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UG TRB
BOTANY
2023-2024

UNIT-1

VIRUS, BACTERIA, PHYCOLOGY, MYCOLOGY

Your Success is Our Goal....

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UG TRB BOTANY – 2023-24

UNIT 1 – VIRUS, BACTERIA, PHYCOLOGY & MYCOLOGY

1. VIRUS

1.1 INTRODUCTION:

- Viruses occupy the twilight zone that separates the 'living' from the 'non-living'. They do not have a cellular organization and contain only one type of nucleic acid, either DNA or RNA but never both. The medical importance of viruses lies in their ability to cause a very large number of human diseases. Viral diseases range from minor ailments like common cold to terrifying diseases like rabies and AIDS.

1.1.1 Concept of Viruses in relation to other Organisms:

- Viruses occupy the twilight zone that separates the 'living' from the 'non-living'. They do not have a cellular organization and contain only one type of nucleic acid, either DNA or RNA but never both. Viruses are obligate intracellular parasites. They lack the enzymes necessary for protein and nucleic acid synthesis. They are dependent for replication on the synthetic machinery of host cells. They multiply by a complex process and not by binary fission. They are unaffected by antibacterial antibiotics. Viruses cause a wide range of human diseases. They cause infections like common cold, chicken pox, measles, viral encephalitis, rabies and AIDS.

1.1.2 Virus History:

- The history of virology goes back to the late 19th century, when German anatomist Dr Jacob Henle (discoverer of Henle's loop) hypothesized the existence of infectious agent that were too small to be observed under light microscope. This idea fails to be accepted by the present scientific community in the absence of any direct evidence.

- At the same time three landmark discoveries came together that formed the founding stone of what we call today as medical science. The first discovery came from Louis Pasture (1822-1895) who gave the spontaneous generation theory from his famous swan-neck flask experiment. The second discovery came from Robert Koch (1843-1910), a student of Jacob Henle, who showed for first time that the anthrax and tuberculosis is caused by a bacillus, and finally Joseph Lister (1827-1912) gave the concept of sterility during the surgery and isolation of new organism.
- The history of viruses and the field of virology are broadly divided into three phases, namely discovery, early and modern. The discovery phase (1886-1913) In 1879, Adolf Mayer, a German scientist first observed the dark and light spot on infected leaves of tobacco plant and named it tobacco mosaic disease.
- Although he failed to describe the disease, he showed the infectious nature of the disease after inoculating the juice extract of diseased plant to a healthy one. The next step was taken by a Russian scientist Dimitri Ivanovsky in 1890, who demonstrated that sap of the leaves infected with tobacco mosaic disease retains its infectious property even after its filtration through a Chamberland filter.
- The third scientist who plays an important role in the development of the concept of viruses was MartinusBeijerinck (1851-1931), he extended the study done by Adolf Mayer and Dimitri Ivanofsky and showed that filterable agent form the infectious sap could be diluted and further regains its strength after replicating in the living host; he called it as "contagium vivumfluidum". Loeffler and Frosch discovered the first animal virus, the foot and mouth disease virus in 1898 and subsequently Walter Reed and his team discovered the yellow fever virus, the first human virus from Cuba in1901.
- Poliovirus was discovered by Landsteiner and Popper in 1909 and two years later Rous discovered the solid tumor virus which he called Rous sarcoma virus. The early phase (1915-1955) In 1915, Frederick W. Twort discovered the phenomenon of transformation while working with the variants of vaccinia viruses, simultaneously Felix d'Herelle discovered bacteriophage and developed the assay to titrate the viruses by plaques. WendellStanley (1935) first crystallized the TMV and the first electron micrograph of the tobacco mosaic virus (TMV) was taken in 1939.
- In 1933 Shope described the first papillomavirus in rabbits. The vaccine against yellow fever was made in 1938 by Thieler and after 45 years of its discovery, polio virus vaccine was made by Salk in 1954. The modern phase (1960-present) During this phase scientists began to use viruses to understand the basic question of biology. The superhelical nature of polyoma virus DNA was first described by Weil and Vinograd while Dulbecco and Vogt showed its closed circular nature in 1963.

- In the same year Blumberg discovered the hepatitis B virus. Temin and Baltimore discovered the retroviral reverse transcriptase in 1970 while the first human immunodeficiency virus (HIV) was reported in 1983 by Gallo and Montagnier. The phenomenon of RNA splicing was discovered in Adenoviruses by Roberts, Sharp, Chow and Broker. In the year 2005 the complete genome sequence of 1918 influenza virus was done and in the same year hepatitis C virus was successfully propagated into the tissue culture. Many discoveries are done using viruses as a model.
- The transcription factor that binds to the promoter during the transcription was first discovered in SV40. The phenomenon of polyadenylation during the mRNA synthesis was first described in poxviruses while its presence was first reported in SV40. Many of our current understanding regarding the translational regulation has been studied in poliovirus. The oncogenes were first reported in Rous sarcoma virus. The p53, a tumor suppressor gene was first reported in SV40.

1.1.3 Discovery and Detection:

- Viruses were first discovered after the development of a porcelain filter, called the Chamberland-Pasteur filter, which could remove all bacteria visible in the microscope from any liquid sample.
- In 1886, Adolph Meyer demonstrated that a disease of tobacco plants, tobacco mosaic disease, could be transferred from a diseased plant to a healthy one via liquid plant extracts.
- In 1892, Dmitri Ivanowski showed that this disease could be transmitted in this way even after the Chamberland-Pasteur filter had removed all viable bacteria from the extract.
- Virions, single virus particles, are very small, about 20–250 nanometers in diameter. These individual virus particles are the infectious form of a virus outside the host cell.
- Unlike bacteria (which are about 100 times larger), we cannot see viruses with a light microscope, with the exception of some large virions of the poxvirus family.
- The surface structure of virions can be observed by both scanning and transmission electron microscopy, whereas the internal structures of the virus can only be observed in images from a transmission electron microscope.

Important discoveries

Date	Discovery
1796	Cowpox virus used to vaccinate against smallpox by Jenner.
1892	Description of filterable infectious agent (TMV) by Ivanovsky.
1898	Concept of the virus as a contagious living form by Beijerinck.
1901	First description of a yellow fever virus by Dr Reed and his team.
1909	Identification of poliovirus by Landsteiner and Popper.
1911	Discovery of Rous sarcoma virus.
1931	Virus propagation in embryonated chicken eggs by Woodruff and Goodpasture.
1933	Identification of rabbit papillomavirus.
1936	Induction of carcinomas in other species by rabbit papillomavirus by Rous and Beard.
1948	Poliovirus replication in cell culture by Enders, Weller, and Robbins.
1952	Transduction by Zinder and Lederberg.
1954	Polio vaccine development by Salk.
1958	Bacteriophage lambda regulation paradigm by Pardee, Jacob, and Monod.
1963	Discovery of hepatitis B virus by Blumberg.
1970	Discovery of reverse transcriptase by Temin and Baltimore.
1976	Retroviral oncogenes discovered by Bishop and Varmus.
1977	RNA splicing discovered in adenovirus.
1983	Description of human immunodeficiency virus (HIV) as causative agent of acquired immunodeficiency syndrome (AIDS) by Montagnier, Gallo)
1997	HAART treatment for AIDS.
2003	Severe acute respiratory syndrome (SARS) is caused by a novel coronavirus.
2005	Hepatitis C virus propagation in tissue culture by Chisari, Rice, and Wakita.
2005	1918 influenza virus genome sequencing.

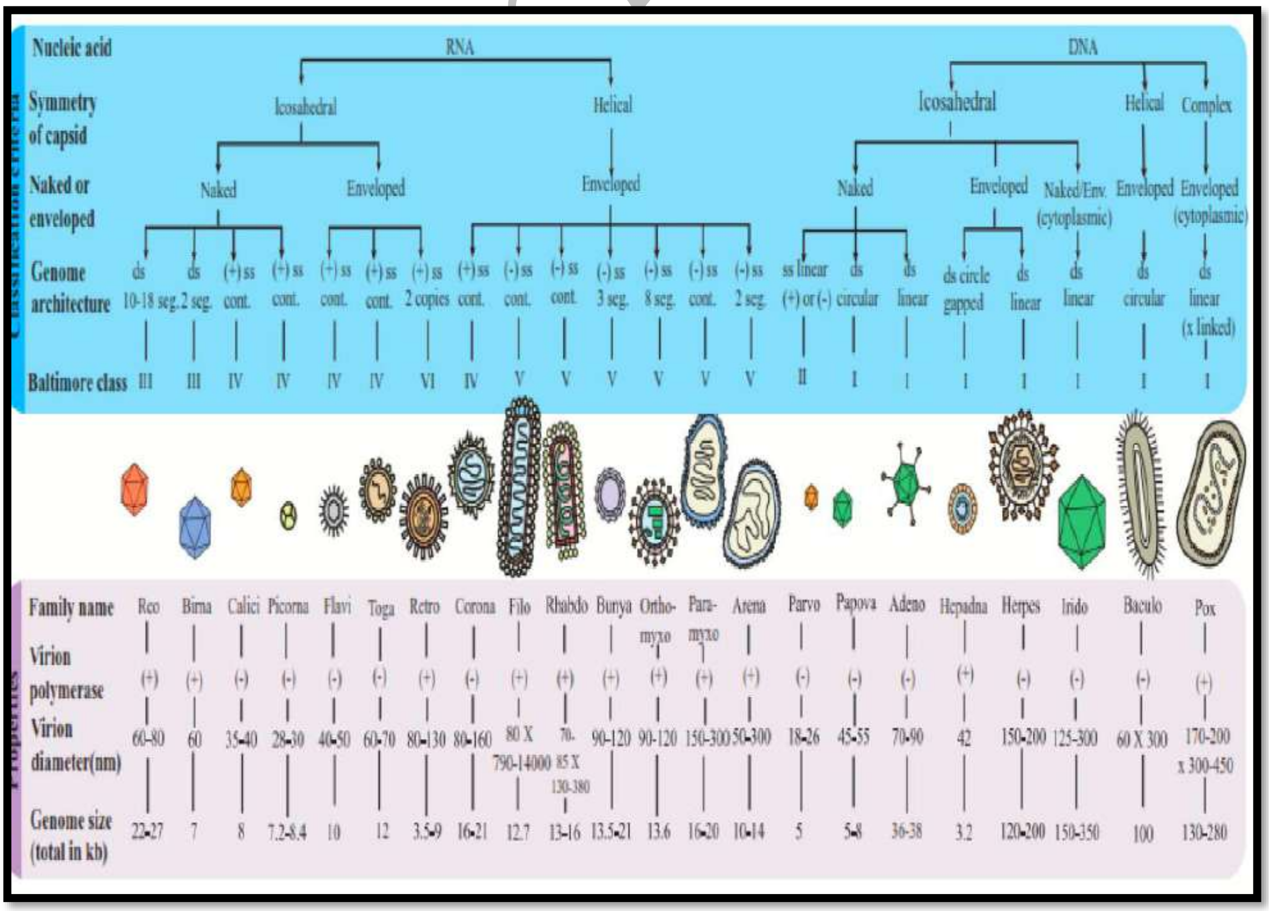
1.1.4 Classification and naming of viruses

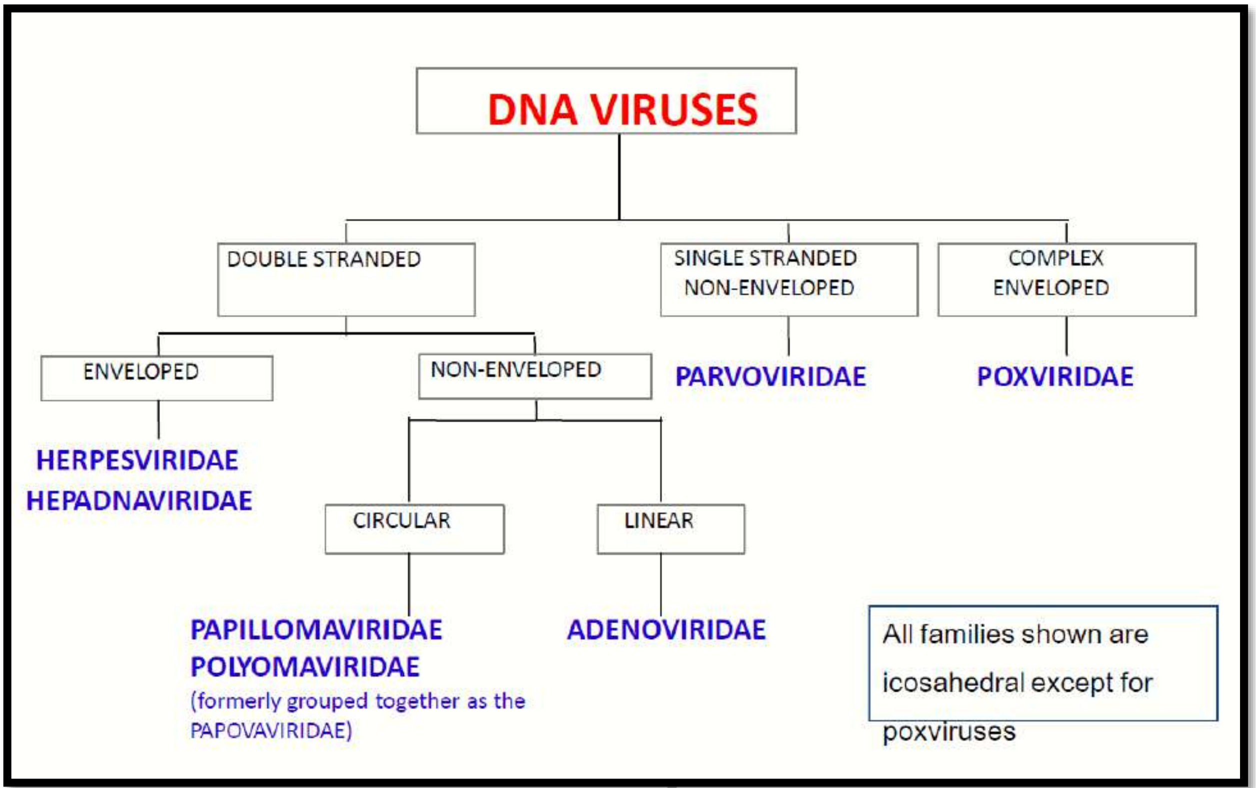
- Till about 1950 little was known of the basic properties of viruses. They werenamed haphazardly, based on the diseases they caused or on the place of theirisolation.
- They were grouped according to affinity to different systems or organsof the body (tropism). So, human viruses were classified as dermotropic, thatis those producing skin lesions (smallpox, chickenpox, measles), neurotropic, that is those affecting the nervous system (poliomyelitis, rabies), pneumotropic, that is those affecting the respiratory tract (influenza, common cold) andviscerotropic, that is those affecting visceral organs (hepatitis). Bawden (1941) made the pioneering suggestion that viral nomenclature and classificationshould be based on the properties of viruses and not upon host responses.
- Fromthe early 1950s, viruses began to be classified into groups based on theirphysiochemical and structural features. Nomenclature and classification are nowthe official responsibility of the International Committee on Taxonomy ofViruses (ICTV).

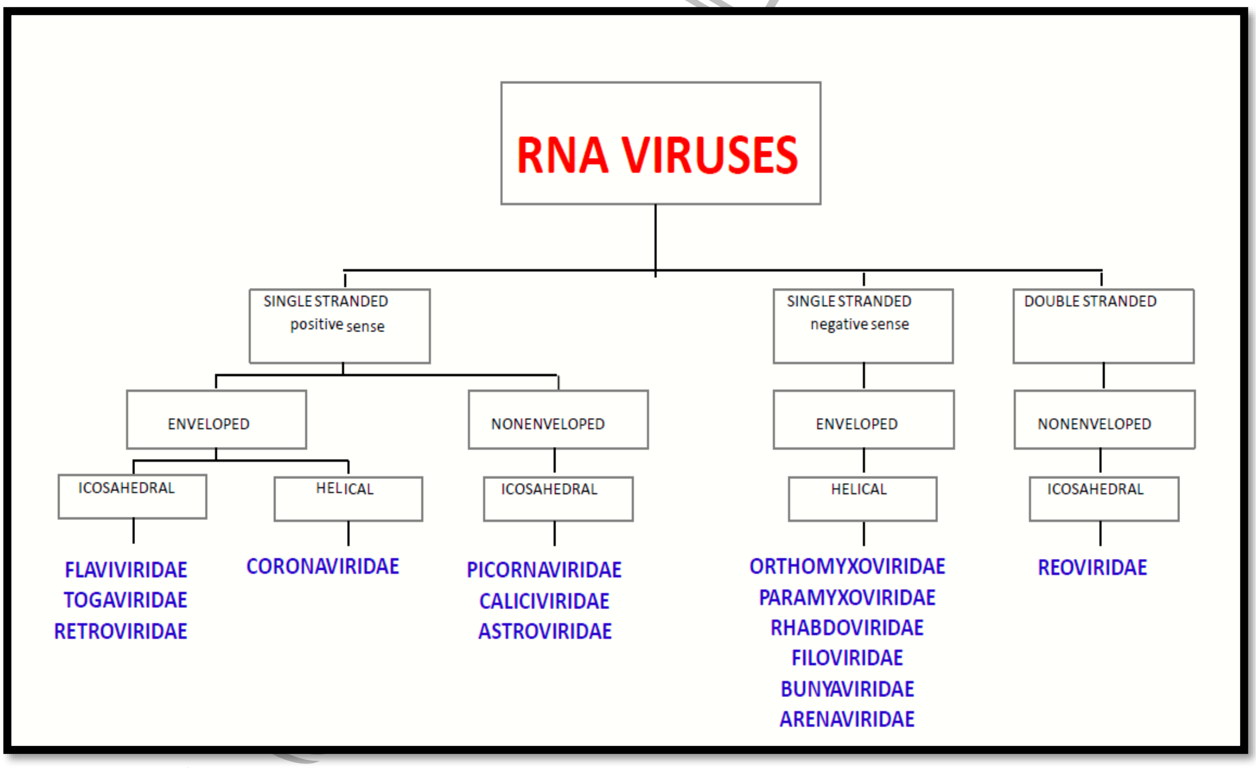
- Viruses are classified into two main divisions based on the type of nucleic acidthey possess: riboviruses contain RNA and deoxyriboviruses contain DNA.Further classification is based on other properties like strandedness of nucleicacid, symmetry of nucleic acid, presence of envelope, size and shape of virionand number of capsomeres.
- DNA viruses: A few medically important families of DNA viruses are
  - Herpesviridae,
  - Adenoviridae,
  - Hepadnaviridae,
  - Parvoviridae and
  - Papillomaviridae.
- The Herpesviridae family consists of enveloped double-stranded DNA viruseshaving an icosahedral capsid.
- Examples of this family are herpes simplex virusand varicella zoster virus. Herpes simplex virus causes skin lesions like herpeslabialis. It can also cause viral encephalitis. Parvoviridae consists of nonenvelopedsingle-stranded DNA viruses, for example Parvovirus B19.
- TheHepadnaviridae family includes Hepatitis B virus which is a partially doublestrandedDNA virus. Papillomaviridae family includes human papilloma viruswhich is responsible for causing skin warts.
- RNA viruses: Some medically important families of RNA viruses are –Picornaviridae, Orthomyxoviridae and Paramyxoviridae, Flaviviridae, Rhabdoviridae and Retroviridae.
- Members of the family Picornaviridaearesmall (20-30 nm), non-enveloped, icosahedral viruses with single-stranded RNAgenome. Examples include poliovirus and coxsackievirus. The viruses includedin Orthomyxoviridae are enveloped viruses carrying haemagglutinin and
- neuraminidase peplomers on the envelope. The genome consists of singlestrandedRNA in several (eight) pieces. Thus, they have a segmented genome.
- An example of this family is influenza virus. Flaviviridae consists of envelopedsingle-stranded RNA viruses. Examples include yellow fever virus, Japaneseencephalitis virus and dengue virus. The members of Retroviridae family areenveloped RNA viruses which have a special enzyme called ‘reverse transcriptase’.

- This enzyme is an RNA dependent DNA polymerase. It is required in thesynthesis of DNA from RNA. An example of the Retroviridae family is HumanImmunodeficiency Virus (HIV) which causes AIDS (acquired immunodeficiencysyndrome). Based on the mechanism of replication, Baltimore (1970) categorisedvirusesinto seven categories. This is called the Baltimore classification.

Diversity among the viruses belonging to different groups







1. Who is the father of Virology?

A) MartinusBeijerinck B) Dmitri Ivanovsky
C) John Ellerman D) Frederick Twort

2. What is Virology?

A) Virology is the study of bacteria B) Virology is the study of viruses
C) Virology is the study of fungi D) Virology is the study of algae

3. Who discovered viruses?

A) John Ellerman B) Frederick Twort
C) Dmitri Ivanovsky D) MartinusBeijerinck

4.Which of the following has responsibility for the assignment of new viruses to specific groupings?

A) ICC B) ICTV C) ITC D) RCM

5.Which of the following viruses are icosahedrons?

A) Filamentous virus B) Complex virus
C) Simple virus D) Isometric virus\\

6.The Baltimore classification was based on the importance of ____________

A) DNA B) mRNA C) rRNA D) tRNA

7.Which of the following class contains all viruses that have dsDNA genomes?

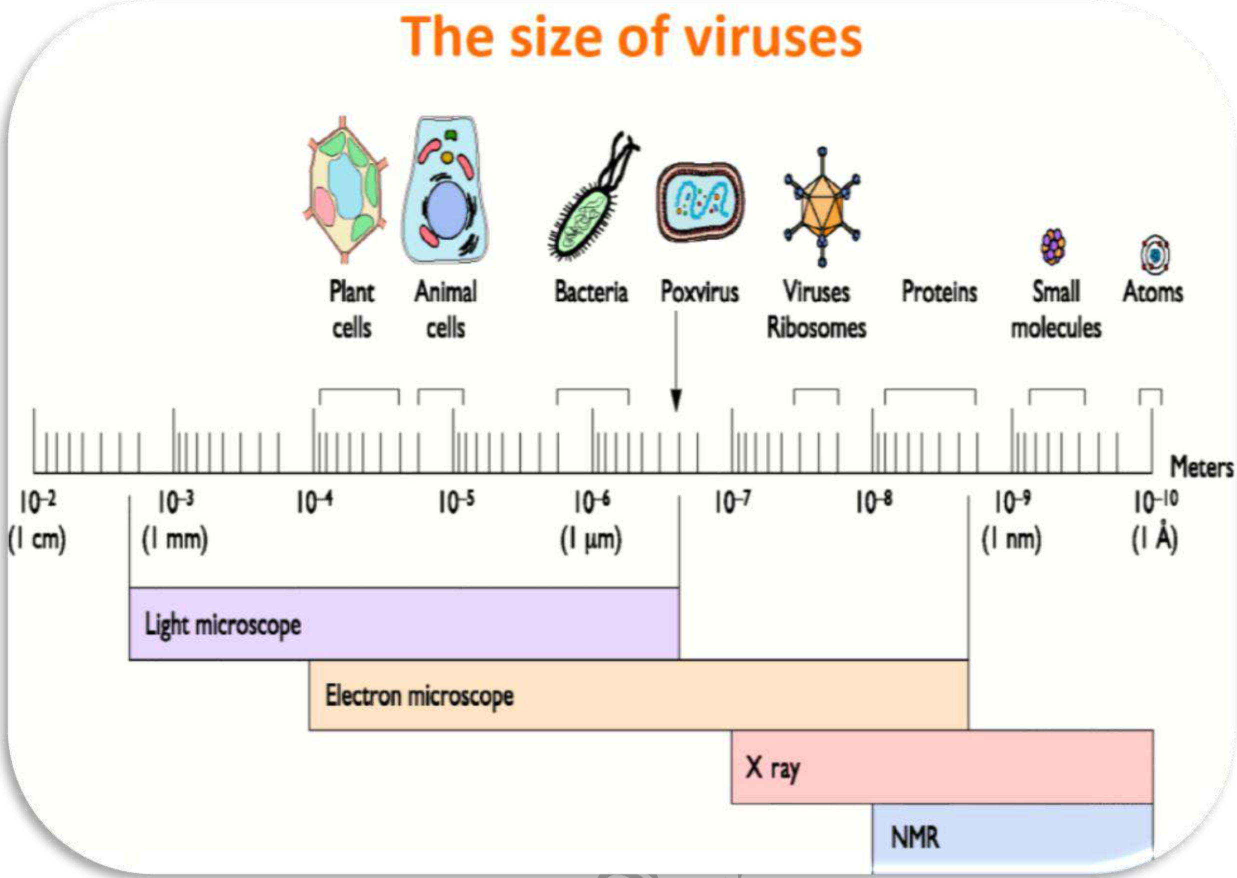
A) Class I B) Class II C) Class III D) Class IV

1.2 STRUCTURE OF VIRUSES:

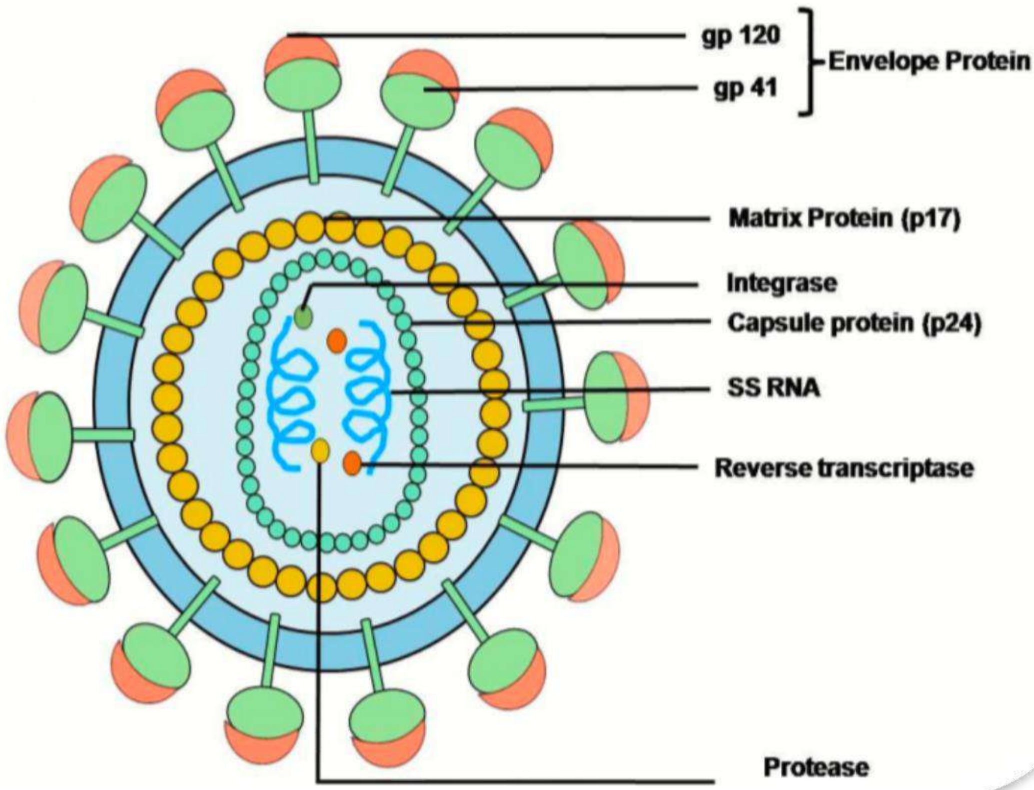
1.2.1 Morphology of Viruses:

1. Size:

- The extracellular infectious virus particle is called virion. Viruses are much smaller than bacteria. They are too small to be seen under the light microscope. Some large viruses like the poxviruses can be seen under the light microscope when suitably stained.
- The viruses range in size from 20 nm to 300 nm. Poxviruses are one of the largest viruses and parvoviruses are one of the smallest viruses.
- The earliest method of estimating the size of virus particles was by passing them through collodion membrane filters of graded porosity.
- The average pore diameter of the finest filter that permitted passage of the virion gave an estimate of its size.
- With the development of the ultracentrifuge, a second method became available. From the rate of sedimentation of the virus in the ultracentrifuge, the particle size could be calculated using Stoke’s law.
- The third and the most direct method of measuring virus size is electron microscopy. By this method, both the shape and size of virions can be studied.



Schematic diagram of HIV



- **Capsid**: the outer protein shell of a virus
- **Envelope**: an enclosing structure or cover, such as a membrane

- **Filamentous**: Having the form of threads or filaments
- **Isometric**: of, or being a geometric system of three equal axes lying at right angles to each other (especially in crystallography)
- **Capsomere**: Any of the individual protein subunits of a viral capsid
- **Icosahedral**: of, relating to, or having the shape of an icosahedrons

1.2.2 Structure, shape and symmetry:

- The virion consists essentially of a nucleic acid surrounded by a protein coat, the **capsid**. The capsid with the enclosed nucleic acid is called the **nucleocapsid**.
- The capsid protects the nucleic acid from harmful agents in the environment. It is composed of a large number of capsomers which form its morphological units.
- The chemical units of the capsid are polypeptide molecules which are arranged symmetrically. They form a shell around the nucleic acid.

