio would be about 0.9.

CHAPTER 11: PLANT GROWTH AND DEVELOPMENT

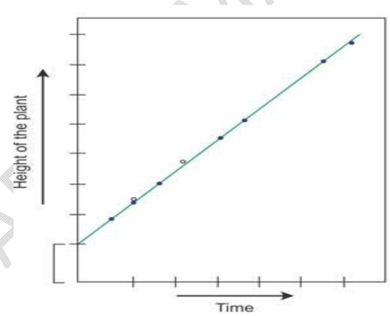
- **Growth**
- Irreversible permanent increase in size of an organ / its parts /of an individual cell.
- Growth is accompanied by metabolic processes occur at the expense of energy.
- Plants can grow throughout their life due to the presence of meristem

- **Open form of growth**- Form of growth where new cells are always being added to the plant body by the activity of meristem.
- **Growth is measurable** –Growth is measured by a variety of parameters like increase in fresh weight, dry weight, length , area, volume & cell number. eg., one single root apical meristem can give rise to more than 17,500 new cell/hour (increase in cell number), Cells in a watermelon increase in size upto 3,50,000times, growth of pollen tube is measured in terms of its length.

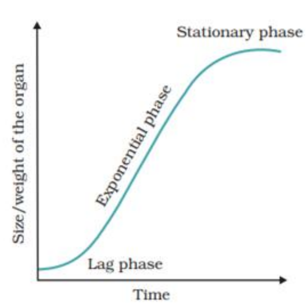
Phases of growth

Meristemmatic phase	Elongation phase	Maturation phase
Root & shoot apical meristem represent this phase. Cells divide constantly.	Cells just next to meristemmatic zone. Characteristics - Cell enlargement, increased vacoulation, new cell wall deposition	Just next to elongation phase. Cells attain maximum size in terms of wall thickening & protoplasmic modifications

- **Growth rate**- Increased growth/ unit time
- **Arithmetic growth curve** - Following mitotic cell division, one daughter cell continues to divide . The other daughter cell differentiates and matures. Equation- $L_t=L_0+rt$. L_t - length at time t, L_0 – length at time 0, r- growth rate



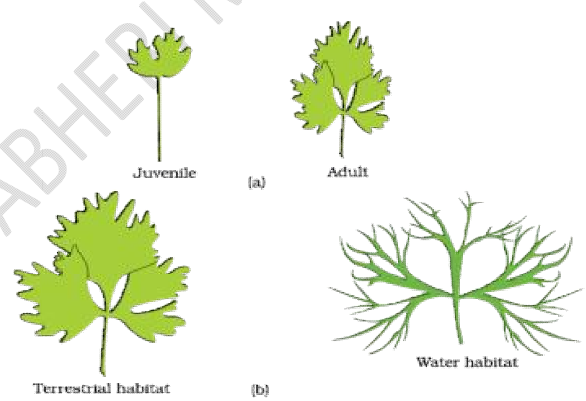
- **Geometric growth curve** –Following mitotic cell division, both the daughter cells retain the ability to divide. Initial growth is slow (**lag phase**). Then growth increases at exponential rate (**log/ exponential phase**) . After some time growth slows down due to limited nutrient supply & leads to **stationary phase.** Sigmoid/ S-curve obtained. Equation – $w_1= w_0\, e^{rt}$. W_1 – final size, w_0 – initial size, r- growth rate, t-time, e – base of natural logarithms.



- Relative growth is the measure of the ability of the plant to produce new plant material referred to as **efficiency index**. Hence final size of w_1 depends on the initial size w_0.
- **Absolute growth rate –**Measurement & the comparison of total growth / unit time
- **Relative growth rate-** Growth of given system / unit time expressed on a common basis.
- Water, oxygen, nutrients & optimum temperature are essential for growth.
- Environmental signals such as light & gravity also affect certain stages of growth.
- **Differentiation-** Cells mature to perform specific functions. Differentiated tissues lost the capacity of division. eg. Formation of permanent tissues from meristem.
- **Dedifferentiation** – Living differentiated tissues (permanent tissues) regain the capacity of division under certain conditions. eg., Formation of secondary meristems (vascular cambium & Cork cambium) from differentiated parenchyma cells.
- **Redifferentiation-** Secondary meristem divide and produce secondary permanent tissues which again lost their capacity of division & mature to perform specific functions. eg., formation of secondary xylem & phloem and periderm formation.