1.2.3 Defective Viruses:

Defective viruses are those virus particles whose genome lacks a specific gene or genes due to either mutation or deletion.

- As a result, defective viruses are not capable of undergoing a productive life cycle in cells.
- However, if the cell infected with the defective virus is co-infected with a "helper virus", the gene product lacking in the defective one is complemented by the helper and defective virus can replicate.
- Interestingly, for some viruses, during infection a greater quantity of defective virionsis produced than infectious virions(as much as 100:1).
- The production of defective particles is a characteristic of some virus species and is believed to moderate the severity of the infection/disease in *vivo*.

1.2.4 Pseudovirions:

- Pseudovirions may be produced during viral replication when the host genome is fragmented.
- As a result of this process, host DNA fragments are incorporated in to the capsid instead of viral DNA.
- Thus,pseudo virions possess the viral capsid to which antibodies may bind and facilitate attachment and penetration into a hostcell, but they cannot replicate once

they have gained access to a host cell, as they have none of the essential viral genes for the process.

1.2.5 Prions:

- Prions are proteinaceousinfectious particles associated with transmissible spongiform encephalopathies (TSE) of humans and animals.
- TSEs include the Creutzfeldt-Jacob disease of humans, scrapieof sheep and bovine spongiform encephalopathy.
- At postmortem, the brain has large vacuoles in the cortex and cerebellum regions an thus priondiseases are called "spongiform encephalopathies". Closer examination of brain tissue reveals the accumulation of prion-protein associated fibrils and amyloidplaques.

1.2.6 Viroids:

- Viroids are naked, low-molecular weight nucleicacids that are extremely resistant to heat, ultraviolet,and ionizing radiation. These particles are composed exclusively of a single piece of circular, single stranded RNA that has some double-stranded regions.Viroids mainly cause plant diseases, such as potato spindle tuber disease.
- These diseases are characterized by loss of motor control, dementia, paralysis, wasting and eventually death.

1.2.7 Virusoids:

- Virusoids (also called satellite RNAs)are similar to viroids in that they are naked,low molecular weight nucleic acids that are extremely resistant to heat and ultraviolet and ionizing radiation.However,they depend on a helper virus for replication.Virusoids replicate in cytoplasm via RNA dependent RNA polymerase.

An icosahedral virion structure showing two, three, and fivefold symmetry

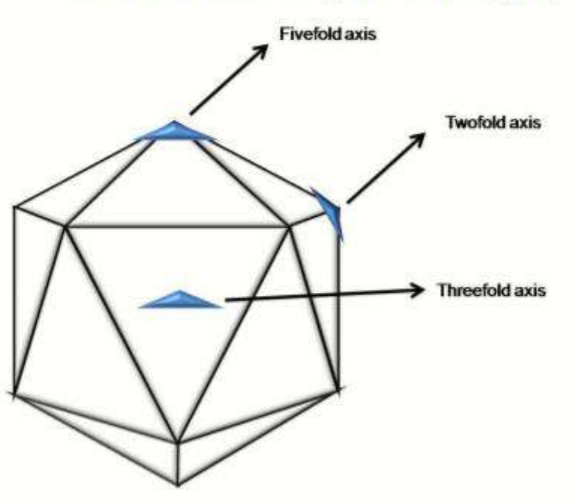
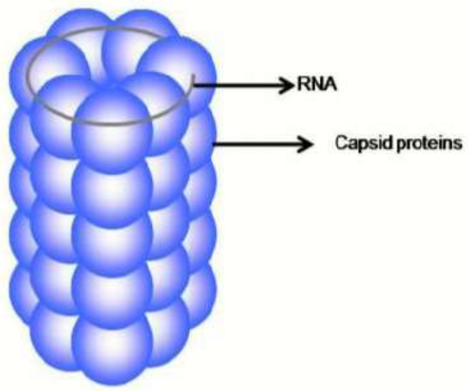


Figure 3.2. Virus structure with helical symmetry.



72) Carrageenan is used as a ______________

A) emulsifier
B) solidifying agent
C) binder
D) emulsifier and binder

73) The famous Japanese dish sushi is made with the help of the red algae named ___

A) Nemalion
B) Porphyra
C) Chondrus
D) Eucheuma

74) Asexual reproduction in Spirogyra

A) takes place by zoospore formation
B) has not been recorded
C) takes place by hypnospore formation
D) takes place by aplanospore formation

75) Agar-Agar is derived from

A) fungi
B) algae
C) bryophytes
D) gymnosperms

76) The number of flagella produced by motile cells in

A) members of the Rhodophyta is greater than members of the Phaeophyta

B) members of the Phaeophyta is greater than members of the Rhodophyta

C) members of the Rhodophyta is exactly or approximately equal to members of the Phaeophyta

D) none of the above

77) Starch is an energy storage material characteristic of

A) chlorophyta
B) chrysophyta
C) phaeophyta
D) rhodophyta

78) Heterocysts are found in

A) Nostoc
B) Cystopus
C) Ulothrix
D) Aspergillus

79) What is the storage product of most algae?

A) Cellulose
B) Glycogen
C) Starch and oil
D) Fat

80) In Ulothrix, reduction division takes place at the time of

A) germination of zygote
B) formation of spores
C) formation of gametes
D) formation of zoospores

81) Agar, which is the solidifying agent in many bacterial culture media, is part of the cell wall of

A) chlorophyta
B) chrysophyta
C) pyrrophyta
D) rhodophyta

82) Number of flagella produced by motile cells in

A) members of the phaeophytais greater than members of the Oomycota

B) members of the Oomycotais greater than members of the Phaeophyta

C) members of the Phaeophyta is approximately equal to members of the Oomycota

D) none of the above

83) Characteristics used to place algae into divisions include all of the following except

A) form of storage material

B) flagella number and location

C) accessor pigments used in photosynthesis

D) all of the above

84) Which of the following is correct?

A) All members of photolithotrophic autotrophs are also members of algae, but not all members of algae are members of photolithotrophic autotrophs

B) All members of algae are also members of photolithotrophic autotrophs, but not all members of photolithotrophic autotrophs are members of algae

C) All members of photolithotrophic autotrophs are members of algae, and all members of algae are members of photolithotrophic autotrophs

D) No member of photolithotrophic autotrophs is a member of algae

85) Zooxanthellae are algal symbiont that live within coral reef animals. These algae belong to

A) chlorophyta B) chrysophyta C) pyrrophyta D) rhodophyta

86) Algae is a nonvalid taxinomic term that refers to

A) eukaryotic organisms that have chlorophyll a and produce O2

B) well developed cellular structure including a conducting system

C) Both (A) and (B) D) none of the above

87) Filaments of Ulothrix are

A) branched B) unbranched C) brick-shaped D) girdle-shaped

88) Which is a rich source of protein?

A) Nostoc B) Anabaena C) Spirulitia D) Oscillatoria

89) Red colour of the red algae is due to

A) y-phycocyanin B) Xanthophyll C) Carotene D) y-phycoerythrin

90) Algae are classified into 6 groups, technically known as

A) categories B) divisions C) genera D) domains

91) Cyanobacteria name has been given to

A) Mycoplasma B) Myxophyceae C) Myxomycetes D) Schizomycetes

92) Spirogyra differs from moss-protonema in having

A) pyrenoids B) branched filaments

C) discoid chloroplasts D) rhizoidal branches

93) Simplest type of reproduction in plants is found in

A) Ulothrix B) Nostoc C) Chlamydomonas D) Spirogyra

94) Parasitic alga is

A) Cephaleuros B) Ulothrix C) Spirogyra D) Chlamydomonas

95) The algae Chlamydomonas demonstrates a complex life cycle that switches between haploid and diploid forms. This life cycle is called

A) the sexual-asexual exchange B) the transposition cycle

C) an alternation of generations D) algal transformation

96) The __________ is the vegetative body of algae.

A) mycelium

B) pseudoplasmodium

C) is scattered the least by smoke or fog

D) thallus

97) Which algal division never produces motile, flagellated cells among any of its members?

A) Chlorophyta B) Chrysophyta C) Phaeophyta D) Rhodophyta

98) Chlamydomonas and Volvox are similar because

A) they both are motile

B) they are members of the Chlorophyta

C) Both (A) and (B)

D) none of these

99) All algae possess

A) nuclei B) chloroplasts

C) Both (A) and (B) D) none of these

100) Bioluminescence is a phenomenon associated with

A) chrysophyta B) phaeophyta C) pyrrophyta D) chlorophyta

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UNIT-2

LICHENOLOGY, BRYOLOGY, PTERIDOLOGY

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UG TRB BOTANY – 2023-24

UNIT - II

1. LICHENOLOGY:

- The term 'Lichen' was used for the first time by Theophrastus (the father of Botany, 371-284 B.C.) to denote a superficial growth on the tree barks. Lichen has been defined as 'a stable selfsupporting association of a phycobiont and mycobiont' in 1989 edition of the 'Dictionary of the Fungi'. Lichen is not a single organism but a small group of curious plants. It is a symbiotic association between a fungus and algae or cyanobacteria. Cyanobacteria are sometimes referred to as 'blue-green algae', though they are quite distinct from the algae. The fungal partner may be referred to as the Mycobiont (Mykes= fungus, bios=life). The non-fungal partner contains chlorophyll and is called the phycobiont (Phykos= alga, bios= life). The lichen symbiosis is thought to be a mutualism, since both the fungi and the photosynthetic partners benefit.

1.1. GENERAL CHARACTERISTICS -STRUCTURE:

- In lichen, the mycobiont produces a thallus, which houses the photobiont. There are three major morphological types of thalli: foliose, fruticose and crustose.

1.1.1 Colour:

- Lichens show many colours such as green, yellow, orange, white, grey etc. The colouration is due to the pigmentation of algal component in the lichens. In some lichens, a special pigment called usnic acid is present which give lichens a variety of colours. In the absence of special pigments, lichens are generally bright green to olive grey when it is wet and grey or grayish-green to brown when dry. In high moisture surroundings, lichens appear greener because the water absorbed fungal mater become more transparent and as a result the green colour algal pigments get exposed. Colours vary due to genetics, age and on the angle of exposure to light

1.1.2 Internal Structure of Lichen:

- Internally the thallus is composed of fungal and algal components. Such type of thallus is called consortium. On the basis of internal structure of thallus, the lichens are divided into two groups, namely, heteromerous and homoiomerous lichens

(a) Structure of Heteromerous Lichen:

- Thalli or most foliose and fruticose lichens are differentiated into several layers of tissues, and therefore known a heteromerous. A transverse section of the heteromerous lichen can be divided into following distinct zone-

i) Upper cortex:

- It forms the upper surface of the thallus. It is thick and protective in nature and consists of fungal hyphae. The compactly interwoven hyphae produce a tissue like layer (Plectenchyma and Pseudoparenchyma) called the upper cortex. The intercellular spaces are absent, if present, they are filled with gelatinous substances. In some species of foliose lichens this layer is interruptions or areas are called breathing pores and serve for aerations. In addition to these certain other structures are also present for gaseous exchange. These are known as cyphellae.

ii) Algal zone or gonidial layer:

- It is a zone below the upper cortex. This layer consists of loosely interwoven hyphae intermingled with algal cells. This algal zone is the photosynthetic region of the lichen. This layer is also known as gonidial layer because of the earlier concept that these cells are having reproductive function.

iii) Medulla:

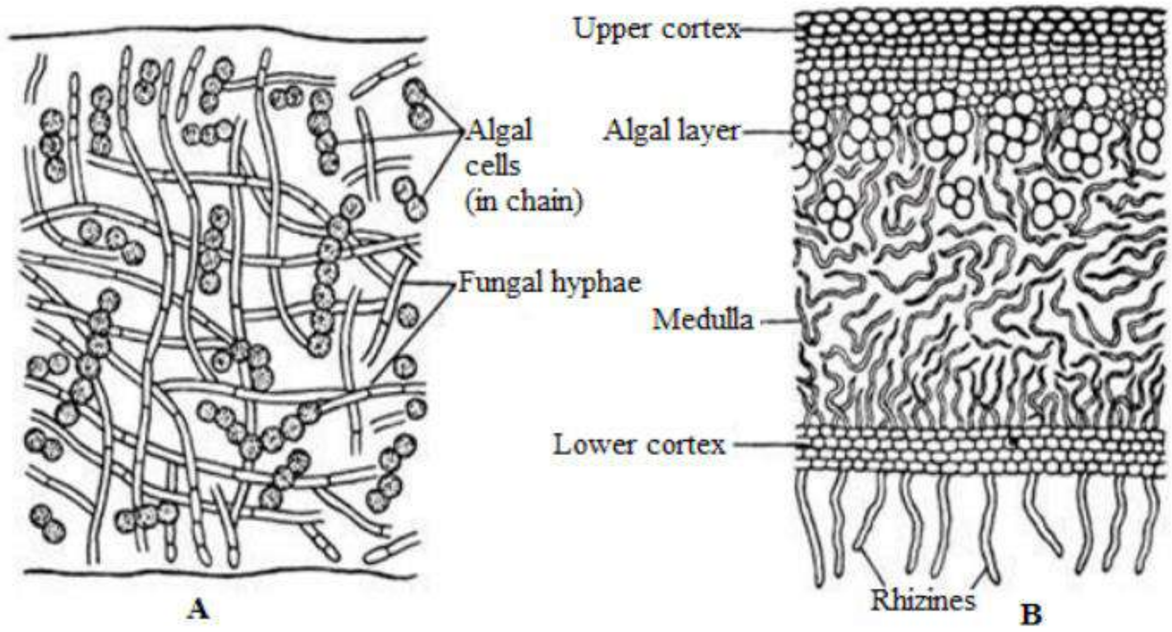
- It is the central core of the thallus and is composed of loosely arranged fungal hyphae with intercellular spaces. The hyphae run in all directions. Usually, the wall of the fungal hyphae is thick and strong.

iv) Lower cortex:

- The lower cortex is below medulla. It is formed by fungal component and made up of compact hyphae. They may be parallel to perpendicular to the surface to the surface of the thallus. Thje bundle of hyphae (rhizinae) arise from the lower surface and penetrate the substratum functioning as anchoraging and absorbing organs. In some lichens, the lower cortex is absent. e.g., Lobaria, Pulmonaira and is replaced with a sheet of hyphae forming hypothallus.

(b) Homoiomerous Lichens:

- In some lichens for example, Collema and Leptogium, the thallus shows a simple structure. It consists of a loosely interwoven mass of fungal hyphae with algal cells equally distributed through a gelatinous matrix. Thalli of such lichens are not differentiated into layers of tissues and therefore, known as homoiomerous.



Internal structure of lichen thallus, A-Homoiomerous thallus, B-Heteromerous thallus

1.The fungal portion in Lichens is known as _________

A) Mycobiant B) Phycobiant C) Capsobiant D) Deuterobiant

2.This is a crutose lichen

A) Peltigera B) Usnea C) Rhizocarpon D) None of the above

3.Most of the scientists deem the algal-fungal relationship in lichens as helotism. Helotism is a

A) master-master relationship B) master-slave relationship
C) a kind of mutualism D) a kind of symbiotic association

4.This lichen is pioneer in xerosere

A) fruticose lichen B) foliose lichen C) crustose lichen D) leprose lichen

5.This about lichens is incorrect

A) Lichens are indicators of pollution
B) They grow rapidly about 2cm every day
C) Some species are eaten by reindeers
D) They have symbiotic relationship between alga and fungus

6.The lichens are

A) Slow gowing, long lived B) Fast growing, long lived
C) Fast growing, short lived D) Slow growing, short lived

7.A common phycobiot in lichen is

A) Trebouxia B) Cetraria C) Microcystis D) Oegogonium

8.Which of the following is a crustose lichen

A) Usnea B) Peltigera C) Soredia D) Rhizocarpon

9.Lichen are formed by the association of

A) Ascomycetes only, with algae only
B) Ascomycetes or basidiomycetes with algae or cyanobacteria
C) Basidiomycetes only with algae or cyanobacteria
D) Ascomycetes only, with algae only

1.2. THALLUS ORGANIZATION:

1.2.1 Anatomy of the Lichen Thallus:

The vegetative structures which are associated with the lichen thallus are

(i) Breathing pores:

- These are localized openings which develop in the upper cortex. In some lichens, e.g., Parmelia, the upper cortex is interrupted by some openings, called breathing pores. The breathing pores serve for aeration and helps in respiration.

(ii) Cyphellae:

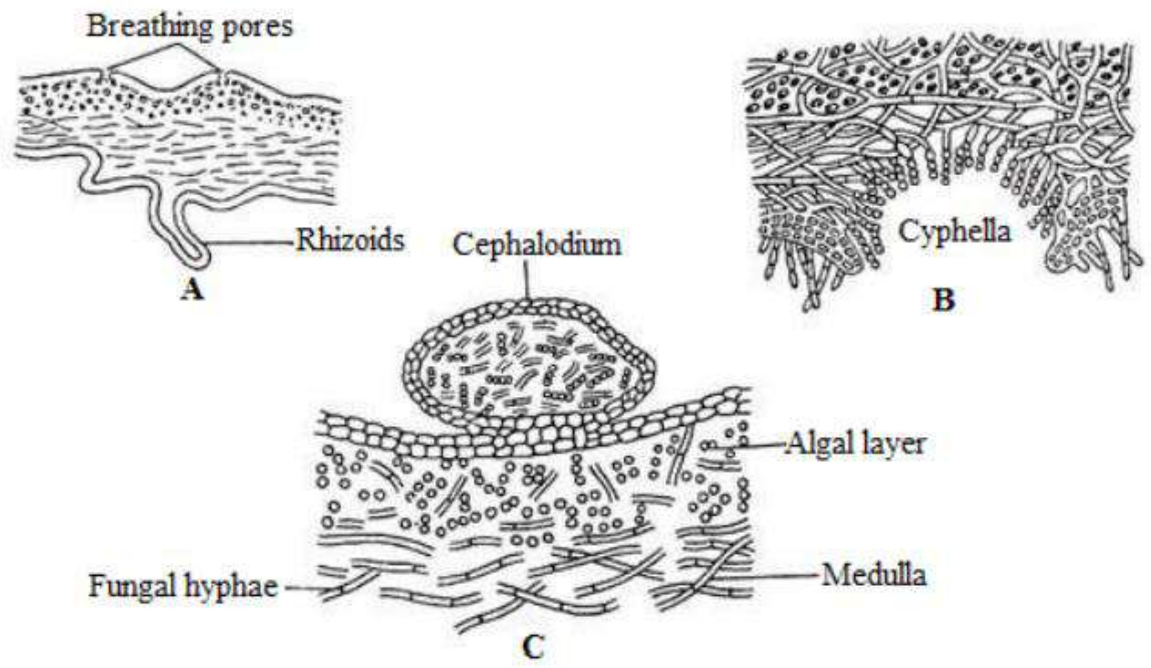
- They occur on the lower surface of the thallus quite commonly in the genus Stricta. If seen with naked eyes these structures appear as cup-like white spots but under the microscope they appear as small, hollow, circular, white cavities. From these cavities medulla is exposed and hyphae protrude out. If these cavities are of a definite form with a distinct border, these are called cyphellae. (The function of these structures is to allow free passage of air to the algal cells.(or their function is aeration.)

(iii) Cephalodia:

- Cephalodia are small, dark-coloured, hard, gall-like structures found in some species of lichens that contain cyanobacterial symbionts. Cephalodia can occur within the tissues of the lichen, or on its upper or lower surface e.g., Peltigera aphthosa, Lobaria, Pulmonaria etc. They contain fungal hyphae of the same type as the mother thallus, but the algal elements are always different. They probably help in retaining the moisture.

(iv) Isidia (Singular "Isidium"):

- Isidium is a vegetative reproductive structure present on the surface of the lichen thallus consisting of both fungal hyphae and algal cells. Isidia are fragile structures and may break off and be distributed by wind, animals, and splashing raindrops. They consist of an external cortical layer and an internal algal layer. In terms of structure, isidia may vary in form in different lichen species as- Cylindrical, warty, cigar shaped, clavate (clubshaped), Scale shaped, coralloid (coral-shaped), rod-shaped etc



Structures of lichen thallus: (A)-Breathing pores, B-Cyphella, C-Cephalodium

1) The specialized structure present in the thallus of lichen that help in nitrogen fixation is

A) Cyphellae B) Isidia C) cephalodia D) soredia

2) A prothallus is

A) a structure in pteridophytes formed before the thallus develops

B) a gametophyte free living structure formed in pteridophytes

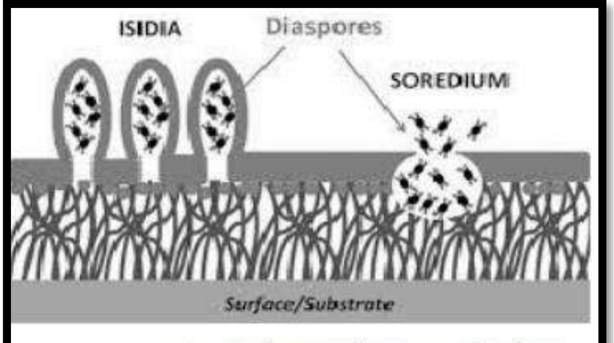
C) a sporophytic free living structure formed in pteridophytes

D) a primitive structure formed afer fertilization in pteridophytes

3) A lichen having much branched system of cylindrical or ribbon like branches but a small thallus is called as

A) foliose lichen B) fruticose lichen C) crustos lichen D) thallose lichen

1.3. REPRODUCTION IN LICHEN:



Asexual reproduction in Lichen

- ❖ Most lichens reproduce asexually; when conditions are favourable they simply expand across the surface of the rock or tree. In dry conditions they become crumbly and small pieces break off and are dispersed by the wind. The fungal part of many lichens also sometimes reproduces sexually to produce spores. These spores must meet up with an algal partner in order to form a new lichen.

1.3.1 Vegetative and Asexual Reproduction:

It takes place by following methods

(i) By Fragmentation:

- It takes place by death and decay of older parts of the thallus produce smaller pieces which give rise to new thallus. This occurs more frequently in pendant thallus e.g., Ramalina reticulata. The new thallus being genetically identical to the thallus from which the fragement came.

(ii) Isidia:

- Isidia are tiny, simple, branched, spiny, elongated out growth from the thallus and contains both photobiont and mycobiont cells covered by the cortical layer of thallus. Each detached isidium may develop into a new thallus under favorable conditions. Common example is Peltigera sp.

(iii) Soredia:

- These are small, minute, powdery granules or bud-like out growth present usually over the upper surface or edges of the thalli of many species of lichens. Each soredium consists of few algal cells surrounded by fungal hyphae Soredia detaches from the thallus and are carried away by wind. Falling on suitable substrate, it germinates and gives rise to new thallus. e.g., Parmedia.

1.3.2 Sexual Reproduction:

❖ In lichens only the fungal partner may reproduce sexually. The sexually reproducing lichens are either ascomycetes or basidiomycetes. Ascomycetes produce their sexual propagules (called ascospores) within microscopic organs called asci and basidiomycetes produce their sexual propagules (called basidiospores) on microscopic organs called basidia. Often ascospores or basidiospores are simply called spores. A very small number of lichens have the fungal part which belongs to the basidiomycetes. The fungal component of most of the lichens belongs to the class Ascomycetes, which produce spores in a sac-shaped container, the ascus. The male reproductive organ is called spermogonium and the female is called as carpogonium or ascogonium.

The Male Sex Organs:

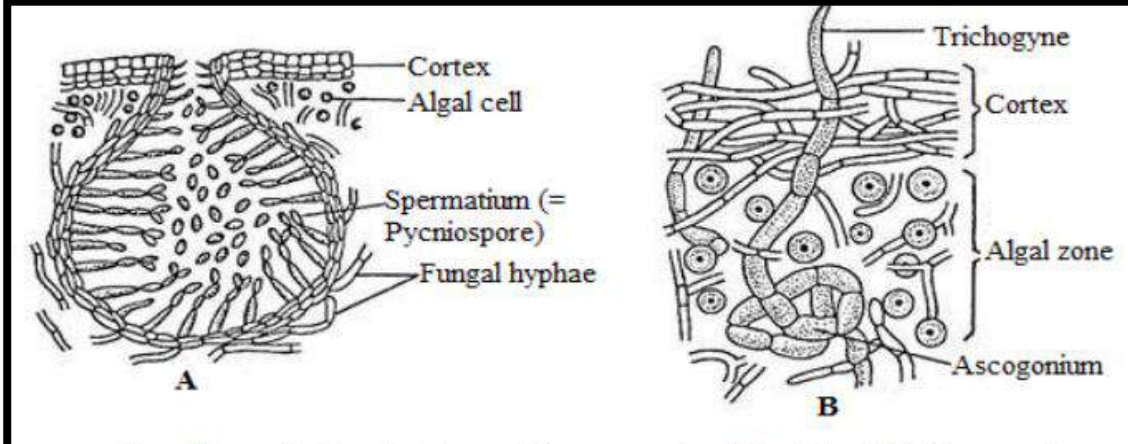
- The male sex organ is known as spermogonia. In some species of lichens, the pycnidia-like structures function as spermogonia. The spermogonia develop in flaskshaped cavities on the upper surface of the thallus. It opens to the exterior by small pore, an ostiole. A number of hyphae develop from the walls of the cavity. Few of them are sterile and others are fertile. The fertile ones produce the non-motile male cells called spermatia. These nonmotile cells develop continuously from the tips of the fertile branches. The spermtaia are set free in a slimy mass through ostiole.

The female Sex Organs:

- The female sex organs are known as carpogonium. The carpogonium develops fron hyphae deep in the algal layer. It consists of two portions, the upper straight portion is called trichogyne and the lower coiled portion is called ascogonium (oogonium). The ascogonium lies deep in the medullary region of the thallus. The terminal portion of the trichogyne ends in a long cell, which projects beyond the surface of the thallus and has a gelatinous cell wall. It is multicellular and the cells are uninucleate or multinucleate in some species. The basal cell of the ascogonium is fertile.

Fertilization:

- A spore called conidium is released from a pycnidia structure. Pycinidia are flasklike structures embedded in the thallus of the lichen. Conidia can act as "spermatia" in sexual reproduction of the lichen. The spermatia are functional male gametes. The spermatium spore finds its way to a tiny thread (trichogyne) on a surface of lichen and attaches itself. The conidia and the trichogyne both are haploid. The growing trichogyne comes in contact with spermatia. The intervening walls between the spermatium and the trichogyne dissolve at the point of contact. The male nucleus gradually passes downward to the oogonium, where it fuses with the female nucleus. The actual migration of the male nuclei down the trichogyne has not yet been observed, but it is assumed. Fused cell produces ascogenous hyphae within which develop 8 ascospores and asci. The hymenium is made up of Asci and Paraphysis. The fruiting body may be either apothecia e.g., Parmelia and Physcia or Perithecia e.g., Peltigera.
- Sexual reproduction results in the formation of apothecia or perithecia. In lichens, fruiting bodies are of following two types:



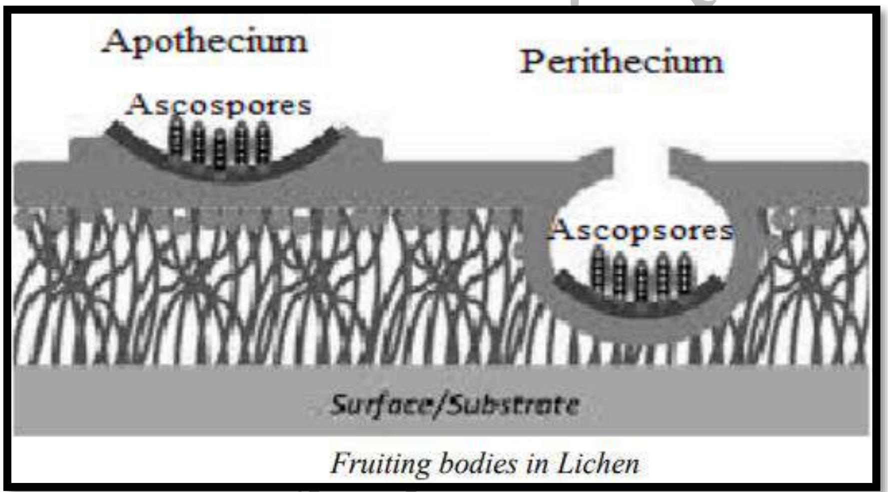
Sexual reproductive structures, A-Spermogonium (Pycnidium), B-Carpogonium

(i) Apothecia:

- The most commonly seen sexual reproduction structures are apothecia. These are typically circular and disc-like or cup-like though there are also species in which the apothecial surface bulges outward. They may be of the same colour as the thallus or strikingly different and vary in diameter from under a millimetre to over two centimetres, depending on species. The structure of the apothecium chiefly consists of three parts: hymenium, Hypothecium, and excipulum. The apothecium has a layer of exposed spore-producing cells called asci. The asci are present in the hymenium layer. The hymenium, composed of sac-like asci and sterile, hair-like fungal hyphae known as paraphyses. Asci and paraphyses form a thin inner lining, which is called as hymenial layer. Each ascus contains eight ascospores. The asci are freely exposed at maturity.

(ii) Perithecia:

➢ Perithecia are generally flask-shaped frutiting bodies in certain ascomycetous fungi that contain the ascospores. Depending on the species perithecia may develop totally on the lichen thallus or embedded in the thallus. It looks like a small black dots on the surface of lichen. At maturity a small opening at the top, called an "ostiole", allows the ascospores to escape.



Fruiting bodies in Lichen

1. Zygote of spirogyra produces four haploid nuclei in which

A) One functional B) Resolution occur

C) Maginication occur D) Resolving power present

2. Branched conidiophores are present in

A) Rhizopus B) Penicillium C) Ustilago D) Aspergillus

3. Sexual reproduction in spirogyra is morphologically characterized by

A) Oogamy B) Anisogamy C) Isogamy D) Isogamy and oogamy both

1.4. OCCURRENCE OF LICHEN:

❖ Lichen is a group of tiny plants that looks like moss and grows on the surface of things such as rocks, trees, and walls. Lichens grow relatively slowly. Growth rate depends both on the species and on the environmental conditions around it. The smaller encrusting lichens may grow as little as 1mm a year. Large forms may grow up to 1 cm per year. Lichens occur from sea level to alpine peaks and from the hot deserts of the world to the cold Arctic and Antarctic. Lichens can grow in locations impossible for most plants, such as bare rock, walls, roofs, sterile soil and sand etc. Based on the substratum on which the lichens are growing, lichens are of following types:

- **Muscicolour lichens:** Lichens growing along with mosses. e.g., Cladonia.
- **Follicolous lichens:** Lichens growing on the surface of leaves. e.g., Calicium.
- **Terricolous lichens:** Lichens growing on the surface of soil, in hot climate with sufficient rain and dry summer (terrestrial) e.g., Cladonia, Florekeana, Lecidea, Collema etc.
- **Saxicolous lichens:** Lichens growing on the surface of rocks and stones in cold climate. e.g., Dermatocarpon, Xanthoria, Verrucaria etc.
- **Corticolous lichens:** Lichens growing on the surface of barks of trees mainly in the subtropical and tropical regions. e.g., Parmelia, Usnea, Grpahis.
- **Lignicolous:** Grow directly on wood. e.g., Calicium etc.
- **Marine Lichens:** Grow on siliceous rocky shores of Sea e.g., Verrucaria, Caloplaca etc.
- **Fresh water lichens:** Grow on hard siliceous rocks in fresh water. e.g., Epheba, Hymenelia etc.

1. Earliest settelers on barren land and rocks are

A) Mosses B) Lichens C) Fern D) None

2. Lichens are not found

A) In big cities B) Arctic region C) In villages D) On bark rocks

1.5. CLASSIFICATION OF LICHEN:

1.5.1 Lichens are Classified on the Basis of Growth Forms:

1) Crustose Lichens (Encrusting Lichens):

- These lichens occur as thin or thick crust over soil, rocks or tree barks. These are very closely adhered to the substratum on which they are present and it is difficult to remove them from substratum. Fruiting bodies are present on the upper surface, common examples are Ochrolechia, Graphis scripta, Rhizocarpon, etc.

2) Foliose Lichens (Leafy lichens):

- These lichens have a flat, expanded, leaf like thallus (generally grayish or brownish in colour) which spread out in a horizontal layer over the surface. They are attached to the substratum by rhizoid like outgrowth called the rhizines and can be easily dismantled without damaging the substrates. Common examples are Physcia, Parmelia, Gyrophora, etc.

3) Fruticose Lichens (Shrubby Lichens):

- These are the upright or hanging lichens. These lichens have a thallus that is branched and bushy and can hand from the substrate. It may be erect or pendant. These are flat, cylindrical, or ribbon like, well branched and resemble with little shrubs. These lichens are attached only at the base by a flat disc and can be removes from the surface by hand. e.g., Cladonia rangiferina, Usnea barbata etc.

There Are Few Intermediate Categories of Growth Forms Such As:

4) Leprose Lichens:

- A leprose lichen is a lichen with a powdery or granular surface. In leprose lichens the thallus surface is composed of granules containing algal cells and fungal hyphae. Leprose lichens lack an outer "skin", or cortex. Leprose lichens have no inner or outer cortex. They sometimes have a weak kind of medulla. e.g., Leparia incana.

5) Squamulose lichens:

- Squamulose lichens are a group of lichens that are scale-like. They are somewhere in between the foliose lichens (flat leaf-like) and the fruticose lichens (erect growing). In Squamulose lichens, the thallus is composed of usually small, flat, usually massed, often overlapping scales- 'squamules'. If they are raised from the substrate and appear leafy, the lichen may appear to be foliose lichen, but the underside does not have a "skin" (cortex), as foliose lichens do e.g., Normandina pulchella.

6) **Filamentous Lichens:**

- Filamentous lichen is a lichen that has a growth form like a mass of thin, stringy, non-branching hairs or filaments of the alga (Trentepohlia or trichome-forming cyanobacteria). These lichens are generally darker in colour and unlike most other lichen growth forms, the filaments of fungus do not determine the shape. e.g., Cystocoleus, Ephebe, Coenogonium, Racodium etc.

7) Gelatinous Lichens:

- Gelatinous lichens are lichens in which the phycobiont (the principal symbiont) is a cyanobacterium. In gelatinous lichens the cyanobacteria produce a polysaccharide that absorbs and retains water. They become gelatinous when wet and brittle when dry.

8) Dimorphic lichens:

- In dimorphic lichens single characters of both foliose/ Squamulose and fruticose lichens. The squamulose and fruticose lichens. The squamules are the primary thallus, which bears erect body of fructicose lichen, the secondary thallus.

9) Placodioid:

- A placodioid lichen is a crustose lichen (the thallus is generally crustose) with a growth form that radiates out from a center, sometimes peeling up at the ends of the radial arms to have a leafy form, but without a cortex on the underside, like a foliose lichen. Some placodioid species can be confused with foliose species, e.g., Crustose- Placodioid species of caloplaca, especially C. flavescens, can resemble the foliose Xanthoria elegans, but the latter has true foliose lobes with a lower cortex

1.5.2 On the Basis of Nature of Fungal Componenet:

- The fungal partner mainly belongs to ascomycetes apart from basidiomycetes and rarely deuteromycetes. On the basis of the nature of fungal components, lichens are divided to three classes-

(i) Ascolichens:

- In this, the fungal component belongs to Ascomycetes. Sexual reproduction of Ascolichens is similar to those of Ascomycotina. They produce ascus with ascospores after sexual reproduction. Majority of lichens (more than 95% of the lichens) are Ascolichens. Such lichens are further divided into two sub groups:

  (a) Gynocarpeae: In which fruiting body (i.e. ascocarp) is apothecium. e.g., Parmelia.

  (b) Pyrenocarpeae: In which the ascocarp is perithicium type. e.g., Dermatocarpon.

(ii) Basidiolichens:

- In this, fungal component belongs to basidiomycetes. e.g., Dictonema, Corella. Sexual reproduction is similar to those of Basidiomycotina. They produce Basidia and Basidiospores during sexual reproduction. Only very few lichen (4 genera reported so far) belongs to Basidiolichen.

(iii) Deuterolichens:

- Deuterolichens are also known as lichen imperfectii. The fungal partners belong to Deuteromycotina division of fungi. These lichens lack sexual reproduction or should say that lichens with sterile thalli are constituted by this group. e.g., Lepraria, Leprocaulo, Crysothrix.

1) A common phycobiont in lichens are

A) Cetraria B) Microcystis C) Trebouxia D) Oedogonium

2.Reindeer moss is a lichen known as

A) Usnea B) Rocella C) Cladonia D) Parmelia

3. Lichen reproduce vegetatively by

A) Fragmentation B) Soredia C) Isidia D) All of these

4. Most lichens are

A) Homoiomerous B) Heteromerous C) Both D) None of these

5. Lichens growing on rocks are called

A) Corticoles B) Saxicoles C) Lignicoles D) Tericoles

6. The symbiotic association of fungi and algae is called

A) Lichen B) Mycorrhiza C) Rhizome D) Endomycorrhiza

1.6. ECONOMIC AND ECOLOGICAL IMPORTANCE:

1.6.1 Economic Importance:

Lichens are very important economically. Some are given below

1.6.1.1 As a Source of Food:

❖ Certain species of lichens are valuable sources of food. The edible lichens are harvested and dried for human consumption or as fodder for animals. They are rich in polysaccharides. Some vitamins, and certain enzymes. Cetraria islandica (Iceland moss) is taken as food in Norway, Sweden, Iceland, Scandinavian countries etc.

60. In homosporus species germination of spore is.

A) Exosporic B) Endosporic C) Mesosporic D) Episporic

61. Homosporusspeices are.

A) Monoecious B) Hermephrodites C) Dioecious D) Both (A) and (B)

62. Apical pole give rise to.

A) Root B) Shoot C) Leaves D) All of above

63. Star shaped xylem is character of.

A) Haplostele B) Actinostele C) Plectostele D) Protostele

64. Stele with pith in the centre is called.

A) Protostele B) Siphonostele C) Actinostele D) Plectostele

65. Invasion of pith occurs through the leaf gap?

A) Intra-steler origin of pith B) Extra-steler origin of pith

C) nvasion D) All of above

66. Siphonostele which is perforated at the place of origin of leaf trace is called.

A) Protostele B) Siphonostele C) Actinostele D) Solenostele

67. Each separate vascular strand in dictyostele is called

A) Plectostele B) Meristele C) Polystele D) Eustele

68. Anatomically shoot and root in Rhynia are.

A) Different B) Identical C) Both a and b D) None of above

69. Rhynia lacks.

A) Root B) Stem C) Leaves D) All of above

70. Horizontal stem in Rhynia is connected with soil through.

A) Rhizome B) Rhizoids C) Root hairs D) Roots

71. Rhynia was evolved in.

A) Carboniferous period B) Devonian period

C) Jurrasic period D) Palazioc period

72. Zosterophyllum has sporangium.

A) Single B) Clusters C) Both (A) and (B) D) None of above

73. Oldest representatives of Rhyniophyta belongs to genus.

A) Zosterophyllum B) Cooksonia C) Psilophyta D) All of above

74. First vascular plant was evolved.

A) 400 million years ago B) 400 billion years ago

C) 4 million year ago D) None of above

75. Psilotum belongs to class.

A) Psilotophyta B) Psilopsida C) Psilotopsida D) Psilotales

76. Common name of Psilotum is.

A) Fern B) Whisk Fern C) Horse tail D) Club moss

77. Psiltum is found in.

A) Saline soil B) Loamy soil C) Humus rich soil D) Silty soil

77. Sporangium of Psilotum is called?

A) Triads B) Synangium C) Sori D) Both (A) and (B)

78. In Psilotum stomata are present in.

A) Leaves B) Stem C) Roots D) Both (A) and (B)

79. In stele of Psilotum all components are present except.

A) Pericycle B) Pith C) Endodermis D) Both (A) and (B)

80. In rhizome of psilotum epidermis is.

A) Conspicuous B) Inconspicuous C) Thick D) Thin

81. Spores in fern are produced by.

A) Sexual B) Asexual C) Mitosis D) Binary fission

82. Synangium in Psilotum is.

A) Sessile B) Petiolated C) Stalked D) All of above

83. Synangium in Psilotum is.

A) Ramal B) Cauline C) Both (A) and (B) D) None of above

84. Gametophyte in Psilotum take nutrition from.

A) Synthesize its own food B) Take it from sporophyte

C) From dead organic matter D) Hetrotrophic mode

85. One or two peripheral layers persist for the nourishment of the developing spores. These nourishing cells form:

A) Elators B) Sopores C) Jacket D) tapetum.

86. Match gametophyte with one of the followings:

A) Prothellus B) Thallus C) Cone D) Strobilus

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UG TRB
BOTANY
2023-2024

UNIT-3

GYMNOSPERMS, PALEOBOTANY, EVOLUTION.

Your Success is Our Goal....

INDEX

UG TRB BOTANY – 2023-24

UNIT - III

1.GYMNOSPERM

1.1. GENERAL CHARACTERS OF GYMNOSPERMS:

- Gymnosperms represent a primitive group of seed belaring plants (Spermatophytes) in which the seeds are naked i.e. they are not covered by the fruit wall as in Angiosperms (The word Gymnos means naked and spermos means seed). This is because in Gymnosperms the ovules are exposed and they are not covered by ovary. The ovules are borne directly on open carpellary leaves called megasporophylls and hence they are naked and they develop into naked seeds after fertilization.

- Gymnosperms were most abundant during the Mesozoic era (225 million years) ago. The living Gymnosperms include middle –sized or tall trees and shrubs and number approximately 70 genera and 900 species distributed in tropical and temperature regions. Most of them are conifers mostly evergreen, with needle like leaves. The roots are generally tap-roots, but mycorrhizic and coralloid roots are known in some genera (Pinus, Cycas). The stems are aerial, erect unbranched (Cycas, Zamia) or branched (Pinus, Cedrus etc).

- In some genera (Pinus) the branches may be of two types: (1) The long shoots; and (2) the dwarf shoots that bear at their apices, bundles or clusters of green leaves and are collectively known as spur. Both the microphyllous (small and scale like) and the megaphyllous (large and well-developed) leaves are known among the gymnosperms. The venation may be reticulate (Gnetum), parallel (Welwitschia) or even dichotomons (Ginkgo).

- The secondary wood in the Gymnosperms may be (1) Manoxylic or (ii) Pyconxylic. The manoxylic wood is found in cycadophyta and is porous, soft and more Parenchymatous in nature. It has wide medullary rays and is useless commercially. The pycnoxylic wood is characteristic or coniferophyta and is compact and has narrow medullary rays. It is of great commercial use. The xylem lacks wood vessels (except in Ephedra, Welwitschia and Gnetum), where as phloem is devoid of companion cells.
- The sporophyte bears two types of fertile leaves, the microsporophyll that produces microspores and megasporophyll that produces megaspores. The microspores on germination develop into male gametophytes and megaspore develops into female gametophyte.
- Mostly the spores are grouped into compact cones or strobili. The plant body is the sporophyte (diploid) mostly a tree with well developed roots, stem and leaves. Ovules are naked. Pollination is mostly by wind (anemophilous). Fertilization involves only one fusion. Seeds are naked and not embedded in fruit.

1.1.1 Distribution :

- The modern gymnosperms are commonly grouped under four orders : The Cycadales, the Ginkgoales, the Coniferales and the Gnetales. The Ginkgoales and the Cycadales include living members that have a long fossil history and can be regarded as 'Living fossils'. Ginkgoales in the past (early Mesozoic) were represented by widely distributed group of plants, but now the order is represented by a single species Ginkgo biloba. Similary cycads flourished well during the Mesozoic and are now represented by nine well-defined genera that are confined to limitted areas in the tropical and subtropical countries of the world. The Coniferales form the most conspicuous order of the living Gymnosperms include the most familiar and economically important plants like Pinus, Cedrus, Abies, Juniperus, Cupressus, Thuja etc. Some of them are the world's tallest and long-lived plants, eg., Sequoia gigantea lives for 4000 years and grows very tall. The conifers are cosmopolitan and widely distributed throughout the northern and southern hemispheres of the globe and form extensive forests.
- The Gnetales are represented by three living genera e.g., Gnetum, Ephedra and Welwitschia. The last named genus is monotypic and is represented by Welwitschia mirabilis in some deserts in South-West Africa. Gnetum (40 species) and Ephedra (30-40 species) include many species that are distributed in tropical and temperate

regions of Asia, Africa and South America. The living Gymnosperms include 22 genera that are monotypic.

1.1.2 Phylogeny:

- The Gymnosperms arose in the Paleozoic, alominated the world during the Mesozoic the age of the dinosaurs, and the earlier members of the group have become extinct today. The Paleozoic groups Cycadofilicales and Cordaitales represent the historical background of Gymnosperms. The Cycadofilicales are so fern like in every features except their seeds, that their derivation from some ancient fern stock (called provisionally Primofilices) is as certain as phylogenetic connections can be. The origin of the Cordaitales, therefore, presents two alternatives: either they arose independently from the same ancient fern stock, or they were differentiated from the Cycadofilicales very early. The Gymnosperms began with Cycadofilicales more ancient than any yet known; that Cordaitales branched off from Cycaodofilicales earlier than our present records, and that the two groups constituted the extensive Gymnosperm flora of the Carboniferous.
- This Paleozoic display of Gymnosperms was succeeded by a Mesozoic display, in which at least four groups are recognized. From the Cycadofilicales there arose the Mesozoic Bennettitales and the cycadales; and from the Cordaitales the Mesozoic Ginkgoales and coniferales were derived. The relation of the Bennettitales to the Cycadales is not so clear; either the two groups were differentiated from a common stock that arose from the Cycadofilicales and confined into the Mesozoic. In the Gymnosperm flora of today, therefore, the Cycadales, although relatively a modern group, are the nearest representatives of the PaleozoicCycadofilicales.
- The Ginkgoales and Coniferales have both been traced into late and independent paleozoic connection with the Cordaitales, and were welldisplayed during Mesozoic. The Ginkgoales, while widely distributed during the Mesozoic, apparently were never a large group. The Coniferales, on the other hand, began that extensive differentiation during the Mesozoic which has resulted in six recognized tripes in our present flora. Among these tribes the earliest to be recognized are the Abietineae and the Araucarineae.
- The Taxodineae and Cupressineae, and possibly the Taxineae, arising from the Mesozoic Abietineae; and the Podocarpineae possibly arising from the Mesozoic Araucarineae.

- The connections of the Gentales are altogether obscure, and every openion as to their origin must be regarded as very tentative. Evidence seems to be accumulating that they may have been derived from Cupressineae, or at least that they are closely related to that tribe in origin.

1. Which of the followings is correct for vascular bundle of gymnosperms?

A) Stele | B) Exarch
C) Collateral | D) Conjoint

2. Secondary growth occurs by the activity of:

A) Phloem | B) Xylem
C) Cambium | D) Bark

3. Which of the followings is absent in the xylem of gymnosperms?

A) Trachieds | B) Parenchyma
C) Fibers | D) Vessels

4. Bark is produced by the activity of:

A) Phloem | B) Xylem
C) Cambium | D) Phellogen

5. Generative cell represents the reduced:

A) Antheridium | B) Archegonium
C) Oogonium | C) Antherozoids

6. The unutilized prothalial cell becomes:

A) Endosperm | B) Archegonium
C) Oogonium | C) Antherozoids

1.2. CLASSIFICATION OF GYMNOSPERM:

SPORNE CLASSIFICATION OF GYMNOSPERMS:

❖ Fossil plants presents problem to the taxonomist, but living plants are classified based on the totality of characters. But for fossil plants, it is most convenient to have a separate classification for stem, leaves, and seeds and so on. Sporne has adapted Engler's method of classification.

lasses	Orders	Families	Examples
1.Cycadopsida	1.Pteridopermles*	1.Lyginopteridacea	*Lygnopteris*
		2.Meulosaceae	*Medullosa*
		3.Calamopityceae	*Calamopitys*
		4.Glossopteridaceac	*Glossopteris*
		5.Peltaspermaceae	*Lepidopteris*
		6.Corystospermaceae	*Xylopteris*
		7.Caytoniaceae	*Caytonia*
	2.Bennettitales*	1.Williamsoniaceae	*1.Williamsonia*
		2.Wielandiellaceae	*2.Wielandiella*
		3.Cycadeoideaceae	*3.Cycadeoidea*
	3.Pentoxylales*	1.Pentoxylaceae	*1.Pentoxylon*
	4.Cycadales	1.Cycadaceae	*1.Cycas*
		2.Nilssoniaceae	*2.Nilssonia*
2.Coniferopsida	1.Cordaitales*	1.Erytophytaceae	*1.Erytophyton*
		2.Cordaitaceae	*2.Cordaites*
		3.Poroxylaceae	*3.Poroxylon*
	2.Coniferales	1.Lebachiaceae	*1.Lebachia*
		2.Voltziaceae	*2.Voltziopsis*
		3.Palissyaceae	*3.Palissya*
		4.Pinaceae	*4.Pinus*
		5.Taxodiaceae	*5.Taxodium*
		6.Cupressaceae	*6.Cupressus*
		7.Podocarpaceae	*7.Podocarpus*
		8.Cephalotaxaceae	*8.Cephalotaxs*
		9.Araucariaceae	*9.Araucaria*

	3.Taxales	1.Taxaceae	*1.Taxus*
	4.Ginkgoales	1.Trichopityaceae	*1.Trichopitys*
		2.Ginkgoaceae	*2.Ginkgo*
3.Gnetopsida	1. Gnetales	1.Gnetaceae	*1.Gnetum*
		2.Welwitschiaceae	*2.Welwitschia*
		3.Ephedraceae	*3.Ephedra*

Order1. Pteridospermales:

- Plants with relatively slender stems. Primary xylem mesarch (rarely exarch) in the form of a solid or a medullated protostele or reduced to circum-medullary strands. Sometimes polystelic. Secondary wood limited in amount, manoxylic and composed of trachieds with multiseriate piting, especially on the radial walls. Leaves mostly large and fern-like, often many times pinnate. Ovule and seed borne either on the frond or on a specially modified frond (megasporophyll) which is not part of a cone.

Order 2. Bennettitales:

- Stem with wide pith, stout and pachycaulic or relatively slender and forking. Leaves compound (rarely simple) with open (rarely closed) venation. Stomata syndetocheilic. Reproductive organs in hermaphrodite or unisexual 'flowers', protected by numerous bracts. Ovules stalked, very numerous, scattered over a conical, cylindrical or dome shaped receptacle, along with interseminal scales, more or less uinted at the distal end to form a shield, through which the micropyles protruded. Seeds with two cotyledons. Pollen bearing organs in a whorl, free or united, pinnate or entire, with numerous microsporangia, usually in capsules.

Order3. Pentoxylales:

- Fossil plants, habit unknown, but probably shrubs or very small trees. Long and short shoots, the latter bearing reproductive organs terminally and spirally arranged leaves. Stems- polystelic. Wood rays uniseriate. Leaves thick, simple, lanceolate. Venation open (anastomoses very rare). Female organs like stalked mulberries; seeds sessile, united by fleshy outer layer or integument. Male organs consisting of a whorl of branched sporangiophores, fused basally into a disc.

Order4. Cycadales:

- Woody plants with stems unbranched or with occasional adventitious branching. Manoxylic. Mucilage canals in pith and cortex. Some genera with additional co-axial vascular cylinders. Leaves large, pinnate (rarely bi-pinnate). Leaf trace diploxylic (except in Nilssoniaceae). Dioecious. Reproductive organs in cones (except female *Cycas*) cones terminal or lateral. Megasporophylls with sterile tips and 8-2 orthotropus ovules. Seeds large. Microsporophyll scale-like or peltate with pollen-sacs on the abaxial side. Sperms with spiral band or flagella.

Order 5. Cordaitales*

- Mostly tall trees with slender trunks and a crown of branches. Primary wood scanty. Secondary wood mostly pycnoxylic. Leaves spirally arranged, simple, up to 1 meter long, grass like or paddle-shaped, with parallel venation. Cones compound, unisexual, consisting of a main axis with bracts subtending secondary fertile shoots bearing sterile and fertile appeanages. Female fertile appendages with one to four ovules. Male fertile appendages with four to six terminal pollen sacs. Seeds bilateral.

Order 6. Coniferales:

- Branching woody plants, often with long and short shoots. Secondary wood pycnoxylic, made up of tracheids with large uniseriate (rarely multiseriate) pits on the radial walls, and small wood rays. Resin canals in leaves, cortex and (sometimes) in wood. Leaves spirally arranged form opposite, rarely whorled, needle- like or scale-like, rarely broad. Reproductive organs unisexual cones. Female cones fundamentally compound; a main axis with infinite to few bract scales each subtending, or fused with one ovuliferous scale bearing infinite to 2 ovules (rarely one). Male cones simple, usually with many scale-like microsorophylls with 2 to infinite fused or free pollen sacs. Embryo with two to infinite cotyledons.

Order 7. Taxales:

- Profusely branching, evergreen shrubs or small trees, with spirally arranged small linear leaves. Wood pyconxylic, tracheids with abundant tertiary spirals, no resin canals in wood or leaves. Ovules solitary, arillate, terminating a dwarf shoot, with decussate bracts microsporangiophores in small cones, scale-like or peltate, with two to eight pollen sacs. Embryo with two cotyledons.

Order 8. Ginkgoales:

- Branching trees with long and short shoots (except in the earliest fossil members). Wood- pycnosylic. Leaves leathery, strap-shaped or fan shaped, often deeply divided, with dichotomous venation. Ovules two to ten, terminal on axillary branching or almost unbranched, axes. Seeds large, with fleshy outer layer and stony middle layer. Male organs axiallary, unbranched, catkin-like, bearing micro sporangiophores each with two to twelve pendulous microsporangia. Sperm with spiral band of flagella.

Order 9. Gnetales:

- Woody plants; trees, shrubs, lianes or stumpy turnip-like plants with stem partly below ground. Leaves opposite or whorled, simple, broadly elliptic or strap shaped or reduced to minute scales. Secondary wood with vessels. 'Flowers' unisexual and normally dioecious (except some Gnetum sp.). Flowers organized into compound strobili or 'infolorescence'. Female flowers with a single erect ovule, the nucellus of which is surrounded by two to three enveloped, the micropyle projecting as a long tube. Male flowers with a perianth and antherophores with one to eight synangia. Fertilization by means of a pollen-tube with two male nuclei. Embryo with two cotyledons.

1. Which of the following is incorrect?

A) Phanerogams contain specialized reproductive organ and don't follow cryptogamae

B) Phanerogams are classified as Gymnosperms and Angiosperms based on the type of seed they produce

C) Gymnosperms have covered seeds and Angiosperms have naked seeds

D) Angiosperms bear fruit whereas Gymnosperms don't

2. Which among the following are incorrect?

A) Gymnosperms are fruitless plants that are mostly found in hilly areas

B) Gymnosperms are perennial, evergreen and woody trees

C) Gymnosperms have needle-shaped leaves that are well-adapted to withstand extreme weather conditions

D) Gymnosperms are also termed as hard wood trees

3. Which among the following are incorrect?

A) Microsporophylls are spirally arranged to form Strobili to form a cone shaped structures called microsporangiate

B) Microsporangiate is also called as male strobili because they contain microspores that form male gametophyte

C) Gametophytes can't exist independently i.e. free living

D) Microsporangiate and macrosporangiate exists within the same plant

4. Which among the following is incorrect?

A) Some Gymnosperms have algal association in their roots and it is termed as mycorrhiza

B) Leaves of Gymnosperms can be either simple/ compound

C) Gymnosperms have either branched/unbranched stems

D) The roots in Pinus exist in the form of mycorrhiza

1.3. STRUCTURE OF GYMNOSPERM:

- The gymnospoerms (gymnos-naked; sperma-seed) are naked seeded plants.
- The group includes about 70 genera and 725 living species. Besides it includes a large number of extinct fossil plants.

1. Habit:

- They are represented by the plant bodies which are diploid (sporophyte). They are perennials of usually arboreal evergreens (*Sequoia* up to 125 meters height and 30 meters girth), shrubby habits, or rarely climbers (Gnetales) occurring mostly under xerophytic conditions of life. No herbs are seen.

2. Roots:

- The radicle forms the tap root. The tap root system is exarch and diarch to polyarch. The tap roots may contain fungus (mycorrhiza) or algal cells (coralloid root of *cycas*).

3. Stem:

- Stems are tall erect. In some it is underground tuberous- *Zamia pygmia.* Tht stem is generally branched. But it is unbranched in cycas. Mostly they are woody. They bear characteristic leaf scars.

- In some genera (*Pinus*) two types of branches are seen: Long shoots and dwarf shoots that bear at their apices a clusters of green leaves collectively known as spur.
- Majority of the gymnosperms are monostelic with distinct pith, though a few may be polystelic.
- Vascular tissue is well developed. Stem possess collateral, endarch and open vascular bundles. Due to the presence and activity of cambium, secondary growth is present.
- Xylem consists of xylem parenchyma and trachieds. The trachieds are homoxylous with bordered pits in their radial walls. Vessels or wood fibres are absent except in Gnetales.
- Phloem consists of sieve tubes, phloem parenchyma and sometimes fibres. Companion cells are absent. Resin ducts are abundant.
- The secondary wood may be either manoxylic or pycnoxylic.
- The manoxylic wood is without any commercial value; it is soft and relatively thinly distributed with very wide rays made of parenchyma cells. *E. g*., Cycadales.
- The pycnoxylic wood is of much commercial importance, as it forms the most important constituent of the total timber output of the world. This type of wood is dense, compact and possesses very narrow wood-rays. *E. g.,* Coniferales.