Development - All changes from germination to senescence. Development= Growth+differentiation

- **Plasicity** – Ability of a plant to follow different pathways in response to environment to form different types of structures. eg., heterophylly in cotton, coriander & larkspur



- Development in plants is under the control of intrinsic (genetic factors & activity of hormones) and extrinsic factors (light, temperature, water, oxygen, nutrition).
- **Plant Growth Regulators** :-
- Small simple molecules of diverse chemical composition.
- They could be Indole compounds (IAA), adenine derivatives (kinetin), derivatives of carotenoids (ABA), terpenes (giberellic acid), or gas (ethylene).
- Plant growth regulators are also known as Plant growth substances, Plant hormones or Phytohormones.

- Plant growth promoters :- involved in growth promoting activities like cell division, cell enlargement, tropic growth, flowering, fruiting ,seed formation etc. eg., auxin, giberellin, cytokinin.
- Plant growth inhibitors :- important role in plant responses to wound & stresses. Also involved in inhibiting activities like dormancy & abscission. eg., ABA & ethylene .
- For every phase of growth, differentiation and development of plants, one or other Phytohormones has some role to play. Such roles could be complementary /antagonistic.
- Number of events in the life of a plant where more than 1 PGR interact to affect that event. eg., dormancy in seeds / buds, abscission, senescence, apical dominance etc.

- **Physiological Effects Of Phytohormones**
- **Auxin**
- **Discovery**- First persons associated with the discovery of auxins -Charles Darwin & his son Francis Darwin . Auxin was isolated by F.W. Went from tips of coleoptiles of oat seedlings.
- Auxin (from Greek 'auxein' : to grow) was First isolated from human urine.
- Produced by the growing apex of stem & root, from where they migrate to regions of action.
- Natural auxins (derived from plants) :- IAA (indole-3-acetic acid) & IBA (indole butyric acid)
- Synthetic auxin :- NAA (Naphthalein acetic acid), & 2, 4-D (2,4-dichlorophenoxyacetic acid)
- Physiological responses:-
    1. **Apical dominance** - (Inhibition of growth of lateral bus by the terminal bud due to the presence of auxin). When apical bud is removed (decapitation) lateral buds sprout & this is widely used in tea plantations and hedge making.
    2. Initiate rooting in stem cutting.
    3. Promote flowering in pineapple.
    4. Prevent fruit & leaf drop at early stages but promote the abscission of older mature leaves & fruits.
    5. Induce Parthenocarpy. eg., in tomatoes.
    6. Weedicide (2,4-D used to kill dicot weeds, & does not affect monocot plants) used to prepare weed-free lawns by gardners.
    7. Auxin control xylem differentiation & helps in cell division

Giberellin

- **Discovery** – E. Kurosawa reported the symptoms of the ' bakane' (foolish seedling) disease in uninfected rice seedling , when seedlings were treated with sterile filtrates of Giberella. Fujikuroi (a fungal pathogen) Active substance is later identified as giberellic acid.
- More than 100 giberellins are reported from different organisms like fungi & higher plants. All GAs are acid.

- Physiological responses :-
    1. Promote Bolting (Internode elongation before flowering) in beet, cabbage etc.
    2. Increase the length of stem & Increase the yield in sugarcane.
    3. Speed up maturity period of juvenile conifers & leads to early seed production
    4. Speed up malting process in brewing industry.
    5. Delay senescence.
    6. Increase the length of grapes stalks.