4. Leaves:

- Leaves are mono or dimorphic.
- If dimorphic, two widely different types of leaf are found- the microphyll and megaphyll.
- Microphyll are usually small, deciduous leaves with only one or two veins; but sometimes rather larger leaves with parallel venation are also meant by the same. In *Pinus* they are needle like.
- Megaphyll is meant to relatively larger type of cutinized leaves with a fern-like branching and having branched veins. They may be pinnately compound as in *Cycas*.
- Leaves are mostly evergreen and possess resin passages (Pinus), or lacks resin passage (e.g., Gnetales) and posses' latex tubes.

- Usually the leaves are arranged in a spiral manner except in Cupressaceae and Gnetales where their arrangement is cyclic(*Cedrus*) or opposite decussate (*Gnetum, Weltitschia, Ephedra*). Forking of rachis and that of leaflets is seen in *Cycas circinalis*.
- The venation may be reticulate (*Gnetum*), parallel (*Welwitschia*) or even dichotomous (*Ginkgo*).
- The leaves of conifers and cycads possess a transfusion tissue.
- Stomata may be syndetocheilic or haplocheilic. The stomata may be on both surface (*Ginkgo biloba*) and on lower epidermis alone (*Cycas, Taxus).*
- The mesophyll may (Cydacs, *Gnetum*) or may not (*Pinus*) be distinguished into palisade and spongy parenchyma.
- Leaves may be triangular (*Pinus roxburghii*), semi circular (*Pinus sylvestris*), circular (*Pinus monophylla*) and bifacial (*Cycas, Gnetum*).

1. ‘Saccus’ term is used for

A) exine of pollen grains of Pinus B) intine of pollen grains of Pinus

C) Wings of pollen grains of Pinus D) Wings of seeds of Pinus

2. Flowers and cones are similar because

A) both assist seed dispersal

B) both are responsible in attracting insects to pollinate

C) both are shoy and bright

D) both are reproductive structures

3. An autotrophic, prokaryotic, nitrogen fixing symbiont is present in

A) Cicer B) Cycas C) Sequoia D) Pinus

4. Pick the pair that is incorrectly matched

A) Cycas – coralloid roots B) Abies – wood tar, wood gas

C) Pinus – Mycorrhizal roots D) Sequoia – Red wood tree

5. This serves as a connecting link between the angiosperms and gymnosperms

A) Gnetales B) Coniferales C) Ginkgoales D) Cycadales

83. Which of the following statements is true?

A) Ground water percolation can hinder mineralization of bone

B) Bones usually contain organic as well as inorganic molecules

C) Jellyfish can become fossils as their body contains hard parts

D) None of the above

84. Which of the following can be inferred from studying the fossilized skeletons of animals?

A) Pathologies B) Life expectancy

C) Growth pattern D) All of the above

85. Paleoanthropology is the study of _____

A) Fossils of early birds and their ancestors

B) Fossils of early humans and their ancestors

C) Fossils of early fish and its descendants

D) Fossils of early reptiles and its descendants

86. A holotype is a ______

A) A single physical example of an organism known to have been used when the species was described

B) A term used to describe special type of bones found exclusively in birds

C) A recently formed fossil specimen

D) None of the above

87. Radiocarbon dating can help find the age range of biological specimens no older than:

A) 50,000 years B) 100,000 years C) 500,000 years D) 1,000,000 years

88. The scientific study of the structure of bones, skeletal elements and microbone morphology is called:

A) Osteology B) Herpetology C) Entomology D) None of the above

89. Atoms of AA decay to atoms of BB with a half-life of 100,000 years. If there are 20,000 atoms of AA to begin with (and 0 atoms of BB), how long will it take for there to be 2,500 atoms of AA?

A) 100,000 yrs B) 200,000 yrs C) 300,000 yrs D) 400,000 yrs

90.In the past there were (more or less) atoms of radioactive Uranium?

A) Less B) More C) No wat to tell D) high

91. Which of the following represents the longest time period

A) Precambrian B) Paleozoic C) Mesozoic D) Cenozoic

92. The Paleozoic does not include the

A) Ordovician B) Jurassic C) Mississippian D) Permian

93. The _________ was an era dominated by the dinosaurs

A) Precambian B) Paleozoic C) Mesozoic D) Cenozoic

94. The boundaries between _______ seem to coincide with major changes in the life forms present on Earth.

A) Precambrian B) System C) Eras D) Epochs

95. Radiometric age is often referred to as __________ age.

A) Total B) Absolute C) Historic D) Geologic

96. The principal of original horizontality states that ________ .

A) Most rocks in the Earth's crust are layered horizontally

B) Igneous rocks form essentially horizontal layers

C) Metamorphic gradients are essentially horizontal before deformation

D) Sediments are deposited as essentially horizontal layers

97. Microscopic granules of silicon dioxide that enter a plant's cells and take their shape are called

A) Phytoliths B) Middens C) fission tracks D) pollen

98.During in which geological period did the earth become oxygen rich?

A) Orosirian period B) Ediacaran period

C) Devonian period D) Ordovcian period

99.The first green plants and fungi appeared on land during which period.

A) Ediacaran period B) Devonian period

C) Orosirian peiod D) Ordovcian period

100.Flowering plants first appeared during which period?

A) Jurassic peiod B) Carboniferous period

C) Cretaceous period D) Stone period

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UG TRB BOTANY 2023-2024

UNIT-4

ANGIOSPERM - MORPHOLOGY, TAXONOMY AND ECONOMIC BOTANY

Your Success is Our Goal....

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BOTANY

UNIT - 4

ANGIOSPERM - MORPHOLOGY, TAXONOMY AND ECONOMIC BOTANY

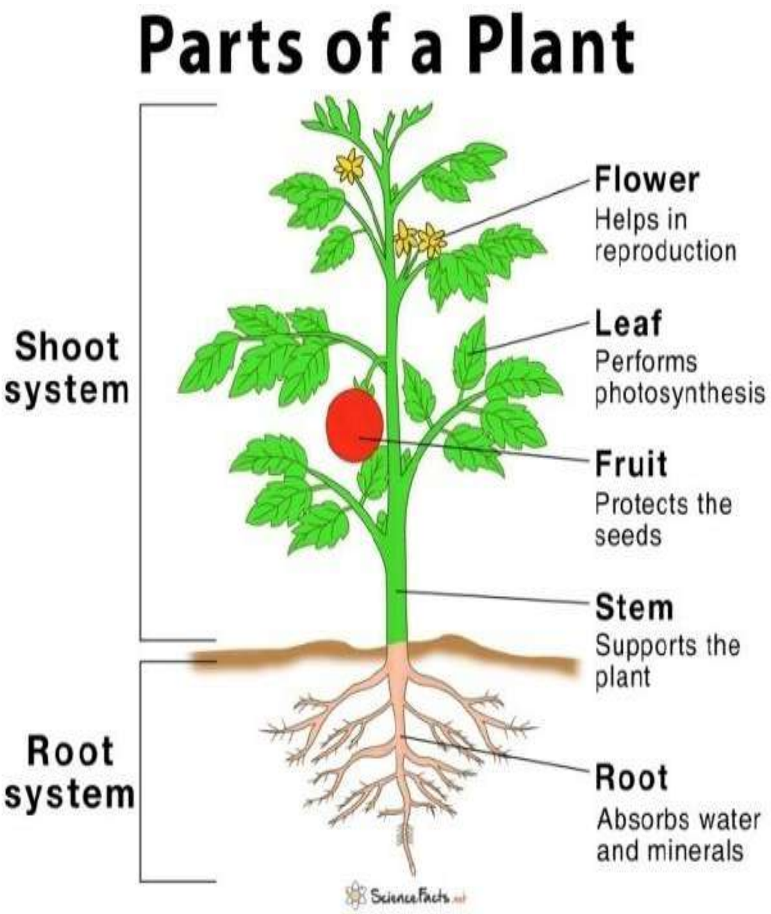
1.ANGIOSPERM MORPHOLOGY

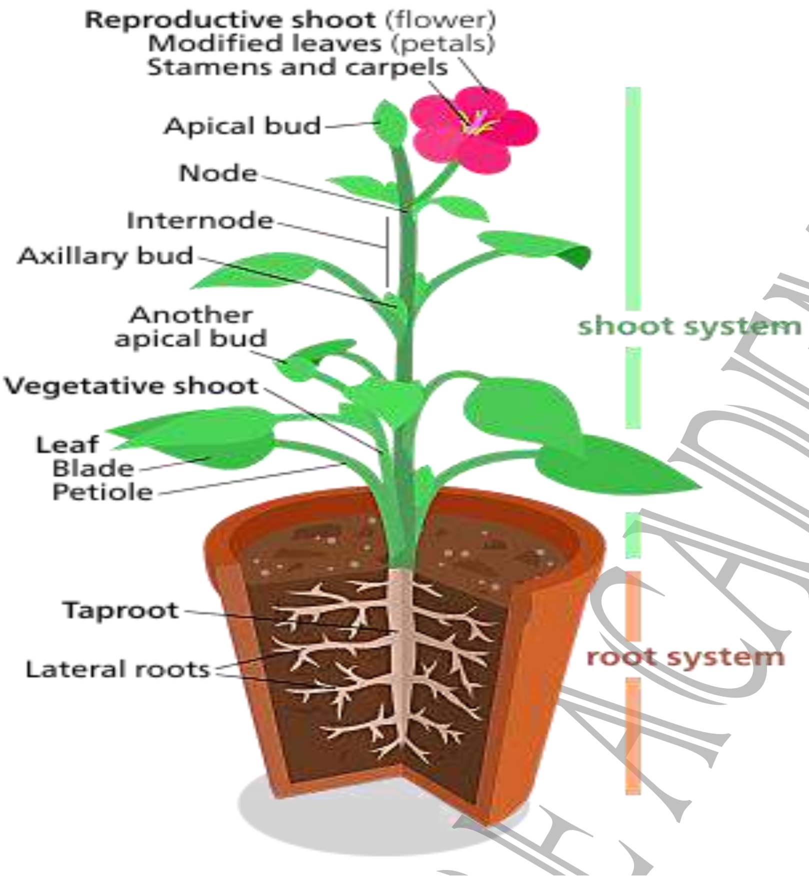
1.1 PLANT BODY PARTS:

- **The basic parts of most land plants are roots, stems, leaves and flowers, fruits and seeds**
- **The plant body consists of a number of organs**
- **The three main parts are: the roots, the leaves and the stem (fundamental)**
- Each part has a set of jobs to do keep the plant healthy
- The roots absorb water and minerals from the soil and anchor the plant in the ground.
- The stem supports the plant above ground and carries the water and minerals to the leaves

PLANT BODY PARTS: (COMMON)

SHOOT, ROOT, LEAVES, FLOWERS, FRUITS AND SEEDS





1. Which among the following is incorrect about the root?

   A) Radicle grows to form a primary root inside the soil

   B) From the primary roots grows the secondary roots from lateral surfaces

   C) Most of the monocotyledons adopt tap root system

   D) Adventitious roots are present in Banyan tree

2. The word morphology means ___________

   A) Study of structure B) Study of bones

   C) Study of change D) Study of skin

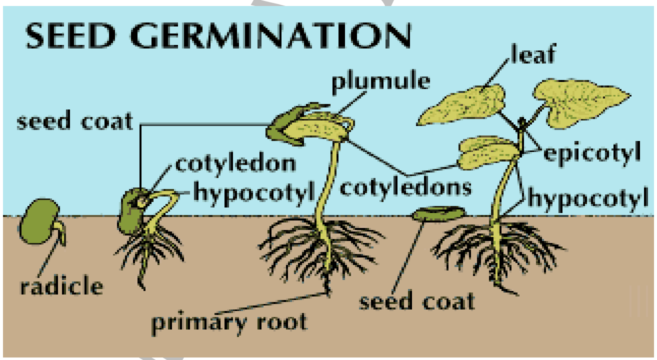
1.2 ROOT SYSTEM

- **The underground part of the main axis of a plant is known as root**
- **Root has no nodes, internodes and flower buds**
- **The root is subterranean and positively geotropic**
- **It is endogenous in origin**
- Its primary function are anchorage of the plant, absorption of water and minerals from the soil and its provides the stems and leaves

- The structure of the root consists of the root cap, apical meristem, epidermis, root hairs and root cap
- **In vascular plants, the roots are the organs of a plant that typically lie below the surface of the soil**
- **Roots can also be aerial or aerating that is growing up above the ground or especially above water**
- The primary root or radicle is the first organ to appear when a seed germination

Characters:

- **They are colourless and cylindrical structures**
- **They lack nodes, internodes, leaves and buds**
- Root is positively geotrophic, negatively phototrophic and positively hydrotrophic



1.2.1 Root Parts:

1. Root cap:

- It is a type of tissue at the tip of a plant root and it is also called calyptra

2. Root hairs:

- Each of a large number of enlarged microscopic outgrowths from the outer layer of cells in root and it absorbing moisture and nutrients from the soil
- Root hairs are always intercellular.

1.2.2 TYPES OF ROOT SYSTEM:

1. Primary or Tap Root system:

- **A tap root system always develops from the radicle and grows faster**
- **It is usually underground and is positively geotrophic**
- **The taproot system is characteristic or most the dicotyledonous plants and gymnosperms**
- It is extensively develops and occupies a very large and deep area in soil

- Its help for absorption of water, minerals and for a firm anchorage of the plant in the ground
- A straight growing vertically downwards with many smaller lateral root hairs
- The secondary and tertiary root grow form primary roots

2. Adventitious Root system:

- **Adventitious roots are that from any non root tissue and are produced both during normal development and in response to stress conditions such as flooding, nutrient depletion and wounding**
- **It almost all the monocotyledons including the cereals, the main root system is the adventitious root**
- **It may be underground or aerial**
- This root is short lived and the root arise from any part of the plant except the radicle
- Functions such as mechanical support, anchorage, storage of food, viral functions etc.

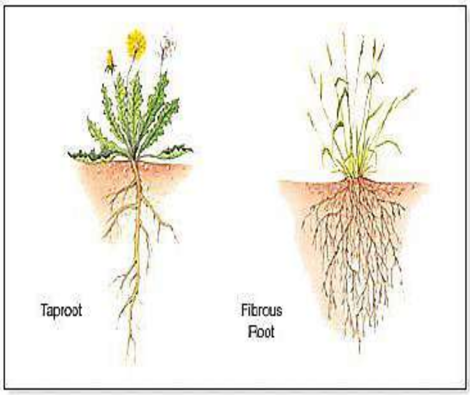
3. Aerial Roots:

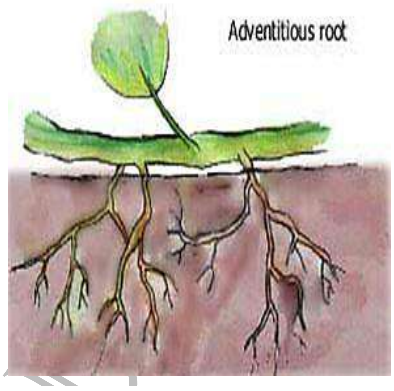
- **A root that develops from a location on a plant above the surface of the earth or water, as from a stem.**
- They are above the ground the plants and they are found in diverse plant species, including epiphytes such as orchids, tropical coastal swaps trees such as Mangroves, etc.
- Some type of aerial roots also absorb moisture and nutrients from soil

4. Fibrous Roots:

- **This system forms a dense network of roots that is closer to the soil surface**
- **It is found only in monocots**
- **It is usually formed by thin with root hairs**
- **Example: Grasses, wheat, rice, carrot**
- Their function is mainly absorption of nutrient and water from soil
- They have same length and same size.

TYPES OF ROOTS





1. Which among the following is incorrect about adventitious root system?

   A) Adventitious roots when buried in soil grows into new roots

   B) These roots provide additional anchoring to a plant

   C) These are the roots that grow from parts that are other than the radicle

   D) Adventitious roots are present in Turnip

2. Which among the following is an incorrect statement about root?

   A) The root is covered at the end by a thimble like structure called root cap

   B) Meristematic tissue helps in the growth of plants

   C) Mersistematic cells when mature forms the so called growing cells

   D) Root hairs increase the surface area which helps in increasing the levels of water absorption

3. Which among the following is incorrect about the modifications in roots?

   A) Roots undergo modifications to perform conduction of water and minerals

   B) Prop roots help in anchoring banyan tree to the ground

   C) Pneumatophores are present in maize and sugar cane that help them to respire easily

   D) Tap roots in turnip and carrot store food in their roots

4. Which among the following is incorrect about shoot system?

   A) The portion of a plant that grows above the soil is called shoot system

   B) Aerial roots are a part of shoot system

   C) Shoot system comprises of leaves, branches, flowers and fruits

   D) The shoot system develops from plumule

5. Which among the following is incorrect about tap root and fibrous root?

A) Tap root grows deep into the soil

B) Fibrous root grows laterally

C) In fibrous root system, one primary root and more than one secondary root is Present

D) Most of the dicotyledons adopt tap root system

6. Which among the following is incorrect about root system in carrot?

A) In carrot, roots are edible

B) They adopt fibrous root system

C) Turnip and beetroot also adopt the same type of root system

D) In this root system, one primary root present grows deep into soil and many secondary roots grow along the sides of the primary roots

1.3 ROOT MODIFICATION

Definition:

- In some plants, the **roots change their shape and get modified**

1.3.1. TAP ROOT MODIFICATION

1.3.1.1 STORAGE ROOTS (TUBEROUS ROOTS)

- In some plants, the primary taproots are modified for storing reserve food materials
- They are usually swollen and assume various forms

1. Conical:

- It is **Conical; swollen root** is broad at the above, tapers below and giving a shape of cone.
- Eg. Carrot (Daucus carota)

2. Fusiform:

- It is **Spindle shaped, broad at the centre** and tapers both upwards and downwards.
- Eg. Radish (Raphanus sativum)

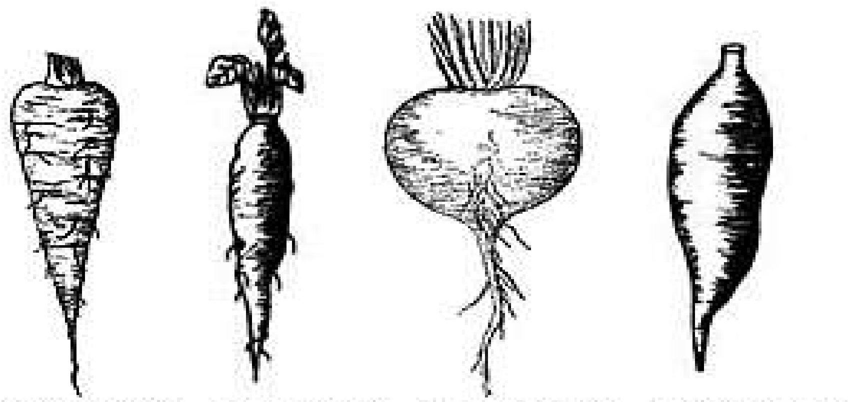
3. Napiform:

- The roots is **Nearly globular or spherical in shape**

- The basal portion is much swollen a tapers at the apex. Eg. Turnip (Brassica rapa), Sugar beet

4. Tuberous roots:

- They have no specific shape and they **appear thick and fleshy.** Eg. Dahlia.



Conical root Fusiform root Napiform root Tuberous root

1.3.2 MODIFICATION OF FIBROUS ROOTS

1.3.2.1 FOR STORAGE FOOD

1. Simple tuberous roots:

- They are **Swollen and do not assume any shape** Eg.Sweet potato

2. Nodulose roots:

- It is the fibrous root modification for food storage
- They are **Single beads and they become swollen at the tip**
- They have a definite shape Eg.Ginger

3. Fasiculated tuberous roots:

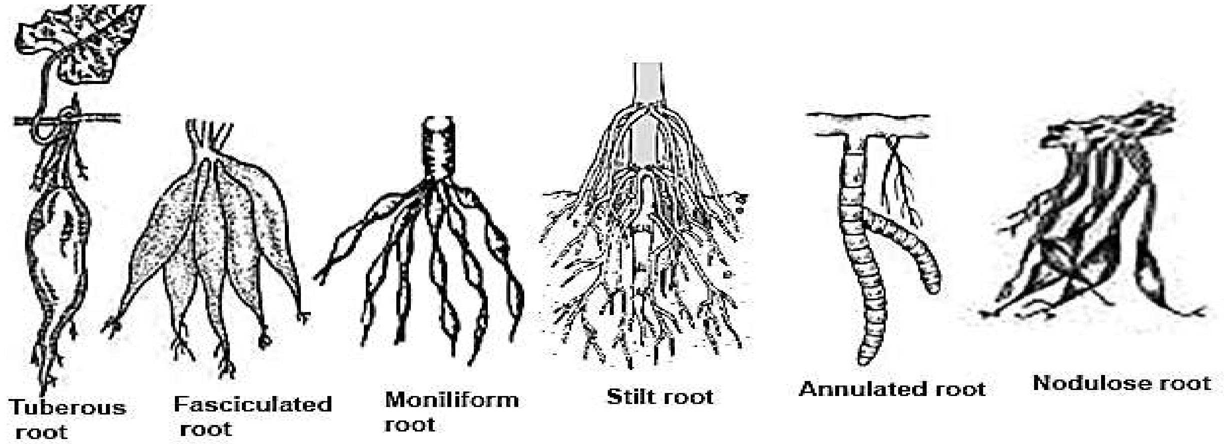
- **It is the cluster** of fibrous root modification for food storage
- They have a definite shape Eg. Sweet potato, Dahlia.

4. Moniliform roots:

- It is the fibrous root modification for food storage
- They are **Swollen up at intervals to give a beaded appearance**. Eg. Grasses

5. Annulated roots:

- It has an **Appearance of ring-like discs** placed one over the other Eg.lepecae (Cephaelis)
- It is a disc-like fibrous root modifications to store food material



1.3.3 ADVENTITIOUS ROOT MODIFICATION

1.3.3.1 FOR SUPPORT

1. Prop roots:

- These roots develop form the branches of the tree and **hang downwards**
- They penetrates into the ground thereby supporting the tree
- They are aerial and **they are pillar-like** and they give support to the huge tree
- Eg. Roots of the banyan tree

2. Slit roots:

- They are aerial **which develops from basal nodes of the stem**
- They are Provides mechanical support to the plants Eg. Roots of the sugarcane

3. Climbing roots:

- They are aerial and they arise from the nodes of the stem
- Its **help for climbing**. Eg. Pothos, Piper nigrum

4. Buttress roots:

- They are **Plank-like,** flat, broad aerial roots, **which spring from vertically elongated basal part of the stem which spread in different directions in the soil**. Eg.Salmalia, Ficus.Etc.

BUTTRESS ROOTS **PROP ROOTS** **SLIT ROOTS** **CLIMBING ROOTS**

1.3.4 ROOT MODIFICATION FOR SPECIAL FUNCTION

1. Epiphytic roots or Velamen roots:

- **These roots are aerial hanging and they are aerial root modification and these possess a special spongy-like tissue known as Velamen Eg. Vanda**
- Velamen absorbs and stores moisture from the air since these plants do not have direct contact with the soil and this root helps fix the plant and supporting branch

2. Respiratory roots or Pheumatophores:

- **These are aerial roots which are negatively geotrophic. Eg. Aviennia, Rihizophora,etc**
- **These root are found in mangroves plants, which grows in saline marshes**
- **Root have specialized structure called Pheumatophores** are minute aperture called lenticels through which exchange of gases take place

3. Parasitic or Haustorial roots:

- **Parasitic roots are aerial roots live in parasitic plant to suck food material from the host** and these roots serve to absorb water, nutrients. **Eg. Cuscuta**

4. Floating roots:

- **Floating roots are aerial root modification produced in hydrophytes** to provides buoyancy **Eg.Jussieua**

5. Balancing roots:

- These roots aerial root modification which are produced clusters and balance the plant while floating in water **Eg. Eichchornia (floating hydrophytes)**

6. Photosynthetic roots or Assimilatory roots:

- These are also known as photosynthesis roots. These when exposed to the sun develop chlorophyll and **manufacture food material and these roots become greenish**. Eg.Tinospora

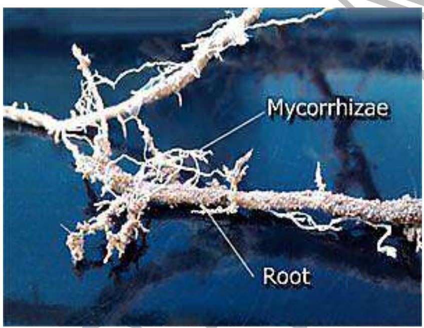
7. Mycorrhizal roots:

- **The symbiotic association of a fungus with higher plant root is called Mycorrhizal roots**
- The fungus absorbs moisture and nutrients from the soil for the plant and plant in turn produce organic food to it. Eg. Pinus (gymnosperm)

8. Reproduction Roots:

- In some plants such as sweet potato, the **adventitious roots give rise to buds** which develop into leafy shoots. This produce buds to help in vegetative propagation Eg. Guava, Milligtonia

PICTURES



1. Which of the following is an edible modified root?

(A) Potato (B) Sweet potato (C) Groundnut (D) both (a) and (b)

2. Clinging roots are found in

(A) Podostemon (B) Orchid (C) Trapa (D) Screwpine

3. Where do you find velamen?

(A) in roots of screwpine (B) in aerial roots of orchids

(C) in leaves of Ficus (D) in aerial and terrestrial roots of orchids

4. Which of the following has buttress roots?

(A) Banyan (B) Sorghum (C) Pandanus (D) Terminalia

5. Roots of which of the following plants contains an oxidising agent?

(A) Soybean (B) Radish (C) Mustard (D) Carrot

6. Roots developing from a part of the plant other than radicle are called

(A) Fibrous (B) Adventitious (C) Epicaulous (D) Epiphyllous

1.4 SHOOT SYSTEM:

- **SHOOT SYSTEM= LEAVES+ STEMS+ FLOWER**
- **Shoot or stem hold the leaves and flowers in plants**
- **Stems contain the plumbling that carries nutrients to different parts of the parts**
- **Shoot system consists of stem, branches, leaves and flowers**
- The shoot system which is above ground consisting of supporting stems, photosynthetic leaves and reproductive flowers
- The shoot system conduction of mineral solutions from the root to the leaves and of prepared food from the leaf to the different parts goes on through the xylem and the phloem
- First stem of a plant develops from part of a seed embryo called epicotyls

Shoot system function:

- **Photosynthesis, Reproduction, Storage, Transport, Hormones**

1.4.1 PARTS OF SHOOT SYSTEM

1.4.1.1. VEGETATIVE SHOOT:

It refers to the stem, leaves and growing tips of the plant shoot buds, nodes and internodes

1.STEM:

- **Stems are usually above ground, but there are some plants that have stems underground, such as bulbs or tubers**
- Stems are generally round like a stick and may be herbaceous or woody
- Stem is a main body or stalk of a plant and typically rising above ground but occasionally subterranean
- The stem of the plant connects the roots to the leaves in plants

STEM SYSTEM

- **The Shoot System represents the aerial part of the plants**
- It is the part of the plant that lies above the ground and Few stems are also found underground, so they are considers to stem modification
- **It consists of stem, branches, leaves and flowers**

- **It develops from the plumule of the embryo**
- **The aerial part of the main axis of a plant is the stem**
- **It grows against gravitational force and so it is negatively geotrophic**
- The stem has nodes, internodes, bears buds and stem hairs
- The main function of stems to support and elevation of leaves, fruits and flowers

STEM TYPES

- Based on their location with represent to the ground, there are three types of stems
- **Aerial stem, Underground stem and Sub aerial stem**

1. Aerial Stem:

- **A Stem with an erect or vertical growth habit above the ground**

2. Uuderground Stem

- **Underground Stems are modified plants that derive from Stem tissue but exist under the soil surface**

3. Sub Aerial Stem

- **Sub Aerial stems are the stems grow just above the ground**

Stem Consist of Some Parts:

1.Buds:

- **It is a small protuberance or round structure**
- A compact growth on a plant that develops into a leaf, flower and shoot

2.Apical buds:

- **The apical buds are otherwise called terminal buds**
- **The apical bud of a plant is the primary growing point located at the apex (tip) of the stem**
- Apical bud release a hormone called Auxin (IAA) or that can inhibit the growth of lateral bud.
- This phenomenon is termed as apical dominance

3.Axillary buds:

- **Axillary buds are otherwise called lateral buds**
- The axillary buds arise from the leaf node of the stem
- Hence both terminal and axillary buds arise from the apex (apical meristem) of the stem

4.Buds function:

- Buds arise from meristem tissue shoot.
- Each bud has the potential to form shoots and may be specialized in producing either vegetative shoots (stems, branches and leaves) (axillary buds) and reproduction shoots (apical buds)

5.Nodes:

- **A point in a network or diagram at which lines or pathways interest or branch**
- **Node are the points on a stem where the buds, leaves and branching twigs originate**
- They are crucial spots on the plant where important healing, structural support and biological processes. The number of leaves that appear at a node depends on the species

6.Internodes:

- **The intervals on the stem between the nodes are called internodes**
- The function of an internodes is to link the nodes of a plant together
- This allows food, hormones and water to be distributed throughout the nodes of the plant
- The internodes are easily visible on a plant

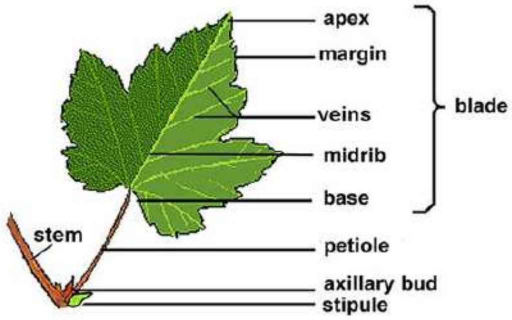
Stem Function:

- It helping to transport absorbed water and minerals to different parts of the plants
- It also help to transport the products of photosynthesis (sugars) from the leaves to the rest of the plant

2.LEAVES:

- **The leaf-singular (plural-leaves) is the principal appendage of the vascular plant stem**
- **It is usually borne above ground and in general, leaves are thin, flat organs**
- **The leaves and stem together form the shoot system of the plant**
- **It is an expanded structure, usually green of vascular plants, characteristically consisting of a blade like expansion attached to a stem and functioning for photosynthesis and transpiration**

- Leaves are typically comprised of a distinct upper and lower surface, stomata for gas exchange, waxy coating, hairs and venation, petiole, blade



- A leaf part is attached to it by a stem or stalk
- Three basic types of leaf arrangements found in trees and shrubs are alternate, opposite and whorled
- **The leaves are collectively referred to as foliage**
- It developing from a node and having a bud in its axils

A. PARTS OF LEAVES

1.Venation:

- **The arrangement of veins in a leaf is called the venation pattern**
- **Monocots have parallel venation while dicots have reticulate venation**
- **The veins are composed of xylem and phloem**
- The vein xylem transports water from the petiole and the phloem transports sugars out of the leaf to the rest of the plants

2.Petiole:

- **The petiole is long, thin stalk that attaches the leaf blade to the stem**
- This gives a characteristic foliage arrangements to the plant

3.Blade:

- **The leaf blade or lamina consists of a central tissue called the mesophyll surrounded on either side by upper and lower epidermis**
- The blade collects sunlight and its main function are photosynthesis and gas exchange

4. Leaf base (Hypopodium):

- **The leaf bases if the slightly expanded area where the leaf attaches to the stem**
- It protects the young axillary bud

5. Leaf margin:

- **The leaf margin is the boundary area extending along the edge of the leaf**

- There are lots of different types of leaf margins that are important for plant identification

6.Midrib:

- The central and usually the most prominent vein of a leaf
- It is a thick, linear structure that runs along the length of a plant thallus or lamina
- It provides support to the leaf

7.Stipules:

- A small leaf-like appendage to a leaf
- Typically it borne in pairs at the base of the leaf stalk
- Common on dicotyledons and some monocotyledons plants display stipule like structures
- Leaves with stipules are called stipulate and the leaves without stipules are called exstipulate leaves
- Its protect the emerging leaf or bud

8.Stomata parts:

- **It is a pore found in the epidermis of leaves and some stems and other organs**
- **The main function is regulating water movement through transpiration**
- They control water loss and gas exchange by opening and closing
- In general, stomata open by day time and close at night time

Function of leaves:

- The main function of a leaf is to produce food for the plant by photosynthesis
- Its protect vegetative and floral buds
- **Gas exchange** : the exchange of oxygen and carbon-dioxide in the leaf occurs through posses pores called stomata
- **Transpiration**: is a process where water evaporates through openings in the leaves of plants called stomata and the function of transpiration is to keep plants cool and deliver water all over the plant

1.4.1.2. REPRODUCTION SHOOTS:

- Reproduction shoot system over time form its formation to the mature structure
- **Reproduction shoots to form flowers. So it is also called flowering shoot**

90. This system of classification was used by Linnaeus

(a) Phylogenetic system
(b) Natural system
(c) Artificial system
(d) Asexual system

91. Pick the right sequence of taxonomic categories

(a) division-class-family-tribe-order-genus-species
(b) division-class-family-order-tribe-genus-species
(c) division-class-order-family-tribe-genus-species
(d) division-order-class-family-genus-tribe-species

92. 'New Systematics' term was coined by

(a) Linnaeus
(b) Bentham and Hooker
(c) A.P. de Candolle
(d) Juliane Huxley

93. The document that includes all the information related to a particular genus or plant family is termed as:

A. Monograph
B. Record
C. Revision
D. Plant Module

94. Systematic Biology is the term used to refer:

A. Phenetics + Plant Taxonomy
B. Phylogenetic + Biology
C. Systematics + Plant Taxonomy
D. Dendrogram + Biology

95. Who was the first-ever philosopher to classify living organisms?

A. Whittaker
B. Aristotle
C. Linnaeus
D. Charles Darwin

96.Taxon is-

a) A taxonomic unit
b) A species
c) A taxonomic group of any rank
d) A genus

97. The National Botanical Research Institute is located at

a) Dehradun
b) Delhi
c) Gangtok
d) Lucknow

98. Which year marked birth of modern system of biological nomenclature?

a)1753
b)1857
c)1757
d)1854

99. Level of taxonomic study concerned with the biological aspects of taxa, including intraspecific populations, speciation, evolutionary rates and trends

a) alpha taxonomy b) beta taxonomy

c) gamma taxonomy d) theta taxonomy

100. Binomials with identical genus name and specific epithet are called

a) Homonym b) Tautonym c) Basionym d) Synonym

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UNIT-5
ANATOMY AND EMBRYOLOGY

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BOTANY

UNIT - 5

ANATOMY AND EMBRYOLOGY

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UNIT V

1.ANATOMY

1.1 MERISTEM

- All living organisms are made up of basic units known as cells. The individual cells are grouped to form tissues which perform a specific function. The cells have distinctive shapes, wall characteristics and show specific physiological properties. Depending upon the organization of cells, tissues have been categorized into different types. In this unit you will study about different types of tissues found in plants. Some cells develop specialized structures, some carry out limited functions while the others carry out multiple functions. Cells mainly participate in growth, cell division and differentiation. The detailed information about function of various tissues with emphasis on their role in plant growth will be provided to you in this unit.
- Meristematic tissue or meristems, as they are also called are tissues that have the ability to enlarge, stretch and differentiate into other types of cells as they mature. The cells of this tissue are generally young and immature, with the power of continuous division.
- Meristematic cells are all living cells. The meristematic cells can be oval or rounded or polygonal in shape. They have a large nucleus with no vacuoles. Intercellular space between cells is absent. The cells are also small in size but have a high capacity of cell division.
- Depending on the occurrence of the meristematic tissue on the plant body, we can classify the meristems into three types. They are:

  1.Apical Meristems: These meristems are located on the tip of the root, stem, etc. They help in the growth of the root system as well as the shoot system. The various cell divisions along with the cellular enlargement help in the growth of the stem above the ground and the growth of the root below the ground.

  2. Intercalary Meristems: The intercalary meristems are located at the internodes or the base of the leaves. The intercalary meristems help in increasing the length of the internode. This is usually seen in monocotyledonous plants.

  3.Lateral Meristems: The lateral meristems are present on the lateral side of the stem and root of a plant. These meristems help in increasing the thickness of the plants. The vascular cambium and the cork cambium are good examples of a lateral meristematic tissue.

1.1.1 ORGANIZATION OF MERISTEMS

- A meristem is the tissue in most plants containing undifferentiated cells (meristematic cells), found in zones of the plant where growth can take place. Meristematic cells give rise to various organs of a plant and are responsible for growth. Differentiated plant cells generally cannot divide or produce cells of a different type. Meristematic cells are incompletely or not at all differentiated, and are capable of continued cellular division. Therefore, cell division in the meristem is required to provide new cells for expansion and differentiation of tissues and initiation of new organs, providing the basic structure of the plant body. Furthermore, the cells are small and protoplasm fills the cell completely. The vacuoles are extremely small. The cytoplasm does not contain differentiated plastids (chloroplasts or chromoplasts), although they are present in rudimentary form (proplastids). Meristematic cells are packed closely together without intercellular cavities. The cell wall is a very thin primary cell wall as well as some are thick in some plants. Maintenance of the cells requires a balance between two antagonistic processes: organ initiation and stem cell population renewal. There are three types of meristematic tissues: apical (at the tips), intercalary (in the middle) and lateral (at the sides). At the meristem summit, there is a small group of slowly dividing cells, which is commonly called the central zone. Cells of this zone have a stem cell function and are essential for meristem maintenance. The proliferation and growth rates at the meristem summit usually differ considerably from those at the periphery.
- The term meristem was first used in 1858 by Carl Wilhelm von Nägeli (1817–1891) in his book (Beiträge zur Wissenschaftlichen Botanik) ('Contributions to Scientific Botany'). It is derived from the Greek word merizein, meaning to divide, in recognition of its inherent function.
- Plants have meristematic tissue in several locations. Both roots and shoots have meristematic tissue at their tips called apical meristems that are responsible for the lengthening of roots and shoots. The shoot apical meristem is formed during embryonic development, but after germination gives rise to the stem, leaves, and flowers. The root apical meristem is also formed during development, but during germination gives rise to the root system. Cell division and cell elongation in the apical meristem is called primary growth and results in an increase in plant height and root length. Increasing root length enables the plant to tap into the water and mineral resources of a new region or layer of soil. Increasing shoot length makes the plant taller, thus allowing it better access to sunlight for photosynthesis.
- Many types of plants also increase the diameter of their roots and stems throughout their lifetime. This type of growth is called secondary growth and is the product of

lateral meristem. Lateral meristem is called the vascular cambium in many of the plants in which it is found. Secondary growth gives a plant added stability that allows for the plant to grow taller. Lastly, some plants have intercalary meristem. These are areas of plants that help in the regeneration of parts of the plant that have been damaged by predators or the environment. Intercalary meristems produce growth at the base of grass blades, for instance.

- Meristematic tissues are found in many locations, including near the tips of roots and stems (apical meristems), in the buds and nodes of stems, in the cambium between the xylem and phloem in dicotyledonous trees and shrubs, under the epidermis of dicotyledonous trees and shrubs (cork cambium), and in the pericycle of roots, producing branch roots. The two types of meristems are primary meristems and secondary meristems.

On the basis of the development, tissues have been classified into two groups:

- ✓ Meristematic Tissue, Permanent Tissue

1.Meristematic Tissue:

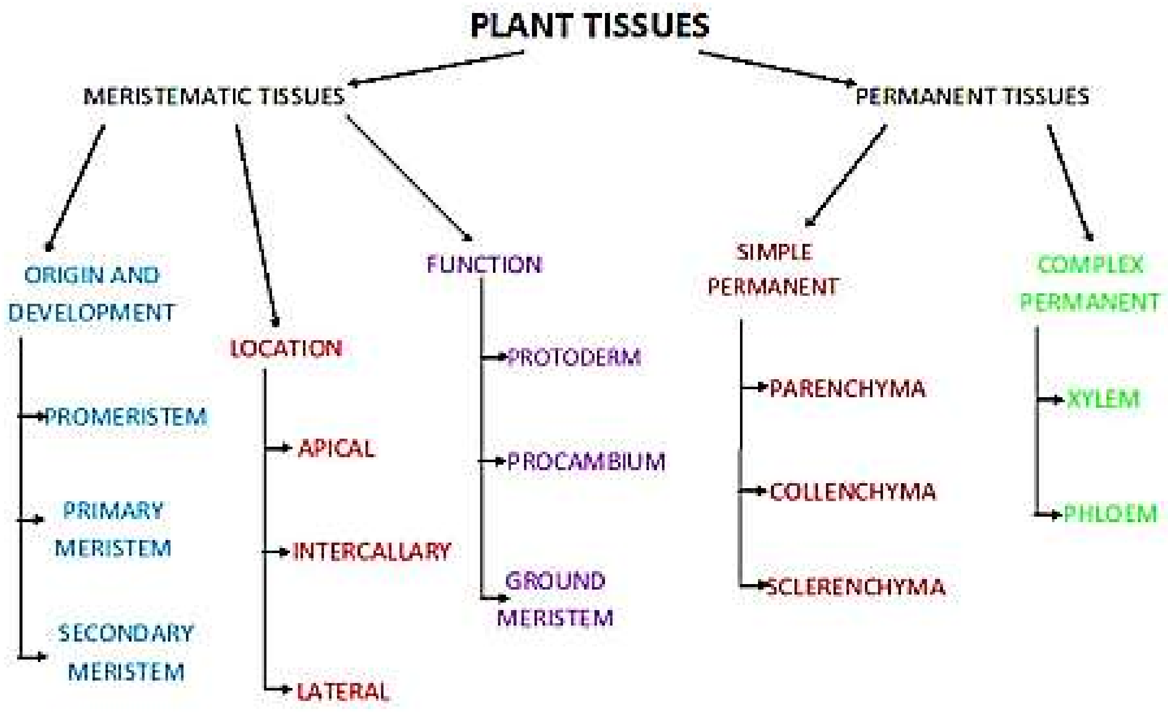
- It consists of a group of cells that divide continuously and the daughter cells differentiate into the permanent tissue. The cells of the meristematic tissue have the capability to divide indefinitely. The cells are isodiametric in shape. They have thin cellulosic wall with dense cytoplasm and large nucleus. Vacuoles are either absent or if present are very few in number except the cambial cells which show vacuolation. They are tightly packed without any intercellular spaces. Plastids occur in the form of proplastids. Mitochondria and endoplasmic reticulum are not well developed. They have very high metabolic rate.

2.Permanent Tissue:

- The cells of this tissue have lost their ability of division. They are thin or thick walled, living or dead, with well-developed intercellular spaces and cell organelles.

1.1.2 CLASSIFICATION OF MERISTEM

- The meristem can be classified on the basis of origin, plane of division, function and position in the plant body.



1.1.2.1 Meristem on the Basis of Origin

Following are the meristems based on the origin:

- Primordial Meristem, Primary Meristem, Secondary Meristem

1.Primordial Meristem:

- The undifferentiated group of cells is termed as promeristem. It is also known as primordial meristem or embryonic meristem. The cells are thin walled isodiametric cells with dense cytoplasm and large nuclei. Promeristem differentiates into primary meristem.

2. Primary Meristem:

Primary meristem originates from the promeristem and differentiates into the permanent tissue. It forms the fundamental parts of the plant and persists throughout the life of plant. The main primary meristems are root apical and shoot apical meristem. It also occurs at the tip of the leaf and forms the abaxial and adaxial surface of the leaf which encloses mesophyll and vascular tissues. The primary tissue of the plant such as epidermis, cortex, xylem, phloem, pith all are the derivatives of primary meristem. After the differentiation some permanent cells regain the capability of division and this is known as dedifferentiation.

3.Secondary Meristem:

This meristem develops from the permanent tissue which has undergone the dedifferentiation. New tissues are added to dermal and epidermal tissue system. It is usually developed either at the time of emergency or to effect secondary growth. Cork cambium and vascular cambium are the examples of secondary meristem. Vascular cambium produces secondary xylem towards inner side and secondary phloem towards outer side. Cork cambium also known as phellogen, produces cork (phellem) towards outer side and secondary cortex (phelloderm) towards inner side. Phellem, Phellogen and Phelloderm constitutes the periderm which is protective in nature.

1.1.2.2 Meristem Based on the Function

Following are the meristems based on the function:

- ✓ Protoderm, Procambium, Ground Meristem

1.Protoderm:

- It is the outermost layer of young growing regions which develops into the epidermis. It is protective in nature and forms the part of dermal tissue system. Stomata, trichomes and all glandular hairs develop from the protoderm.

2.Procambium:

- It consists of narrow, elongated meristematic cells which develop into primary vascular tissue. The cells are densely cytoplasmic and consist of large nucleus. In stem, the cells of procambium develop primary xylem towards inner side and primary phloem towards outer side. In dicotyledons stem, a portion of procambium remains between primary xylem and primary phloem and later differentiates into cambium, which forms open collateral vascular bundles.

3.Ground Meristem:

- It consists of large thin walled cells which later on differentiate into hypodermis, cortex, pericycle, pith and medullary rays.
- Mesophyll cells of leaf and additional procambial bundles also derive from the ground meristem.

1.1.2.3 Meristem Based on the Position

Following are the meristems based on the position

- ✓ Apical Meristem, Intercalary Meristem, Lateral Meristem

1.Apical Meristem:

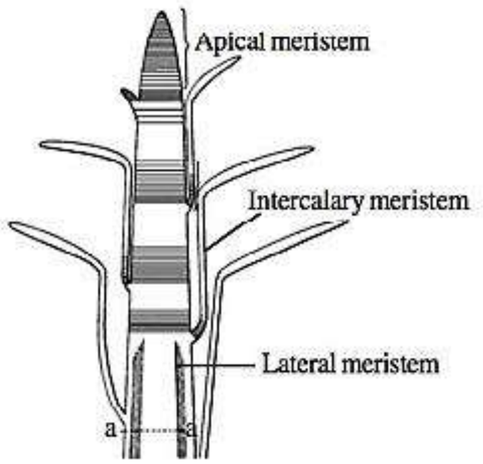
- It is present at the apex of root and apex of main and lateral shoots. Apical meristem is the growing point of shoot and forms leaves and branches. Flowers also differentiate from apical meristem. It is responsible for increasing the length of root and shoot.

2.Intercalary Meristem:

- The meristem which is present between the regions of permanent tissues is known as intercalary meristem. It is present at the base of internode of grasses.

3.Lateral Meristem:

- It is located parallel to the long axis of root and shoot and predominantly divide periclinally. They are responsible for increasing the diameter and form secondary permanent tissue. Vascular cambium and cork cambium are the examples of lateral meristem.



1.1.2.4 Meristem Based on the Division

Following are the meristems based on the division:

- ✓ Rib or File Meristem, Plate Meristem, Mass Meristem

1.Rib or File Meristem:

This meristem divide at the right angles to the longitudinal axis of the plant organ, and therefore parallel files of cells are formed. For example, cortex and pith of root and stem.

2.Plate Meristem: It consists of parallel layer of cells which divide anti-clinally and bring intercalary growth. This meristem is present in leaf and increases the surface area without increasing the number of mesophyll layers.

3.Mass Meristem: The cells of this meristem divide in all possible planes therefore, the tissue increases in volume. For example, embryo and endosperm.

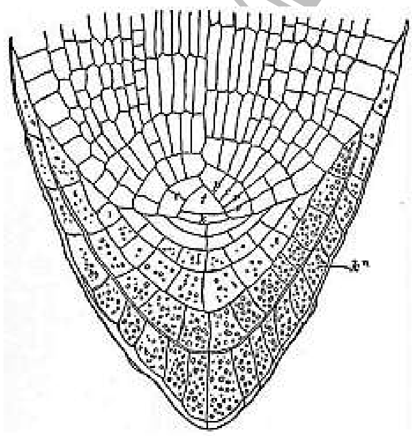
1.1.3 THEORIES OF ROOT APICAL MERISTEM

The cells forming the apical meristem of primary root are densely cytoplasmic with large nuclei. They undergo active division and all the permanent tissues of the root are derived from the root apical meristem. The position of root apical meristem is sub-terminal as terminal position is occupied by a root-cap. The meristem that generates root cap is known as calyptrogen.

There are mainly three theories to explain the root apex of vascular plants, i.e., as follows:

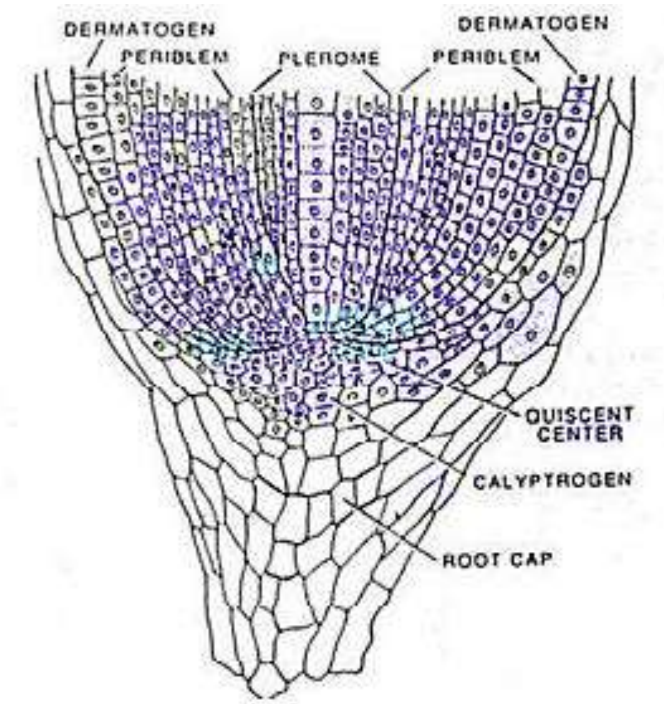
Apical Cell Theory, Histogen Theory, Korper–Kappe Theory

I. Apical Cell Theory:



- This theory was proposed by Nageli. According to this theory, there is a single apical tetrahedral cell which gives rise to all the tissues of the root.
- The root cap is derived from the base of the apical cell and all other tissues like epidermis, cortex and vascular cylinder originate from the upper three sides of apical cell. This theory is restricted to the vascular cryptogams only because in flowering plants a group of the initial cells has been observed in the root apical meristem.

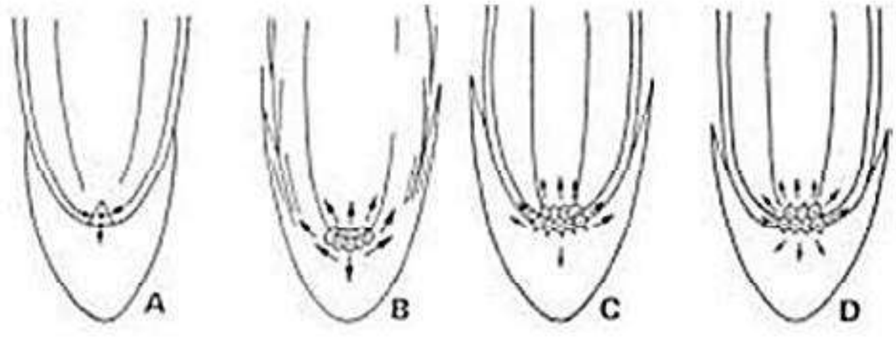
II. Histogen Theory:



- On the basis of cellular configuration, Schuepp divided the root apical meristem into four types :
- Type A: All the permanent tissues of root are derived from a single apical cell. It is present in all vascular cryptogams.
- Type B: There are two separate groups of initials. Vascular cylinder is derived from one group and epidermis, cortex and root cap originates from other group. It is common in gymnosperms.

Type C: There are poorly individualized initials which give rise to root cap, cortex and vascular cylinder. It is present in dicotyledons.

Type D: In this type, there are three separate groups of initials. One group forms root cap, epidermis and cortex derive from other group and vascular cylinder originates from separate group. This type is common in monocotyledons.



Organization of Root Apical Meristem

Guttenberg also divided the root apical meristem into two types

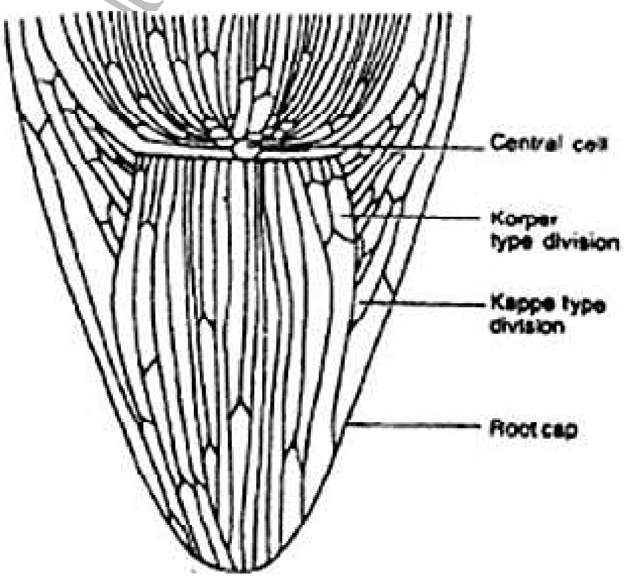
- ✓ Enclosed Type, Open Type

Enclosed Type: The initials of the various tissues lie closer to the central cells. Cortex and vascular cylinder have separate initials. Root cap and protoderm may have common or separate initials.

Open Type: In this type, the initials of various tissues are at some distance from the cemtral cells. Only vascular cylinder originates from separate initial and all other tissues have common origin.

III. Korper–Kappe Theory:

- This theory was proposed by Schuepp (1917). According to this theory, the cells at the root apex divide in two planes. First, a cell divides into two by a transverse division and then one of the daughter cells divides by a longitudinal division and therefore, a T shaped structure is formed. It is also known as T division.



- On this basis, root apical meristem has been divided into two distinct zones, Korper (cap) and Kappe (body). In the inner region, the second division occurs in upper daughter cell and therefore, inverted T shaped structure is formed and it is known as Korper (cap).
- In the outer region, the second division occurs in lower daughter cell and straight T shaped structure is formed, known as Kappe (body). The central region of root cap is known as columella where the cells are arranged in longitudinal files.

- These cells divide rarely. The korper-kappe theory of root apex is similar with tunica-corpus theory of shoot apical meristem as both are based on the plane of cell division.

Quiescent Centre

- In the root tip of Zea, Clowes observed a central cup like hemispherical region between the root cap and active meristematic zone. The cells of this zone have less amount of DNA, RNA and protein and these cells also show very low mitotic activity. They do not actively synthesize DNA. The cell organelles are also less in numbers. They have few mitochondria, less endoplasmic reticulum, small dictyosomes, nuclei and nucleoli. This zone was termed as quiescent centre (Refer Figure 1.7). Later on, the existence of quiescent zone has been observed in the root tips of many plants. When the cells of this zone are exposed to X-rays, the meristematic cells stop dividing and the cells of quiescent centre become active. It is because the cells of quiescent centre are more resistant to the radiations than actively dividing cells.
- Therefore, quiescent centre is regarded as central mother cells that form promeristem of the apex. It provides a reservoir of diploid cells when the root tip is damaged. It is also considered the site of hormone synthesis.

1.1.4 THEORIES OF SHOOT APICAL MERISTEM

- Shoot apical meristem is more complicated than root apical meristem and it shows the differences in the following aspect:
- Shoot apical meristem is terminal in position whereas root apical meristem is sub-terminal as root cap occupies the terminal position. Shoot apical meristem produces cells toward the axis but root apical meristem produces cells toward the axis as well as away from the axis to initiate the root cap. Shoot apex shows the rhythmic changes in shape and size before and after the initiation of leaf primordium. It widens considerably before leaf initiation and again becomes narrow after leaf initiation. Root apical meristem does not show any kind of rhythmic changes in shape and size. Shoot apical meristem is associated with the formation of lateral appendages (branches), but in root the lateral organs (lateral roots) are formed behind the root apical meristem. Theories of Shoot Apical Meristem
- Several theories have been proposed to describe the organization of shoot apical meristem:
  - ✓ Apical Cell Theor, Histogen Theory, Tunica-Corpus Theory

1.Apical Cell Theory:

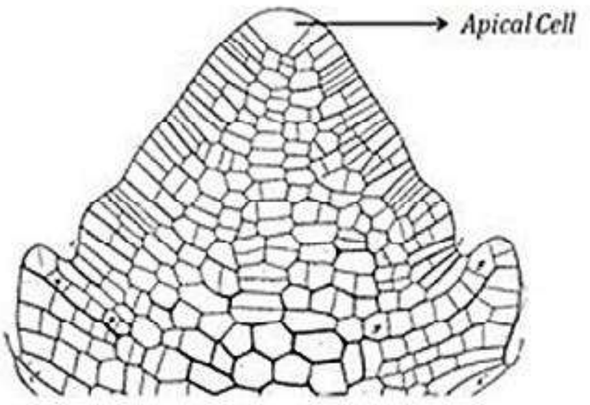
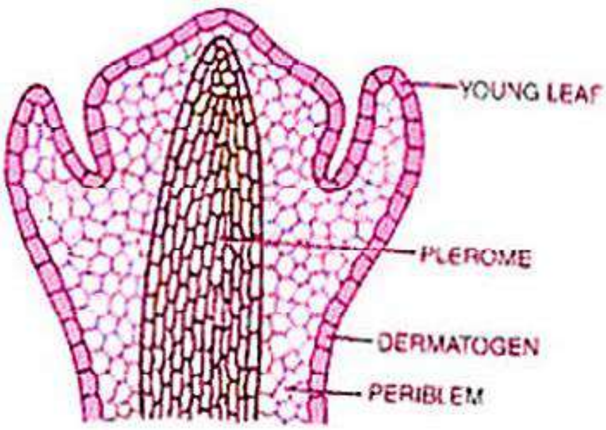


Diagram Showing the Shoot Apex with a Single Apical Cell

- This theory was proposed by Nageli. According to this theory, there is a single apical tetrahedral cell in the shoot apex and it is considered the 'structural and functional unit' of apical meristem. The single apical cell divides to give rise to all the tissues of the shoot (Refer Figure 1.8). This theory is restricted to the vascular cryptogams only. In flowering plants a group of the initial cells has been observed in the root apical meristem and therefore this theory was discarded.