Cytokinin

- **Discovery**- Skoog & Miller identified and crystallized cytokinesis promoting active substance ,kinetin
- kinetin :- first cytokinin discovered from the autoclaved herring sperm DNA. Kinetin does not occur naturally in plants.
- Zeatin :- Natural cytokinin present in corn-kernels and coconut milk.
- Physiological responses :-
    1. Overcome apical dominance
    2. Shoot initiation
    3. Cell division & differentiation
    4. Promote nutrient mobilisation.
    5. Delay senescence.
    6. Produce new leaves & chloroplasts in leaves

Ethylene :-

- **Discovery**- Cousins confirmed the release of volatile substance from ripened organs.
- Only gaseous hormone. Most widely used PGR in agriculture.
- **Ethephon:-** Aquous solution which is readily absorbed and transported within the plant & release ethylene slowly
- Physiological responses :-
    1. Fruit ripening .
    2. Enhance Respiratory climactic (Rise in rate of respiration during ripening of fruit).
    3. Breaks seed & bud dormancy (initiate germination in peanut seeds, sprouting of potato tubers)
    4. Initiate flowering & synchronise fruit set in pineapple.
    5. Induce flowering in mango
    6. Promote female flowers in cucumbers & thus increase the yield.
    7. Promote senescence & abscission of leaves , flowers & fruits.
    8. Promote root &root hair formation, thus helping plants to increase absorptive surface.
    9. Promote rapid internode /petiole elongation in deep water rice plants (So leaves & upper part of shoot remain above water)

Abscisic acid (ABA)

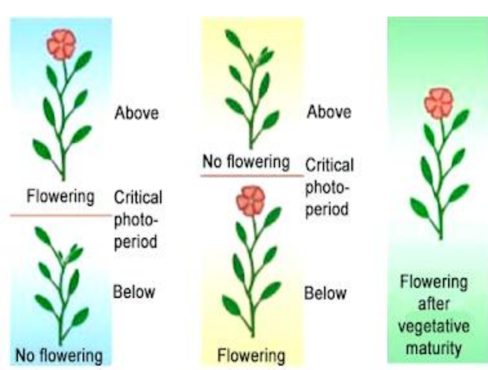
- **Discovery**- Three independent researches reported the purification & chemical characterization of three different kinds of inhibitors , inhibitor-B, abscission –II & domain. Later all three were proved to be chemically identical, named ABA

Physiological responses :-

1. Stimulate the closure of stomata & increase the tolerance of plants to various kinds of stresses. So ABA is called **Stress hormone**
2. Promote Abscission (leaf fall).
3. Inhibit seed germination.
4. Induce dormancy (help seeds to withstand desiccation & other factors unfavourable for growth)
5. ABA act as an Antagonist to giberellin (Action of ABA inhibit / limit the action of giberellin)

Photoperiodism

- Response of plants to Photoperiod (period of day / night) expressed in the form of flowering.
- Site of perception of light / dark duration are the leaves . hormone responsible for flowering, migrate from leaves to shoot apex to induce flowering only when the plants are exposed to necessary photoperiod.
- Critical Photoperiod :- Length of day / light required to induce flowering
- Classification of plants based on photoperiodism :-
    1. Long day plant (LDP) which flower when they are exposed to photoperiod longer than critical photoperiod (require more than 12 hous of light). eg., Spinach, radish, sugar beet, potato etc.
    2. Short day plants (SDP) which flower only when day length is less than critical period (require less than 12 hours of light). They requires a long period of darkness. eg., Chrysanthemum, soyabean, sugarcane etc.
    3. Day neutral plants (DNP) :- Exposure to light / Photoperiod does not affect flowering. eg., Cucumber, Corn, Pea etc.



Long day plant Short day plant Day neutral plant

Vernalisation - Low temperature treatment for flowering.

- Plants like Wheat, barley & rye have two kinds of varieties: Winter & Spring varieties.
- Spring varieties planted in the spring and come to flower & produce grain before the end of season
- Winter varieties, planted in autumn, they germinate & over winter come out as seedlings, resume growth in the spring & are harvested around mid-summer.
- Cold treatment stimulate photoperiodic flowering response in biennial plants like Cabbage, Carrot, Sugarbeet etc.