2.Histogen Theory:



- This theory was advocated by Hanstein. According to this theory, there are three distinct meristematic zones which arise from the independent initial of the apical mersitem. These layers are termed as histogens. The outermost histogen is known as dermatogen, middle one periblem and the inner most plerome. Epidermis originates from dermatogen, cortex from periblem and vascular cylinder from plerome. This theory was not accepted as these layers are not specific in their functions. In gymnosperms and angiosperms, it was not possible to make clear distinction between periblem and plerome. Haberlandt suggested protoderm, ground meristem and procambium for these three histogens.

3.Tunica-Corpus Theory:

- Tunica-corpus theory was proposed by Schmidt (1924). This theory was based on the plane of cell division in the apex. According to this theory, there are two distinct layers in the shoot apex of angiosperms. These two distinct zones were termed as tunica and corpus. The outer zone consisting of one or more layers of regularly arranged cells known as tunica in which only anticlinal division (perpendicular to the surface) occurs.

- Therefore, tunica develops as a layer but does not increase in thickness. In a same species, variations in the number of tunica layers have been observed in the different stages of development of shoot apex. These variations may be due to the plastochron periodicity. Usually tunica gives rise to epidermis. The inner zone of shoot apex is known as corpus, which is covered by tunica. Here, the cells divide in all possible planes.
- Therefore, shoot apex increases in volume. Corpus gives rise to cortex and vascular tissue. In some grasses like maize, periclinal divisions have also been observed. Therefore, some scientists consider that tunica should include only those layers in which only anticlinal divisions occur. The other layers of tunica in which cells divide by periclinal division, they should be termed as corpus. To accommodate these fluctuations in tunica and corpus, Popham and Chan (1950) suggested mantlecore hypothesis.
- They divided shoot apex into two zones but not on the basis of cell division. Mantle included all the outer layers of the apex and tunica was restricted only to those layers which divide anticlinally. The inner mass of cells covered by mantle termed as core. Both of these layers have separate set of initials which are adjacent with one another at the tip of the apex. These cells can be easily identified by their larger size and more vacuolation. The shoot apex of most of the gymnosperms does not exhibit tunica-corpus organization as their shoot apex does not have a surface layer which divides anticlinally.
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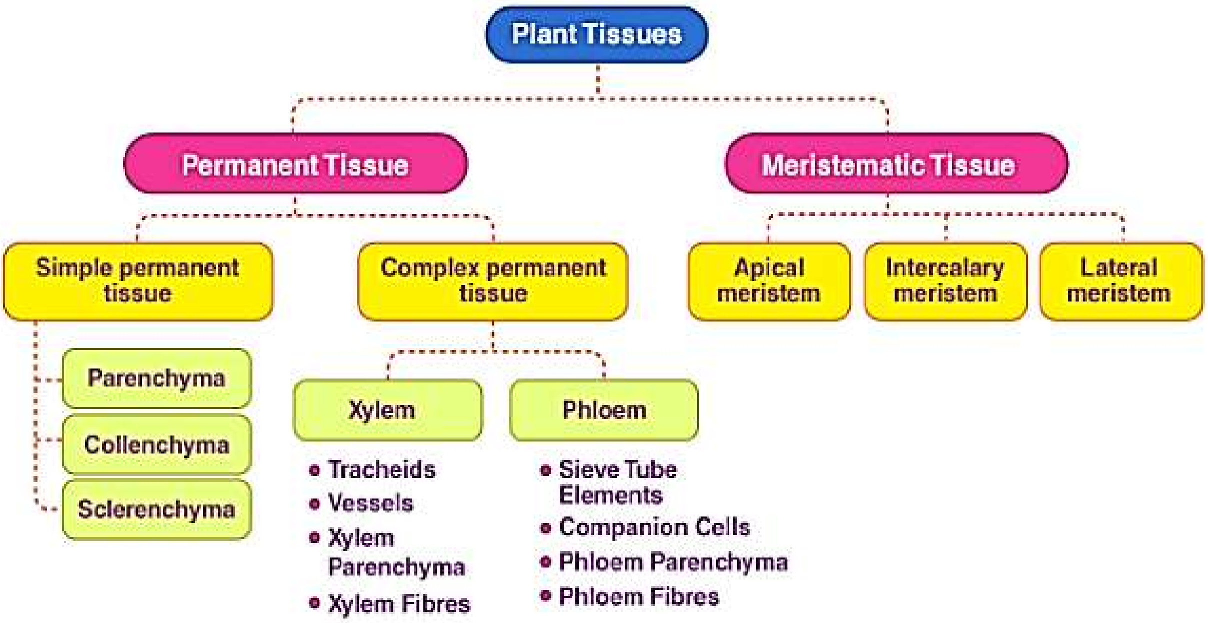
Types of Shoot Apex

- Newman (1965) gave this concept, and according to this there is nothing like a group of permanent initial cells in the shoot apex, instead there is a sequence of meristematic cells and it is known as continuing meristematic residue. He classified shoot apex into three types.

Monoplex Type:

- It is found in vascular cryptogams and ferns; here the shoot apex is denoted by one or more cells which divide by walls parallel to the inclined walls in the stem.
- Simplex Type: It is found in gymnosperms; it consists of one or more initial cells arranged in a single layer; these cells divide anticlinally and periclinally.
- Duplex Type: It is found in the shoot apex of angiosperms; it consists of atleast two successive layers of cells; the cells of surface layer divide anticlinally and that of inner layer divide in more than one plane.



Question of the following:

1): _____ is a group of organized cells with a common origin, similar or different structure and function.

a) Cell b) Tissue c) Organelle d) None of these

2): The group of plant cell which is in active state of division is known as _____

a) Meristematic tissue b) Permanent tissue

c) Special tissue d) Rhomboid tissue

3): ______type of meristematic is present at the shoot apex and it can be found at the leaf apices of developing leaves.

a) Intercalary meristem b) Lateral meristem

c) Apical meristem d) All of these

4): ______ is a type of meristematic tissue which remain embedded within the permanent tissue mainly between two nodes.

a) Permanent tissue b) Lateral meristem

c) Apical meristem d) Intercalary meristem

5): ______ are lateral meristem and primary cambium which remains within the vascular bundles forming the secondary xylem and phloem.

a) Fasicular cambium b) Cork cambium

c) Phellogen cambium d) None of them

6):Which of the following part of meristematic tissue forms primary meristem ____

a) Secondary meristem b) Primary meristem

c) Promeristem d) Interfascicular cambium

7: The secondary meristem origin of meristematic tissue found in vascular region in the form of ______

a) Phellogen cambium b) Cork cambium

c) Fasicular cambium d) Interfascicular cambium

8): ______ is the outermost layer of meristematic where radical division forms epidermal tissue in root.

a) Procambium b) Protoderm

c) Fundamental meristem d) Ground meristem

9): In the plane of division of meristematic tissue _______ type is the cell division takes place in one plane.

a) Plate meristem b) Rib meristem c) Mass meristem d) None of them

10): _______ Is the plane of division where cell division takes place in two plane.

a) Mass meristem b) Ground meristem

c) Plate meristem d) Rib meristem

1.2 TYPES OF TISSUES

- Plant body comprises of several types of tissues, now you are going to study about different types of tissues. Fahn defined tissues as 'complex of cells of common origin'. Tissue comprise of group of cells which may possess a common structure or may perform a common function.

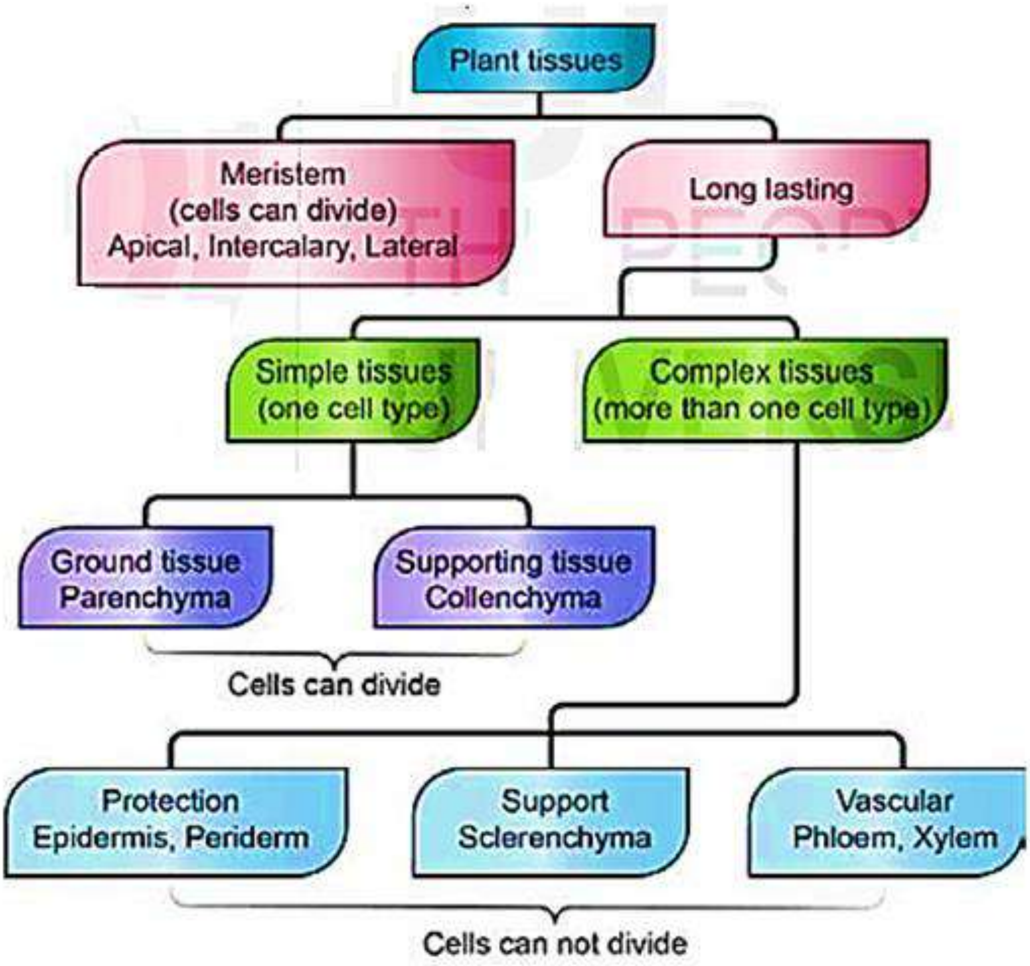
Tissues are classified basically into two types :

- ✓ Simple, Complex

Simple tissues-

- The tissues which consist of similar type of cells are referred as simple tissues. They appear to be homogeneous. These include parenchyma, collenchyma and sclerenchyma.
- Complex tissues- The tissues which consist of more than one type of cells are referred as complex tissues. These include xylem and phloem.
- Based on the stage of development of the plant body, the tissues are also classified into **two types :**

1) Meristematic tissue; and 2) Permanent tissue



68. A diploid female plant and a tetraploid male plant are crossed. The policy of endosperm shall be

(a) tetraploid (b) triploid (c) diploid (d) pentaploid.

69. Which ones produce androgenic haploids in anther cultures?

(a) anther wall (b) tapetal layer of anther wall

(c) connective tissue (d) young pollen grains.

70. Male gametophyte of angiosperms/monocots is

(a) microsporangium (b) nucellus (c) microspore (d) stamen.

71. Female gametophyte of angiosperms is represented by

(a) ovule (b) megaspore mother cell

(c) embryo sac (d) nucellus.

72. Sperm and egg nuclei fuse due to

(a) base pairing of their DNA and RNA

(b) formation of hydrogen bonds

(c) mutual attraction due to differences in electrical charges

(d) attraction of their protoplasts.

73. Entry of pollen tube through micropyle is

(a) chalazogamy (b) mesogamy (c) porogamy (d) pseudogamy

74. Cellular totipotency was demonstrated by

(a) Theodore Schwann (b) A.V. Leeuwenhoek

(c) F.C. Steward (d) Robert Hooke.

75. Pollination occurs in

(a) bryophytes and angiosperms (b) pteridophytes and angiosperms

(c) angiosperms and gymnosperms (d) angiosperms and fungi.

76. Embryo sac occurs in

(a) embryo (b) axis part of embryo

(c) ovule (d) endosperm.

77. Which of the following pair have haploid structures?

(a) nucellus and antipodal cells

(b) antipodal cells and egg cell

(c) antipodal cells and megaspore mother cell

(d) nucellus and primary endosperm nucleus

78. Point out the odd one

(a) nucellus (b) embryo sac (c) micropyle (d) pollen grain

79. Syngamy means

(a) fusion of gametes (b) fusion of cytoplasms

(c) fusion of two similar spores (d) fusion of two dissimilar spores.

80. Double fertilization is fusion of

(a) two eggs

(b) two eggs and polar nuclei with pollen nuclei

(c) one male gamete with egg and other with synergid

(d) one male gamete with egg and other with secondary nucleus.

81. Meiosis is best observed in dividing

(a) cells of apical meristem (b) cells of lateral meristem

(c) microspores and anther wall (d) microsporocytes.

82. A population of genetically identical individuals, obtained from asexual reproduction is

(a) callus (b) clone (c) deme (d) aggregate.

83. Study of formation, growth and development of new individual from an egg is

(a) apomixis (b) embryology (c) embryogeny (d) cytology.

84. Ovule is straight with funiculus, embryo sac, chalaza and micropyle lying on one straight line. It is

(a) orthotropous (b) anatropous (c) campylotropous (d) amphitropous.

85. Double fertilization is characteristic of

(a) angiosperms (b) anatropous (c) gymnosperms (d) bryophytes.

86. Number of meiotic divisions required to produce 200/400 seeds of pea would be

(a) 200/400 (b) 400/800 (c) 300/600 (d) 250/500.

87. Embryo sac represents

(a) megaspore (b) megagametophyte

(c) megasporophyll (d) megagamete.

88. When pollen of a flower is transferred to the stigma of another flower of the same plant, the pollination is referred to as

(a) autogamy (b) geitonogamy (c) xenogamy (d) allogamy.

89. The polyembryony commonly occurs in

(a) tomato (b) potato (c) Citrus (d) turmeric.

90. In an angiosperm, how many microspore mother cells are required to produce 100 pollen grains?

(a) 75 (b) 100 (c) 25 (d) 50.

91. The anthesis is a phenomenon, which refers to

(a) development of anthers (b) opening of flower bud

(c) stigma receptors (d) all of these.

92. If there are 4 cells in anthers, what will be the number of pollen grains?

(a) 16 (b) 12 (c) 8 (d) 4.

93. The role of double fertilization in angiosperms is to produce

(a) cotyledons (b) endocarp (c) endosperm (d) hormones.

94. If an angiospermic male plant is diploid and female plant tetraploid, the policy level of endosperm will be

(a) tetraploid (b) pentaploid (c) haploid (d) triploid.

95. The embryo in sunflower has

(a) two cotyledons (b) many cotyledons

(c) no cotyledon (d) one cotyledon.

96.. An interesting modification of flower shape for insect pollination occurs in some orchids in which a male insect mistakes the pattern on the orchid flower for the female species anr1 tries to copulate with it, thereby pollinating the flower. This phenomenon is called

(a) pseudopollination (b) pseudoparthenocarpy

(c) mimicry (d) pseudocopulation.

97. Type of placentation in which ovary is syncarpous unilocular and ovules are on sutures is called

(a) marginal placentation (b) superficial placentation

(c) apical placentation (d) parietal placentation.

98. The endosperm of gymnosperm is

(a) diploid (b) polyploid (c) triploid (d) haploid.

99. Eight nucleated embryo sac is

(a) only monosporic (b) only bisporic

(c) only tetrasporic (d) any of these formed during the double

100. Endosperm is fertilization by

(a) two polar nuclei and one male gamete

(b) one polar nuclei and one male gamete

(c) ovum and male gamete

(d) two polar nuclei and two male gametes.

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UNIT-6

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UG TRB BOTANY – 2023-24

UNIT – VI – MICRO BIOLOGY & PLANT PAHOLOGY

1. INTRODUCTION ABOUT MICROBIOLOGY

Define Microbiology

- The word microbiology is derived from the Greek "micron" (meaning small) and "biologia" {meaning study of). Thus. *'Microbiology'* is the study of very small living organisms that can be viewed only with a microscope.
- Basically, the limit of resolution with the unaided human eye is about 200 urn, whereas most of the microorganisms have much smaller dimensions and thus, can be visualised only with microscopes having magnifications of about 400x-l500x.
- Microbes are the part of our lives in more most understood. Microbes are present in the both natural and man-made worlds. Every microbe has special qualities which enable it to survive in such unique places as the soil, oceans, hot springs, the human intestine, root of plants and even oil wells.

1.1. HISTORY OF MICROBIOLOGY

1.1.1. Discovery of Microorganisms

1. Hooke (1665-1678)

- He first described “cellulae” (small rooms) in cork in 1665. His discovery led to the formulation of the cell theory, which states that cells are the basic organizational unit of all living things. He was also the first to publish a description of a microorganism (it was a fungus). Many texts have given this distinction to Leeuwenhoeck.

2. Anton Van Leeuwenhoek (1673)

- The discovery of microbiology is usually credited to a Dutch naturalist by the name of Anton Van Leeuwenhoek. He is sometimes referred to as the "father of Microbiology". Van Leeuwenhoek ground fine glass lenses (which could magnify objects about 266 times) and observed living microorganisms (which he called "animacules") from a variety of environments. His investigations were apparently made around 1674 but he was rather secretive about his work and did not explain exactly how he made his lenses or his observations.
- Van Leeuwenhoek's observations may not have been the first, but they were significant because he made numerous drawings and wrote accurate descriptions of what he saw. He documented his findings. For several years, starting about 1684, he sent correspondence to the British Royal Society or Royal Society of London, and thereby aroused considerable interest in microbiology.

1.1.2. Spontaneous Generation

- Van Leeuwenhoek's discoveries did much to revitalize arguments between scientists, philosophers and theologians about the origin of life. It was, at one time, generally accepted that living organisms arose spontaneously from non-living material. This belief, sometimes called the theory of abiogenesis or spontaneous generation (a=without, bio=life, genesis=origins or beginnings) was taught by Aristotlearound 346 BC. He believed that life could and did appear spontaneously from non-living and/or decomposing materials. For example, he wrote that snakes and frogs came from the mud along river banks, that insects came from dew, that flies arose from decaying meat and that rats sprang from refuse heaps. These, like many other beliefs of the Greek scholars, were maintained until relatively recent times.

1. Francisco Reddi (1668)

- Around 1665 the Italian naturalist and physician Francesco Redi demonstrated that spontaneous generation did not occur at a macroscopic levelusing flies. Redi placed raw meat into containers and covered some with gauze and some with paper. Other containers were left open. He found that the meat within the covered containers did not develop flies, but that flies did lay eggs on the gauze and on the paper. The exposed meat developed maggots, but he reasoned that these came from the eggs of flies, not from the meat itself. Regardless of Redi's proof, people still clung to their belief in abiogenesis, and Van Leeuwenhoek's discoveries seemed to support this theory. The first scientist who successfully attempted to disprove this theory is Francisco Reddi.

2. Needham (1745) Vs. Spallanzani (1765) on Spontaneous Generation

- In 1749, John Needham, a Catholic priest, conducted experiments with mutton broth in flasks. He boiled the broth and stoppered the flasks with cork, but later found the broth to be teaming with microorganisms. Needham believed there was a "vital force" present within the broth, and that life had arisen spontaneously.
- In the late 1700's, Lazzaro Spallanzani tried to disprove this by performing a controlled experiment with broth: He put broth into two flasks (glass containers) and sterilized them both by boiling the broth. One of the flasks was left open to the air. The other flask was sealed up to keep out any organisms that might be floating in the air. Microorganisms developed only in the uncovered flask (Figure-1).
- From this, Spallanzani concluded that the microorganisms did not come from the broth, but were in the air that entered the flask. Therefore, not even microorganisms came from nonliving things. Unfortunately, many scientists were not convinced by his experiment. They believed that air needed to enter the flask in order for life to be created from nonliving materials.

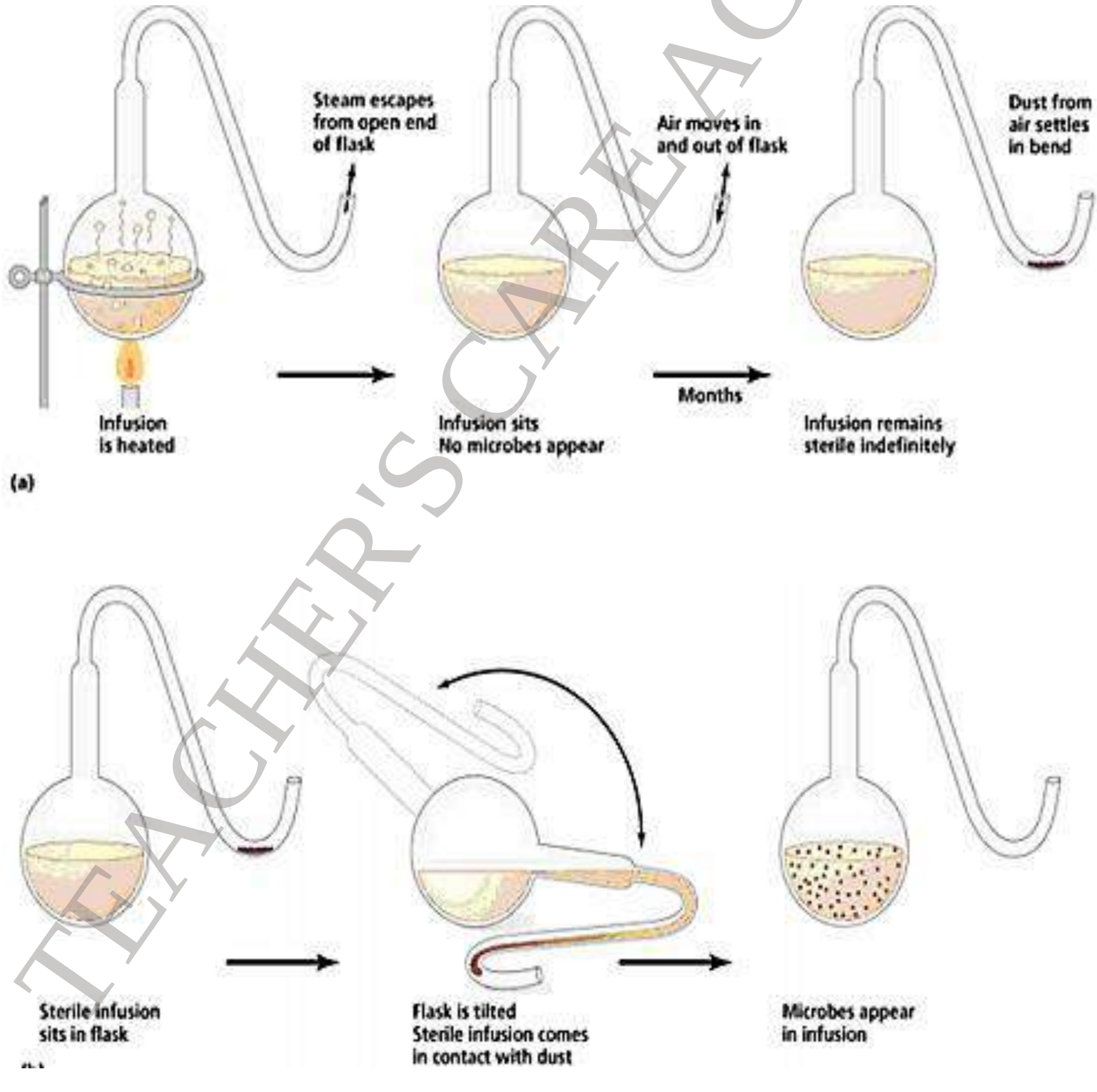
3. Theodore Schwann (1810–1882)

- During the 1830s, Theodor Schwann and Franz Schultz (both German scientists) conducted experiments to disprove abiogenesis. They allowed boiled broth to come into contact with air that was either heated or passed through solutions of toxic chemicals. No microscopic organisms grew in their broth.
- Again the "vitalists", those in favor of spontaneous generation, discredited this work because they said the severe treatment of the air had rendered it inactive. About this same time, another controversy had developed over the cause of fermentation. Biologically inclined investigators (including Schwann) proposed that the products of fermentation, ethanol and carbon dioxide, were made by microscopic life forms. This idea was opposed by the leading chemists of the time who believed that fermentation was strictly a chemical reaction brought about by chemical entities they called ferments.

4. Louis Pasteur (1822 - 1895)

- In 1859 one of the father of modern microbiology Louis Pasteur decided to settle the question of spontaneous generation once and for all. Pasteur first filtered air through cotton and found that objects resembling plant spores had been trapped.
- If a piece of the cotton was placed in sterile medium after air had been filtered through it, microbial growth appeared. Next he boiled meat broth in swan neck flasks and then drew out & curved the neck of the flask in a flame.

- No microbes developed in the flask. When he tilted the flask so some broth flowed into the curved neck and then tilted it back so the broth was returned to the base of the flask, microbes grew.
- He reasoned that the microbes in the air that could contaminate the sterile broth would be trapped on the sides of the thin glass necks before they reached the sterile broth. Pasteur had not only resolved the controversy by 1861 but also had shown how to keep solutions sterile. Fortunately, Pasteur's broths contained no endospore forming bacteria, since endospores are resistant to boiling and had they been present, would have grown.
- Though Pasteur's work was not universally accepted, he had many supporters, it is important to note that few scientific experiments are this straight-forward.



Additional Contribution

- He was able to demonstrate that organisms such as bacteria were responsible for souring wine and beer (he later extended his studies to prove that milk was the same), and that the bacteria could be removed by boiling and then cooling the liquid. This process is now called pasteurisation.
- He invented the process of heating wine to destroy bacteria that would otherwise turn the wine sour (a process now called pasteurization), which saved the wine industry. Pasteur also used this method to preserve milk, beer, and food, keeping it from becoming spoiled.
- In the 1860s, a disease called pebrine was killing large numbers of silkworms and threatening to destroy the French silk making industry. Pasteur discovered that microbes were killing the silkworms, and that eliminating the microbes would wipe out the disease.
- Pasteur also demonstrated that by weakening disease germs in a lab, then injecting the weakened germs into an animal (or person), the animal developed immunity to the disease rather than dying of the disease. This process is called vaccination.
- Pasteur developed an anthrax vaccine and he was also the first scientist to invent a successful treatment for rabies, a nearly always fatal disease. Pasteur had isolated the bacteria responsible for causing chicken cholera (organisms similar to the Vibrio cholerae causing cholera in humans).
- Pasteur introduced the terms aerobic and anaerobic in describing the growth of yeast at the expense of sugar in the presence or absence of oxygen.
- He observed that more alcohol was produced in the absence of oxygen when sugar is fermented, which is now termed the Pasteur's effect.

5. John Tyndall (1820–1893)

- The English physicist John Tyndall dealt a final blow to spontaneous generation in 1877 by set up an elaborate box containing only clean (filtered) air, and showed that broths exposed to this clean air did not grow microorganisms. Tyndall also discovered that some microorganisms were very resistant to being killed by boiling, i.e., those that produced heat resistant endospores. Tyndall found that by alternately boiling and cooling his broths over a period of three days he could eliminate the spore-forming organisms. This process is called tyndallization.

1.1.3. Role of Microorganisms in Disease

1. Girolamo Fracastoro, **(1546)** an Italian physician, recorded his belief that disease was due to organisms too small to be seen with the naked eye.

2. Agostino Bassi (1773–1856) first showed a microorganism could cause disease when he demonstrated in 1835 that a silkworm disease was due to a fungal infection. He also suggested that many diseases were due to microbial infections.

3. M. J. Berkeley (1845) proved that the great Potato Blight of Ireland was caused by a fungus.

4. Jenner (1798) Observed that dairymaids that contracted a mild infection of cowpox seemed to be immune to smallpox; he inoculated a boy with fluid from a cow pox blister and he contracted cowpox; he then inoculated him with fluid from a smallpox blister; the boy did not contract smallpox; the term vaccination came from vacca for cow; the ancient Chinese would grind up scabs from someone recovering from smallpox (the scabs contained weakened viruses); they would sniff the powder and come down with a mild form of the disease; this would protect them from getting it again.

5. Lister (Father of antiseptic surgery) (1827–1912)

English surgeon Joseph Lister (1827–1912) developed a system of antiseptic surgery designed to prevent microorganisms from entering wounds.

Instruments were heat sterilized, and phenol was used on surgical dressings and at times sprayed over the surgical area. It also provided strong indirect evidence for the role of microorganisms in disease because phenol, which killed bacteria, also prevented wound infections.

6. D. Robert Koch - The Germ Theory of Disease (1843–1910)

Germ theory of disease - microbes (germs) cause disease and specific microbes cause specific diseases (one organism, one disease.)

He studied anthrax - disease of cattle/sheep; also, in humans. He observed that the same microbes were present in all blood samples of animals with anthrax; he isolated and cultivated these microbes; he then injected a healthy animal with the cultured bacteria and that animal became infected with anthrax and its blood sample showed the same microbes as the originally infected animals.

Koch's 4 Postulates

1. The causative agent must be present in every individual with the disease.
2. The causative agent must be isolated & grown in pure culture.

3. The pure culture must cause the disease when inoculated into an experimental animal.

4. The causative agent must be reisolated from the experimental animal and re identified in pure culture.

7. Richard J. Petri - developed the Petri dish in which microbial cultures could be grown and manipulated.

8. Fanny Hesse Initial attempts to isolate microbes used sliced potatoes or nutrient media containing gelatin - not ideal media. Then Fannie Hesse (wife of lab worker) suggested agar, a gelling agent used in cooking. Agar rapidly became the standard gelling agent for microbial isolation because it is relatively inert (only some marine microbes have enzymes to digest agar). Agar only melts at high temperatures (100oC); once melted, it remains liquid until about 45oC, at which point it gels.

1.1.4. "Golden Age of Microbiology" (~ 1870-1920)

- Koch's success at identifying anthrax with bacterium Bacillus anthracis led both Koch and Pasteur to identify the causes of many diseases - cholera, tuberculosis, plague, etc. — over the next few decades (late 1880's) - the "Golden Age of Microbiology" (~ 1870-1920). Note that many microbiologists would regard the present as a new "Golden Age", since the development of molecular biological techniques, PCR, molecular phylogeny, and other developments have revealed many new insights and opened a world of new research directions and ways of understanding microbes.

1. Hans Christian Gram (1853-1938) introduced a differential staining method for bacteria.

2. Roux and Yersin (1888) discovered diphtheria toxin and later Kitasato and Von Behring discovered tetanus antitoxin.

3. Ziehl and Neelsen (1892) developed a method of staining Mycobacterium tuberculosis.

4. Edmund E. Nocard (1850-1903) a French Veterinarian and mycologist discovered many pathogenic fungi.

5. Paul Ehrlich (father of chemotherapy) (1890)- A German physician by the name of Paul Ehrlich searched for a "magic bullet", and in around 1910 developed the first effective cure for a bacterial disease. The drug he developed was called salvarsan, and was an arsenic compound that was effective against syphilis.

He developed the guiding principle of chemotherapy, which is selective toxicity (the drug should be toxic to the infecting microbe, but relatively harmless to the host); the first major class of drugs to come into widespread clinical use - sulfa drugs (still used today). He (1896) introduced methods of standardizing toxins and antitoxins.

6. Theobald Smith (1898) differentiated the human and bovine forms of Mycobacterium tuberculosis.

7. Karl Landsteiner (1901) discovered the basic human blood groups.

8. Twort and d'Herelle (1915-1017) discovered bacteriophage.

9. Alice Woodruff (1931) grew a virus for the first time in a fertile egg.

10. Alexander Fleming (1928) discovered penicillin; Waksman, Streptomycin in 1943; Burkholder and colleagues, Chloramphenicol (chloromycetin) in 1947;

Duggar and associates, Chlortetracycline in 1948; and Finlay and associates, Oxytetracycline in 1950.

11. Albert Coons (1941) developed the Fluorescent-Antibody technique.

12. Sarah Stewart (1953) carried out research on tumors in animals induced by viruses.

13. Salk (1953) tested an inactivated vaccine for poliomyelitis.

14. Sabin (1956) developed a live (oral) virus vaccine against poliomyelitis.

1.1.5. Microbes are Important Agents of Environmental Change

1. Martinus Beijerinck (1851-1931)

- Martinus Beijerinck was one of the great general microbiologists who made fundamental contributions to microbial ecology and many other fields.He developed enrichment culture technique, a way to isolate microbes with certain growth preferences.
- He isolated the aerobic nitrogen fixing bacterium Azotobacter; a root nodule bacterium also capable of fixing nitrogen (later named Rhizobium); and sulfate reducing bacteria.

2. Sergei Winogradsky (1856-1953)

- **The Russian microbiologist Sergei N. Winogradsky made many contributions to soil microbiology.**
- He extended awareness of microbial diversity. He discovered bacteria capable of autotrophic ("self-feeding") growth using inorganic compounds such as H2S

as their only energy source, and CO_2 as their only C-source. He discovered that soil bacteria could oxidize iron, sulfur, and ammonia to obtain energy, and that many bacteria could incorporate CO_2 into organic matter much like photosynthetic organisms do.

- Winogradsky also isolated anaerobic nitrogen-fixing soil bacteria and studied the decomposition of cellulose and also discovered groups of photosynthetic bacteria that do not produce oxygen as their waste product.
- Developed culture technique known as Winogradsky column, in which mud and water are left in glass tube exposed to light. Over time, different microbial communities grow and interchange waste products and nutrients.

1.1.6. Some of the prominent scientists who were awarded the Nobel Prize for their contributions in Microbiology

- 1905- Robert Koch (Germany), for work on tuberculosis.
- 1908- Paul Ehrlich (Germany), and Elie Metchnikoff (USSR), for work in immunity.
- 1930- Karl Landsteiner (US) for discovery of blood groups.
- 1945- Sir Alexander Fleming, Ernst Boris Chain and Sir Howard Florey (England), for the discovery of penicillin.
- 1952- Selman A. Waksman (US) for the co-discovery of streptomycin.
- 1954- John F. Enders, Thomas H. Weller and Frederick C. Robbins (US) for work with cultivation of polio virus in vitro.
- 1958- Joshua Lederberg (US), for the work on genetic mechanisms; George W. Beedle and Edward L. Tatum (US) for discovering how genes transmit hereditary characteristics.
- 1960- Sir MacFarlane Burnet (Australia) and Peter Brian Medawar (England), for discovery of acquired immunological tolerance.
- 1962- James D. Watson (US), Maurice H. F. Williams and Francis H. C. Crick (England), for determining structure of deoxyribonucleic acid.
- 1966- Francis Peyton Ross - discovery of a tumor-inducing virus in chickens.
- 1972- Gerald Edelman and Rodney Porter - determination of an antibody’s chemical structure.
- 1975- David Baltimore, Howard M. Temin and Renaio Dulbecco (all US), for work in interaction between tumor viruses and genetic material of the cell.

- 1976- Baruch S. Blumberg and D. Carleton Gajdusek (US), for discoveries concerning new mechanisms for the origin and dissemination of infectious diseases.
- 1980- Baruj Benacerraf, George Snell (US) and Jean Dausset (France) for discoveries in establishing a genetic basis for acquired immune responses.

1. What is Microbiology?

(A) Study of molecules that are visible to human eyes

(B) Study of animals and their family

(C) Study of organisms that are not visible to naked eyes

(D) Study of microscope

2. Who is known as the father of Microbiology?

(A) Edwin John Butler (B) Ferdinand Cohn

(C) Robert Koch (D) Antoni van Leeuwenhoek

3. Which microorganism(s) among the following perform photosynthesis by utilizing light?

(A) Cyanobacteria, Fungi and Viruses

(B) Viruses

(C) Cyanobacteria

(D) Fungi

4. Which part of the compound microscope helps in gathering and focusing light rays on the specimen to be viewed?

(A) Condenser lens (B) Magnifying lens

(C) Objective lens (D) Eyepiece lens

5. Which of the following are produced by microorganisms?

(A) Alcoholic beverages (B) Fermented dairy products

(C) Breads (D) All of the mentioned

6. What is the approximate size of the bacterial cell?

(A) 1mm in diameter (B) 0.5 to 1.0 micrometer in diameter

(C) 2mm in diameter D) 2 micrometer in diameter

1.2. SCOPE OF MICROBIOLOGY:

- Microorganisms are present everywhere on earth which includes humans, animals, plants and other living creatures, soil, water and atmosphere.
- Microbes can multiply in all three habitats except in the atmosphere.
- Together their numbers far exceed all other living cells on this planet.
- Microorganisms are relevant to all of us in a multitude of ways.
- The influence of microorganism in human life is both beneficial as well as detrimental also.
- For example, microorganisms are required for the production of bread, cheese, yogurt, alcohol, wine, beer, antibiotics (e.g. penicillin, streptomycin, chloromycetin), vaccines, vitamins, enzymes and many more important products.
- Microorganisms are indispensable components of our ecosystem.
- Microorganisms play an important role in the recycling of organic and inorganic material through their roles in the C, N and S cycles, thus playing an important part in the maintenance of the stability of the biosphere.
- There is vast scope in the field of microbiology due to the advancement in the field of science and technology.
- The scope in this field is immense due to the involvement of microbiology in many fields like medicine, pharmacy, diary, industry, clinical research, water industry, agriculture, chemical technology and nanotechnology.
- Microorganisms also have harmed humans and disrupted societies over the millennia.
- Many microbes spoil food and deteriorate materials like iron pipes, glass lenses, computer chips, jet fuel, paints, concrete, metal, plastic, paper and wood pilings.
- The study of microbiology contributes greatly to the understanding of life thro ugh enhancements and intervention of microorganisms.

Role and Application of Microbiology in Different Fields

Microbial physiology and Biochemistry	Study the synthesis of antibiotics and toxins, microbial energy production, microbial nitrogen fixation, effects of chemical and physical agents on microbial growth and survival etc.

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UNIT - VII

PLANT PHYSIOLOGY, BIOCHEMISTRY, BIOPHYSICS

INDEX

1. WATER RELATION OF PLANTS

- The interactions between plants and water, including hydration of plant cells and water transport within a plant is termed as plant Water Relation.Water potential is a term used to define the amount of water in the soil, plant and atmosphere.
- Imbibition is a phenomenon of adsorption of water or any other liquid by the solid particles of a substance without forming a solution. Imbibition is an exceptional type of diffusion, which occurs when water is absorbed by solids-colloids causing an increase in volume.
- The solid particles which imbibe water or any other liquid are called **imbibants,** and the liquid which is imbibed is known as **imbibate.**

1.1 IMBIBITION CHARACTERISTICS

Following are the characteristics of imbibition:

1. It is a particular type of diffusion in which water is absorbed by a substance's solid particles (or colloids), resulting in an enormous increase in volume. E.g., if a dry piece of wood is placed in water, it swells up and increases in volume.

2. During imbibition, the water molecules get tightly adsorbed and become immobilised.

3. The absorbed water molecules lose most of their kinetic energy in the form of heat during imbibition, which is called **heat of wetting (or heat of hydration).**

4. The water potential or matric potential of imbibants is negative because water has maximum water potential, i.e., zero (0).(0).

5. Steep water potential is created when a dry imbibants comes in contact with the water.

6. The imbibants hold the imbibate by an attractive force called adsorption.

7. The swelling imbibants develop a pressure called imbibants pressure. This is also called imbibitional pressure.

Fig: The Process of Imbibition

8. The imbibate is held between and over the surface of particles of the imbibant through a process of adsorption and capillarity.

1.1.1 Conditions Required for Imbibition

Following are the conditions necessary for imbibition:

1. A potential water gradient should occur between the imbibing (like a wooden piece) and the liquid being imbibed (e.g., water).

2. There should be some forces of attraction (or affinity) between imbibants and imbibed liquid for imbibition to occur.

3. Adsorption is the property of colloids, and hence the materials which have a high proportion of colloids are good imbibants, and for this reason, only wood is considered to be a good imbibants because it contains protein, cellulose and starch as colloidal substances.

1.1.2 Factors Affecting Imbibition

Following are the factors affecting imbibition:

1. Texture of imbibants: Looseness of imbibant shows more imbibition while compactness less. More colloidal material imbibes easily. For this reason, wood, which contains lignin, cellulose, etc., is a very good imbibant.

2. Temperature: Imbibition increases with the temperature rise. With the temperature rise, liquid viscosity generally decreases, so imbibition, inversely related to viscosity, increases.

3. Pressure: Imbibition decreases with the rise in pressure. If the imbibing substance is kept in a confined place, pressure develops due to increased volume.

4. pH of the medium: Imbibition either decreases or increases depending on the charge of the imbibant.

5. The affinity of the imbibant for the imbibant.

1.1.3 Imbibition in Plants

1. Imbibition in plant cells refers to the adsorption of water by hydrophilic-protoplasmic and cell wall constituents.

2. Imbibition causes swelling of seeds that results in the breaking of the seed coat or testa.

3. Imbibition forms the initial step in seed germination.

4. Imbibition helps in the movement of water into the ovules, which are ripening into seeds.

5. Imbibition is needed in the initial phases of water absorption by the roots.

1.1.4 Imbibition Pressure or Matric Potential

Imbibition pressure is the pressure developed by an imbibant when submerged in a pure imbibing liquid. It is also known as matrix potential (ψm).(�m). When water is in contact with solid or colloidal particles, adhesive intermolecular forces between the water and the solid is the matric potential (= matrix potential). Due to this pressure in plants, seedlings emerge out of the soil and establish themselves. This pressure can be of tremendous magnitude.

1.1.5 Imbibition Importance in Plant Life

❖ It is believed that imbibition plays an important role in plant physiology, apart from seed germination. Sachs proposed the imbibitional theory in 1878.1878.. According to this theory, the upward movement of water (i.e., the ascent of sap) in the stem is due to the force of imbibition. But this theory was rejected because it is evident that a large quantity of water moves through the lumen of xylem vessels, which can be checked by artificially blocking the lumen with gelatin or oil (the plant will show wilting).

1.1.6 Significance of Imbibition

Following are the significance of imbibition:

1. Imbibition plays an important role in the absorption and retention of water.

2. The absorption of water by young cells is mostly through imbibition. The germinating seeds absorb water through imbibition.

3. Breaking the seed coat in germinating seeds is due to greater imbibitional swelling of the seed kernel (starch and protein) compared to seed coverings (cellulose).

4. Seedling can come out of the soil due to the development of imbibition pressure.

5. Jamming of the wooden frames during rainy seasons is caused by swelling of wood due to imbibition.

6. Fruits of many plants develop matric potential in addition to their osmotic potential to maintain the inflow of water even under water scarcity conditions.

7. Imbibition is dominant in the initial stage of water absorption by the roots.

1. Imbibition is commonly seen in _____

A) liquids B) gases C) suspension D) colloids

2. Imbibition is a

A Property of solvent | B Capillary phenomenon

C Protoplasmic phenomenon | D Property of solutes

3. A bottle filled with previously moistened mustard seeds and water was screw-capped tightly and placed in a corner. After 30 minutes, it suddenly blew up. This is the process involved

(A) DPD (B) Osmosis (C) Imbibition (D) Diffusion

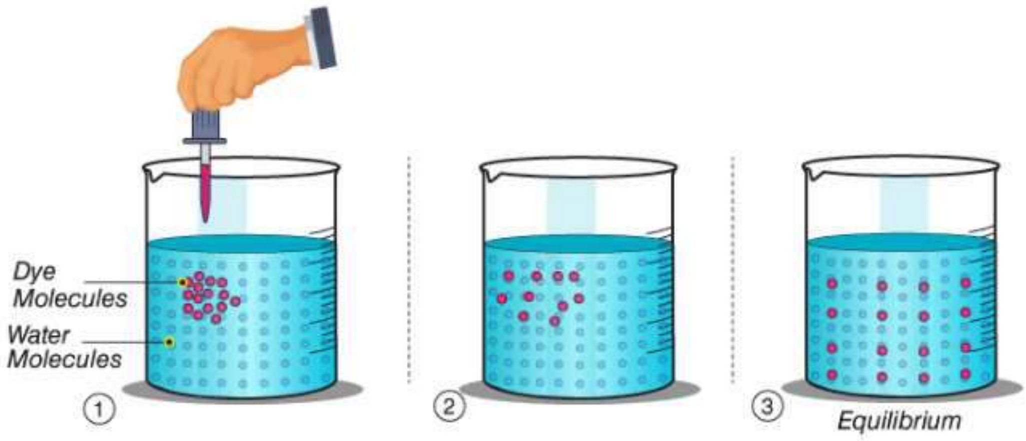
1.2 DIFFUSION

"Diffusion is the movement of molecules from a region of higher concentration to a region of lower concentration down the concentration gradient."

❖ Read on to explore what is diffusion and the different types of diffusion.

❖ Diffusion is the process of movement of molecules under a concentration gradient. It is an important process occurring in all living beings. Diffusion helps in the movement of substances in and out of the cells. The molecules move from a region of higher concentration to a region of lower concentration until the concentration becomes equal throughout.

❖ Liquid and gases undergo diffusion as the molecules are able to move randomly.



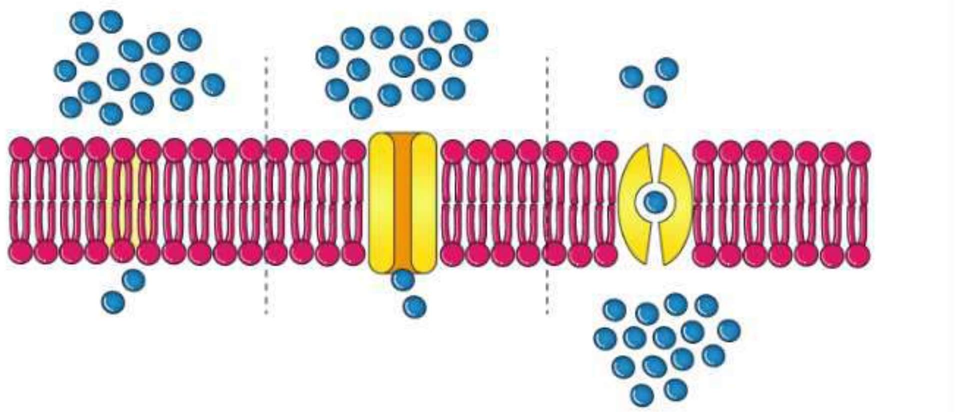
1.2.1 Types of Diffusion

❖ Diffusion is widely used in various fields such as biology, physics, chemistry, etc. Diffusion can be classified into two main types: Simple diffusion and facilitated diffusion.

1.2.2 Simple diffusion

- ❖ A process in which the substance moves through a semipermeable membrane or in a solution without any help from transport proteins. For example, bacteria deliver small nutrients, water and oxygen into the cytoplasm through simple diffusion.

1.2.3 Facilitated diffusion



- ❖ Facilitated diffusion is a passive movement of molecules across the cell membrane from the region of higher concentration to the region of lower concentration by means of a carrier molecule.

1.2.4 Dialysis: It is the diffusion of solutes across a selectively permeable membrane. A selectively permeable membrane is one that allows only specific ions and molecules to pass through, while it obstructs the movement of others.

1.2.5 Osmosis: It is the movement of solvent molecules from the region of lower concentration to the region of higher concentration through a semipermeable membrane. Since water is solvent in every living being, biologists define osmosis as the diffusion of water across a selectively permeable membrane. For example, plants take water and minerals from roots with the help of osmosis.

1.2.6 Factors affecting Diffusion

There are a few factors that affect the process of diffusion, which individually and collectively alters the rate and extent of diffusion. These factors include:

- ❖ Temperature.
- ❖ Area of Interaction.
- ❖ Size of the Particle.
- ❖ The steepness of the concentration gradient.

1.2.7 Examples of Diffusion

- A tea bag immersed in a cup of hot water will diffuse into the water and change its colour.
- A spray of perfume or room freshener will get diffused into the air by which we can sense the odour.
- Sugar gets dissolved evenly and sweetens the water without having to stir it.
- As we light the incense stick, its smoke gets diffused into the air and spreads throughout the room.
- By adding boiling water to the dried noodles, the water diffuses causing rehydration and making dried noodles plumper and saturated.

1.2.8 Causes of Diffusion

- Diffusion is a natural and physical process, which happens on its own, without stirring or shaking the solutions. Liquid and gases undergo diffusion as the molecules are able to move randomly. The molecules collide with each other and change their direction.

1.2.9 Significance of Diffusion

- Diffusion is an important process, which is involved in the different life processes. As mentioned above, it is the net movement of particles, ions, molecules, solution, etc. In all living species, diffusion plays an important role in the movement of the molecules during the metabolic process in the cells.

1.2.10 Diffusion is important for the following reasons:

- During the process of respiration, this process helps in diffusing the carbon dioxide gas out through the cell membrane into the blood.
- Diffusion also occurs in plant cells. In all green plants, water present in the soil diffuses into plants through their root hair cells.
- The movement of ions across the neurons that generates electrical charge is due to diffusion.

1. Phenomena through which water is absorbed by solids such as colloids leading them to increase in volume is

(A) diffusion (B) imbibition (C) facilitated diffusion (D) osmosis

2. In older dying leaves to younger leaves, the mineral ions are assimilated into

(A) deposition of organic and inorganic compound (B) organic compound

(C) inorganic compounds (D) none of these

3. Passage of water across a selectively permeable membrane is

(A) osmosis (B) active transport

(C) facilitated diffusion (D) pinocytosis

4. Wall pressure will______________ with rise in turgidity

(A) increase (B) decrease (C) remain unaffected (D) fluctuate

5. Most effective light for stomatal opening is

(A) Red (B) Blue (C) Green (D) Yellow

6. Diffusion of water through selectively permeable membrane is

(A) osmosis (B) imbibition (C) translocation (D) diffusion

1.3 OSMOSIS

"Osmosis is a process by which the molecules of a solvent pass from a solution of low concentration to a solution of high concentration through a semi-permeable membrane."

- Osmosis is a passive process and happens without any expenditure of energy. It involves the movement of molecules from a region of higher concentration to lower concentration until the concentrations become equal on either side of the membrane.
- Any solvent can undergo the process of osmosis including gases and supercritical liquids.

1.3.1 Osmotic Solutions

There are three different types of solutions:

- Isotonic Solution
- Hypertonic Solution
- Hypotonic Solution

An **isotonic solution** is one that has the same concentration of solutes both inside and outside the cell.

A **hypertonic solution** is one that has a higher solute concentration outside the cell than inside.

A **hypotonic solution** is one that has a higher solute concentration inside the cell than outside.

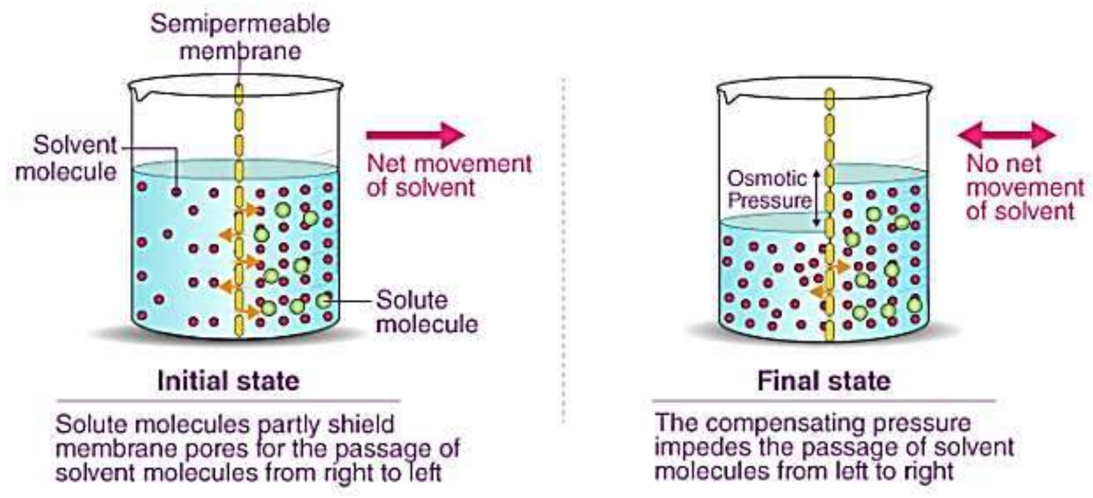
1.3.2 Types of Osmosis

Osmosis is of two types:

- **Endosmosis**– When a substance is placed in a hypotonic solution, the solvent molecules move inside the cell and the cell becomes turgid or undergoes deplasmolysis. This is known as endosmosis.
- **Exosmosis**– When a substance is placed in a hypertonic solution, the solvent molecules move outside the cell and the cell becomes flaccid or undergoes plasmolysis. This is known as exosmosis.

1.3.3 Effect of Osmosis on Cells

- Osmosis affects the cells differently. An animal cell will lyse when placed in a hypotonic solution compared to a plant cell. The plant cell has thick walls and requires more water. The cells will not burst when placed in a hypotonic solution. In fact, a hypotonic solution is ideal for a plant cell.
- An animal cell survives only in an isotonic solution. In an isotonic solution, the plant cells are no longer turgid and the leaves of the plant droop.
- The osmotic flow can be stopped or reversed, also called reverse osmosis, by exerting an external pressure to the sides of the solute. The minimum pressure required to stop the solvent transfer is called the osmotic pressure.



- Osmotic pressure is the pressure required to stop water from diffusing through a membrane by osmosis. It is determined by the concentration of the solute. Water diffuses into the area of higher concentration from the area of lower concentration. When the concentration of the substances in the two areas in contact is different, the substances will diffuse until the concentration is uniform throughout.
- Osmotic pressure can be calculated using the equation:
  $\Pi = MRT$
  where Π denotes the osmotic pressure,
  M is the molar concentration of the solute,
  R is the gas constant,
  T is the temperature

1.3.4 Significance of Osmosis

- Osmosis influences the transport of nutrients and the release of metabolic waste products.
- It is responsible for the absorption of water from the soil and conducting it to the upper parts of the plant through the xylem.
- It stabilizes the internal environment of a living organism by maintaining the balance between water and intercellular fluid levels.
- It maintains the turgidity of cells.
- It is a process by which plants maintain their water content despite the constant water loss due to transpiration.
- This process controls the cell to cell diffusion of water.
- Osmosis induces cell turgor which regulates the movement of plants and plant parts.
- Osmosis also controls the dehiscence of fruits and sporangia.
- Higher osmotic pressure protects the plants against drought injury.

1) ………Provides the primary by which water gets transported into and out of the cells.

A) Osmosis B) Fermentation C) Budding D) Transmembrane

2) Osmosis is a special kind of ……………

A) Regulation B) Absorption C) Diffusion D) Adsorption

3) Which of the following solution contains a low concentration of solute relative to another solution?

A) Hypertonic B) Isotonic C) Deurotonic D) Hypotonic

4) The plant cell absorbs ……………… by osmosis.

A) Water B) Sulphur C) Phosphorous D) Carbon

5) In the osmosis, osmotic potential of the cell is known as …………………

A) Cytotic potential B) Water potential

C) Animated potential D) Generic potential

6) In the plant cell, cell wall exerts an inward pressure when the cell is …………… And it is called as pressure potential.

A) Round B) Square C) Turgid D) Rectangle

1.4 PLASMOLYSIS

- Plasmolysis is defined as the process of contraction or shrinkage of the protoplasm of a plant cell and is caused due to the loss of water in the cell. Plasmolysis is an example of the results of osmosis and rarely occurs in nature.
- The word Plasmolysis was generally derived from a Latin and Greek word plasma – The mould and lusis meaning loosening.

1.4.1 Stages of Plasmolysis

The complete process of Plasmolysis take place in three different stages:

1. Incipient plasmolysis: It is the initial stage of the plasmolysis, during which, water starts flowing out of the cell; initially, the cell shrinks in volume and cell wall become detectable.

2. Evident plasmolysis: It is the next stage of the plasmolysis, during which, the cell wall has reached its limit of contraction and cytoplasm gets detached from the cell wall attaining the spherical shape.

3. Final plasmolysis: It is the third and the final stage of the plasmolysis, during which the cytoplasm will be completely free from the cell wall and remains in the centre of the cell.

1.4.2 Water Pass through the Cell Membranes

- During the process of Plasmolysis within the plant cell, the cell membrane separates the interiors of the cell from the surrounding.
- It allows the movement of water molecules, ion and other selective particles across the membrane and stops others. Water molecules travel in and out of the cell

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BOTANY - UNIT - VIII

CYTOLOGY, GENETICS, PLANTBREEDING, HORTICUTURE

INDEX

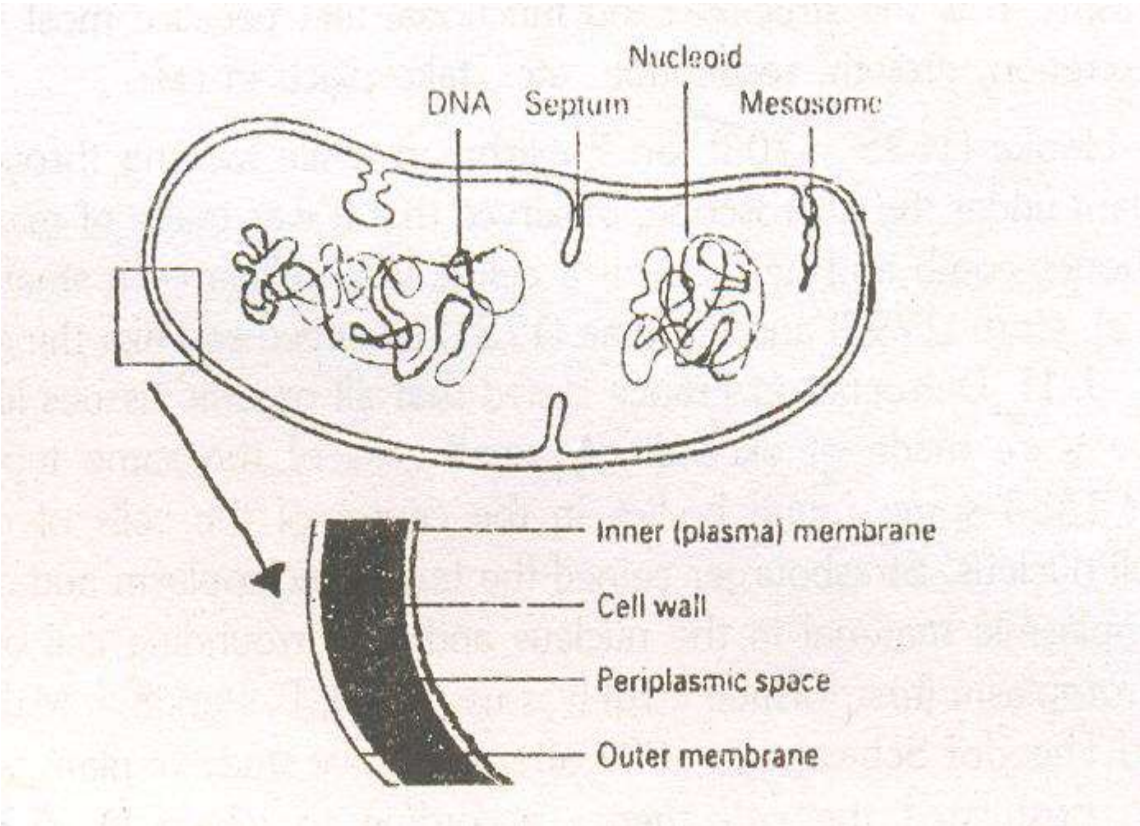
1.CYTOLOGY

1.1 CELL ORGANIZATION

- Cells are the basic unit of life. In the modern world, they are the smallest known world that performs all of life's functions. All living organisms are either single cells, or are multicellular organisms composed of many cells working together.
- Any cellular organism may contain only one type of cell from the following types of cells.
  - **Prokaryotic cells**
  - **Eukaryotic cells**

The terms prokaryotic and eukaryotic were suggested by Hans Ris in the 1960's.

1.1.1 PROKARYOTIC CELLS



- In prokaryotic cells, in the absence of a nuclear envelope, the nuclear material is in direct contact with the cytoplasm. As an example, the structure of the colon bacterium, Escherichia coli can be considered.

Structure of Prokaryotic Cells

Eischerichia coli can be easily cultured in a medium containing glucose solution and some minerals. In this medium, the number of individuals doubles within 60 minutes at 370C. If aminoacids, purines and primidines are added, the generation time can be reduced to only 20 minutes.

- A cell of E. coli is about 2m in length and 0.8m inthickness. A cell wall about 10nm in thickness surrounds the cell. It is made up of protein, polysaccharides inside the cell wall. The and lipid.
- A plasma membrane, lipoprotein, in nature lies inside the cell wall. This limits the cell volume and also regulates the movement of ions into and outside the cell. Enzymes constituting the respiratory chain and involved in the oxidation of metabolites are associated with the plasma membrane.
- The chromosomes of the bacteria are made up of a single circular molecule of deoxyribonucleic acid. This molecule, about 1mm. in length contains all the genetic information, and can code 2000 to 3000 different proteins.
- This DNA molecule is folded and lies free in the cytoplasm in the nuclear-region without any nuclear envelope. In the figure, DNA molecules are shown as the cell is about to divide and replication of DNA has occurred.
- Another characteristic feature membrane. The ribosomes consisting of RNA and proteins surround the DNA molecule and exist in groups called as the polyribosomes. These are made up of larger and smaller subunits. There are about 20,000 to 30,000 of them, each measuring about 25 mm in diameter.
- Water, protein molecules and various other types of molecules including RNA, fill up the remainder of the cytoplasm.
- The pleuropneumonia like organisms range 0.1 to 0.25 m in diameter. These resemble in size the large sized viruses, such as the tobacco mosaic virus.

1.1.2 EUKARYOTIC CELLS

- The eukaryotic cells are characterized by a small amount of cytoplasm, surrounded by a cell membrane and consisting of a nucleus. These cells are differentiated into a number of types depending on their functions in various tissues.

The prokaryotic and eukaryotic types of cells can be differentiated as below:

Differences between prokaryotic and eukaryotic types of cells.

Cell organelles	Prokaryotic cell	Eukaryotic cell
Nuclear envelope	Lacking	Present
Nucleous	Absent	Present
Division	Amitosis	Mitosis or Meiosis
Chromosomes	Single	Many
DNA	Not combined with Protein	Combined with Protein
Mitochondira	Respiratory and Photosynthetic enzymes in plasma membrane	Present
Movement	By single fibril	Cilia, flagella

1.Which of the following statements is true about cell theory?

(A) The Cell theory does not apply to fungi

(B) The Cell theory does not apply to virus

(C) The Cell theory does not apply to algae

(D) The Cell theory does not apply to microbes

2. ____________is the study of the cell, its types, structure, functions and its organelles.

(A) Biology (B) Cell Biology (C) Microbiology (D) Biotechnology

3.Which of the following cell organelles is present in plant cells and absent in animal cells?

(A) Nucleus (B) Vacuole (C) Chloroplast (D) Cytoplasm

1.2 PROKARYOTIC CELLS

- The prokaryotic cells are generally smaller and vary in size in different members.In mycoplasma it is about 0.12 μm while in oscillatoria, a filamentous BGA the size is 40 x 5μ. A great majority of them, however are about smallest are to be found among cocci (0.1μ) while the largest are the spirilla (60 x 6μ).

Bacteria

- Bacteria are unicellular organisms on an average, a cell range from 0.1μ to 1μ in size. Exceptionally some forms may be as large as 15 μ.
- Based on the cell shapes , four morphological forms have been identified in bacteria viz

Bacillus- The cells are rod shaped and elongated.

There are second largest among bacteria

eg. Mycobacterium

Coccus

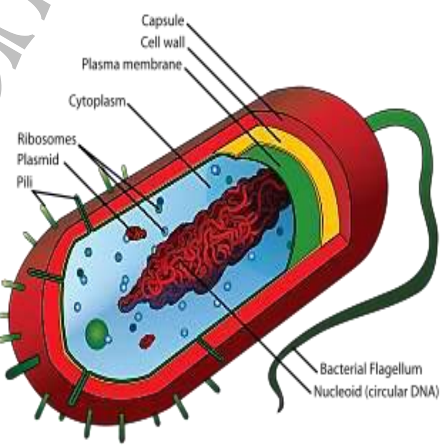
The cells are spherical. These are the smallest among bacteria.

Eg. Streptococcus, staphylococcus

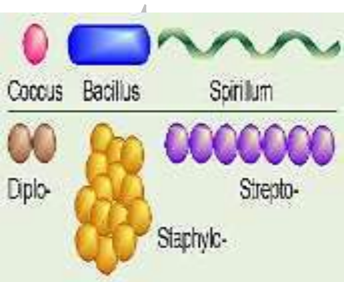
Spirillum

The cell will be in the form of a loose spiral. These forms are the largest.

Eg. Rhodospirillum



Comma



- ❖ The cell will be in the form of punctuation mark, comma. Eg. Vibrio.
- ❖ Coccus form existing as single isolated cell it is called micrococcus, in pairs diplococcus, in chains streptococcus, in sheets staphylococcus.
- ❖ Many bacteria inhibit several shapes or forms. This is known as pleomorphism.

Locomotion

Except the coccus, all the others form of bacteria may possess organs of locomotion. ie. Flagella. The flagellum is a long thread like structures whose length usually exceeds that of the cell. It arises from a basal granule. On the basis of the number and position of flagella, bacterial forms are classified into

- ❖ Atrichous- No flagella. Eg. Cocci
- ❖ Monotrichous- Single flagellum present at one end eg. Vibrio
- ❖ Lophotrichous- Many flagella present at one pole (spirillum undula)
- ❖ Amphitrichous- Two tufts of flagella attached at either poles of the cell Eg. Spirilla
- ❖ Peritrichous- Flagella present all round Eg. Salmonella

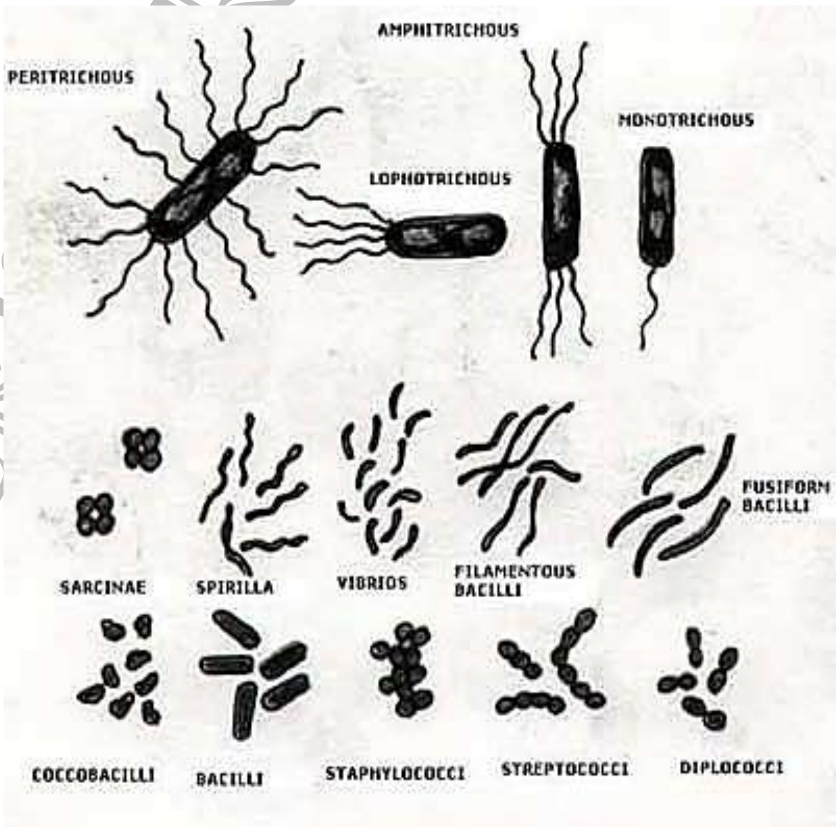


FIGURE : BACTERIAL FORMS AND STRUCTURE

Bacteria move with varied speeds. Some can move about 2,000 times their size in an hour. Hay bacillus can travel at a speed of 200 μ/s.

1.2.1 ULTRA STRUCTURE OF BACTERIA

1. Cell membrane

❖ Internal to the cell wall is the cell membrane or the plasma membrane. It forms the outer boundary of the cytoplasm and is selectively permeable and it thus regulates the entry and exit of molecules into cytoplasm. The membrane is chemically made up of lipoproteins and practically no carbohydrates.

Outer covering

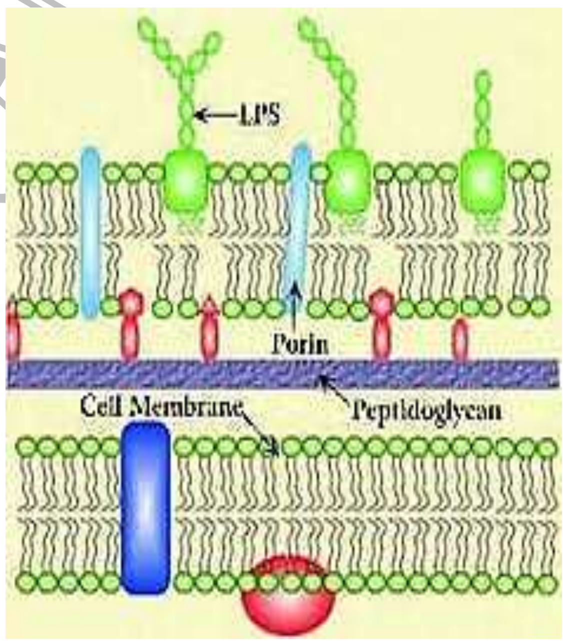
The outer covering of bacterial cell comprises the following 3 layers

- Plasma membrane
- Cell wall
- Capsule

Plasma membrane

❖ The bacterial protoplasts are bound by a living, ultra thin and dynamic plasma membrane.

❖ The plasma membrane chemically comprises molecules of lipids and proteins.Which are arranged in a fluid mosaic pattern.



❖ That is it is composed of lipid bi layer sheet of phospholipids molecule with their polar heads on the surface and their fatty acyl chains forming the interior.

❖ The protein molecules are embedded within the lipid bi layer.

Plasma membrane intrusions

- In folding of the plasma membrane of all gram positive bacteria and some gram negative bacteria give rise to the following two main types of structures.

2. Cell wall

- Cell wall is absent in some prokaryotic members while it forms the outermost boundary in a large majority of them. While have the property of selective permeability it can act as sieve as it is porous.
- The cell wall is thin about 10-25 mm thick and provides rigidity to the cell. Cell wall is visible only under electron microscope. The cell wall accounts for 20-30% of the dry weight of the cell.
- Chemically the cell wall consists of mucopeptide made up of alternating chains of N.Acetylglucosamine and N-acetyl muramic acid molecule. These chains are cross linked by peptide chains are filled by various other species.
- The cell wall composition differed between Gram Positive and Gram Negative bacteria. The cell walls of gram positive bacteria contain up to 95% peptidoglycan and 10% teichoic acids.
- In gram –ve bacteria the cell wall composition is more complex. It is made up of several layers. Next to the cell membrane the peptidoglycal layer.
- Next to this exteriorly periplasmic region consisting of a number of enzymatic proteins. The outer membranous portion joined to the peptidoglycan region by many links of lipoproteins.
- The outer membrane regulates the entry of molecules into the periplasmic space.
- Electron microscope has revealed the fact that the cell wall of gram negative bacteria comprises the following in two layers.
- Peptidoglycan containing periplasmatic space around the plasma membrane.
- The outer membrane which consists of a lipid bilayer traversed by channels of porin polypeptide. There channels allow diffusion of solutes. The lipids of lipid bilayer are phospholipids and lipo polysaccharides.
- The cell wall of gram positive bacteria is thicker, amorphous homogenous and single layered. Chemically it contains many layers of peptidoglycans and proteins, neutral polysaccharides and poly phosphate polymers such as teichoic acids and teichuronic acids.

3.Mesosomes

- In some bacteria particularly in gram positive bacteria, the cell membrane forms vesicle or packet like infoldings into cytoplasm at several regions. These are called mesosomes.

4.Chromatophores

- These are photosynthetic pigment bearing membranous structures of photosynthetic bacteria chromatophores vary in form as vesicles, tubes, bundled tubes, stacks or thylakoids.

5.Capsule

- In some bacteria, the cell wall is surrounded by an additional slime or gel layer called capsule. It is thick, gummy, and mucilaginous and is secreted by the plasma membrane. The capsule serves mainly as a protective layer against attack by phagocytes and by viruses. It also helps in regulating the concentration and uptake of essential ions and water.

6.Cytoplasm

- Cytoplasm is a viscous substance like in eukaryotes but differs from them in not showing streaming movements.
- Cytoplasm includes ribosome, nuclear material, proteins and other water soluble material and reserve food material. Organelle like endoplasmic reticulum, mitochondria, Golgi bodies etc are absent.
- Plasmids and episomes are also found in cytoplasm.

7.Ribosome

- They are dispersed throughout the cytoplasm and as in eukaryotes are involved in protein synthesis. The number of ribosome per cell varies and may reach up to 15,000 per cell.
- Higher number of ribosome is found during increased activity of protein synthesis. Bacterial ribosome are of the 70s type as noticed by their sedimentation properties.

- 8.Nuclear material
- Nuclear material is dispersed in the centre. It is called a nucleoid as it has no membrane or nucleolus.
- Nucleiod consists of closely packed fibrilar DNA.
- Plasmids and episomes
- In many of the bacteria DNA is present outside the chromosome. Such extra chromosomal DNA is often referred to as plasmids or episomes.

9.Fimbriae (pilli)

- These are short, very fine, hair like processes found in some gram negative bacilli also called pilli. They originate from the plasma membrane and their function is to be adhere to the cells particularly during conjugation.

1. What is the name of the region where double-stranded single circular DNA is found in the prokaryotic cell?

(A) Protonucleus (B) Nucleus (C) Nucleoid (D) Nucleoplasm

2. In prokaryotic cells, ribosomes are

(A) 70 S (B) 80 S (C) 60S + 40S (D) 50S + 40S

3. The two domains to which prokaryotes are classified into are:

(A) Bacteria and Protista (B) Bacteria and Archaea

(C) Archaea and Eukarya (D) Eukarya and Monera

4. When a water sample from a hot thermal vent was tested, it was found to contain a single-celled organism having a cell wall lacking a nucleus. What is its classification most likely?

(A) Eukarya (B) Fungi (C) Protista (D) Archaea

5. Which of these is a characteristic of prokaryotic cells?

(A) Absence of cell organelles (B) Absence of nucleus

(C) Presence of 70S ribosomes (D) All of these

6. A difference between eukaryotic and prokaryotic cells is in having

(A) Ribosomes (B) Cell wall

(C) Nuclear membrane (D) None of the above

7. In prokaryotes, the hair-like outgrowths which attach to the surface of other bacterial cells are

(A) Flagella (B) Pili (c) Capsule (D) Plasmids

8. A component of prokaryotic cells:

(A) Plasma membrane (B) DNA (C) Cytoplasm (D) All of these

9. The process of recombination in prokaryotes takes place in this way

(A) Transformation (B) Conjugation

(C) Transduction (D) All of the above

10. The flagella of a prokaryotic and eukaryotic cell vary in

(A) Mode of functioning and location in the cell

(B) Types of movement and placement in the cell

(C) Microtubular organization and function

(D) Microtubular organization and type of movement

1.3 EUKARYOTIC CELLS

- The structures that make up a Eukaryotic cell are determined by the specific functions carried out by the cell. Thus, there is no typical Eukaryotic cell. Nevertheless, Eukaryotic cells generally have **three** main components: A cell membrane, a nucleus, and a variety of other organelles.

1.CELL MEMBRANE

- A cell cannot survive if it is totally isolated from its environment. The cell membrane is a complex barrier separating every cell from its external environment.
- This "Selectively Permeable" membrane regulates what passes into and out of the cell.
- The cell membrane is **a fluid mosaic** of proteins floating in a **phospholipid bilayer.**
- The cell membrane functions like a gate, controlling which molecules can enter and leave the cell.

- The cell membrane controls which substances pass into and out of the cell. **Carrier proteins** in or on the membrane are specific, only allowing a small group of very similar molecules through. For instance, a- glucose is able to enter; but P -glucose is not. Many molecules cannot cross **at all.** For this reason, the cell membrane is said to be **selectively permeable.**
- The rest of the cell membrane is mostly composed of **phospholipid molecules.** They have only **two fatty acid 'tails'** as one has been replaced by a **phosphate group** (making the 'head')
- The head is charged and so polar; the tails are not charged and so are non-polar. Thus the two ends of the phospholipid molecule have different properties in water.
- The phosphate head **is hydrophyllicand** so the head will orient itself so that it is as close as possible to water molecules. The fatty acid tails are **hydrophobic** and so will tend to orient themselves **away** from water.
- When in water, phospholipids line up on the surface with their phosphate heads sticking into the water and fatty acid tails pointing up from the surface.
- Cells are bathed in an aqueous environment and since the inside of a cell is also aqueous, both sides of the cell membrane are surrounded by water molecules.
- This causes the phospholipids of the cell membrane to form
- **two** layers, known as a **phospholipid bilayer**. In this, the heads face the watery fluids inside and outside the cell, whilst the fatty acid tails are sandwiched inside the bilayer.
- The cell membrane is constantly being formed and broken down in living cells.

FLUID MOSAIC MODEL OF CELL MEMBRANES

- Membranes are **fluid** and are rather viscous -like vegetable oil.
- The molecules of the cell membrane are always in motion, so the phospholipids are able to drift across the membrane, changing places with their neighbour.
- Proteins, both in and on the membrane, form a **mosaic,** floating in amongst the phospholipids.

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UG TRB BOTANY 2023-2024

UNIT-9

PLANT ECOLOGY, ENVIRONMENT, CONSERVATION BIOLOGY, PHYTOGEOGRAPHY

Your Success is Our Goal....

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UNIT - IX

PLANT ECOLOGY, ENVIRONMENT, CONSERVATION BIOLOGY, PHYTOGEOGRAPHY

1. PLANT ECOLOGY

1.1. Ecology

❖ The term "Ecosystem" was first coined by A.G. Tansley (1935). The living organisms and non-living environment are inseparably inter-related and also interact with each other. The system resulting from the integration of all the living (BiotiC) and non-living (AbiotiC) factors of the environment. The term "Biocoenosis" was coined by kari mobius and is a synonym for the ecosystem. It is a segment of nature consisting of a community of living beings and A biotic environment both interacting and exchanging materials between them. The ecological system or ecosystem comprises specific units of organisms occupying a given area thereby producing trophic structure, biotic diversity and material cycles.

1.1.1. Ecosystem:

- The word derived from "Eco" - Meaning environment and "System" implying interacting and interdependent complex. The Ecosystem can be defined as any unit, comprising all the organisms (ie., Communities) in a given area interacting with the physical environment resulting in the flow of energy, biotic diversity as well as mineral cycle.
- According to E.P odum (1963) organisms and physical Features of the habitat from an ecological complex (or) ecosystem. Thus, ecosystem is the basic functional unit of ecology embracing biotic communities and abiotic environment both influencing each other. Every ecosystem encompasses interacting organisms that transform and

transmit energy and chemicals. These energy and chemical flow processes support ecosystem organization and are responsible for the functional indentities of ecosystem. The ultimate source of energy for all ecosystem is the sun.

1.1.2. Structure and Function of Ecosystem :

- The structure of an ecosystem is basically a description of the organisms and physical features of environment including the amount and distribution of nutrients in a particular habitat. It also provides information regarding the range of climatic condition prevailing in the area. Form the structure point of view, all ecosystem consists of two basic components. The quantity and distribution of the non-living materials e.g. nutrients, ater, gases…, The range or gradients of condition of existence e.g. Temperature light function dynamics based on rate at materials or nutrients cycling and Biological control, including both regulation of organism by environment.
- Ecosystem and organisms are open thermodynamics systems without equilibrium that exchange energy and matter with the environment continuously to decrease internal but increase external entropy.

1.1.3. Components of Ecosystem:

- All the ecosystems, terrestrial or aquatic from a purely functional point of view have the following two basic components.

    1) Biotic Components

    2) A Biotic Components

1.1.3.1. Biotic Components:

- These are represent trophic (nutritional) structure of any ecosystem where organisms are distinguishing on the basis of their nutritional relationships. It includes the living organisms of the Components. E.g. plants, animals, bacteria, viruses etc.,
- **It includes the following:**

    1. Producers

    2. Consumers

    3. Decomposers

i. Autotrophic Component

ii. Heterotrophic Component

Autotrophic Component : or (Producers)

- The autotrophic component fixes the radiant energy of sun and manufactures food from simple inorganic substances. It includes only green plants and photosynthetic bacteria members of autotrophic components are also known as producers since they produce organic matter like, H20, CO2, and sunlight energy.

Heterotrophic Components : or (Consumers)

- The generalized equation at photosynthesis 6CO2 + 12 H2O 2800kj energy C6 H12 O6 + O2 + 6H2O chl. The heterotrophic component takes food from autotrophic rearranges it and finally decomposes the complex organic materials into simple inorganic forms. The organisms which fall under his category is also known as consumers since they consumers the organic matter produced by the producers.
- The consumers are of two types. These are fungi most of bacteria and animals.
- They have lack of chlorophyll.

1. Macro Consumers : (or) Phagotrophs

- In this category are included heterotrophic organisms mainly animals which eat or ingest other organisms or particular organic matter. In a food chain, the consumers include primary consumers or herbivores eating plants and secondary consumer or carnivores and omnivores eating animals' tissues.
- There can be further tertiary consumers depending on the food chain. These denotes orderly placed animals – such as herbivores (Primary consumers) pattern of food chain.

Micro Consumers :

- Microscopic bacteria and actinomycetes fungi are included in this category. These are known as decomposers as they are capable of decomposing the dead organic matter. Which decompose the complex compounds of dead protoplasm and absorb some of the decomposed products. During this, they release inorganic nutrients, which are taken by producers the materials are then attacked by trans formers another type of bacterium that change the inorganic compounds into forms plants. So that these substances can be reutilized by the primary producers. Organisms which are not capable of under going photosynthetic process are called consumers. Consumers are organisms which eat other organisms. The consumers are further divided into three categories.

A. Primary Consumers :

- An herbivore is a primary consumer that derives its nutrition directly from plants. Elton referred the herbivores as Key industry animals. Ex: Garsshopper, Rabbit, Goat.

B. Secondary Consumers :

- They kill and eat the herbivores. They are also called carnivores. As these carnivores directly depend on herbivores they specially called primary carnivores. Ex: Fox, Wart, Snake.

C. Tertiary Consumers :

- Tertiary consumers are carnivores that feed on other carnivores Ex. Lion, Tiger.

D. Omnivores :

- Some consumers kill and eat producers and consumers. They are often called omnivores. (or) Multilevel consumers. Ex. Birds, Human beings.

A. Scavengers :

- A special type of consumption is that of scavengers, who feed upon dead and decaying plants and animals matter, Vultures, sea gulls and even eagles consume extensively on animals that have died of other causes.

Decomposers :

- If the world only had producers and consumers. It would not work very well because the flow of matter would be in oxy one direction, that is, from lower to higher order compounds. Something needs to return these compounds to more elements forms so that they can be recycled and used over again in the food chain. This process requires a group of organisms known as decomposers. Bacteria and fungi play this role an important role in decomposition on mechanism Bacteria generally act on animal tissue and fungi on plant tissue. Plant and animal materials is degraded enzymatically and released as basic elements into the environment, where the elements are again available to the producers for reuse.
- Some organic matter, such as sugars, lipids and proteins are decomposed rapidly where as others such as, cellulose, lignin, hair bones are decomposed slowly. Aerobic respiration is essentially an oxidative process as represent below.
  - **C6H12 O6 + 602 ----------6Co2 + 6H20 + Energy.**

1.1.3.2. A Biotic Components :

- The term abiotic means nonliving. Thus, there components refer to nonliving elements or factors present in the ecosystem. Ecological relationships are manifested in physico – Chemical environment. The biotic factors of the ecosystem depends on the a biotic factors for their survival. It include the following component.

i) In Organic Substance :

- It include inorganic substance like C, N,P, H2O, H, S, etc.. which are involved in the mineral cycle**.**

ii) Organic Compounds :

- It includes carbohydrates, fats, Proteins which link the biotic and abiotic components. They are formed by decomposition of dead – plants and animals.

iii) Climatic regime :

- Biotic components or abiotic factors are nonliving factors that impact an ecosystem. These factors are part of the ecosystem and influence the associated living things but they are not living. The term abiotic is a mix of two words, these are a- which means without, and bio which means life.

1. Temperature

- A rise in temperature can change the development of an animal, can cause changes in metabolic activity, and much more. All organisms can tolerate a certain range of temperature and how extreme temperatures lead to stressful conditions.

2. Water

- Water covers more than 70% of the earth's surface in one form or the other. Compared to that, living organisms require a small amount of water to live. Water is critical to survival.

3. Atmosphere

- The atmosphere has important components like oxygen and carbon dioxide, which animals and plants breathe to live and combine to produce carbohydrates, other organic materials, parts of DNS, and proteins.

4. Sunlight

- Sunlight is one of the most important abiotic factors and is the primary source of energy. Plants require it for photosynthesis.

5. Chemical Elements

- Chemical elements play a major role within the environment to influence the type of organisms which can grow or thrive in an area. The chemical composition, including pH level, has a huge impact on the plants of an area. For example, plants like azaleas thrive in acidic soils. Some elements, like zinc and copper, are important micronutrients for the development of many organisms.

6. Soil

- Soil is a critical abiotic factor. It is composed of rocks as well as decomposed plants and animals.

7. Wind

- The wind direction and speed in an area affect its temperature and humidity. Very high wind speeds, often in mountainous areas, can be the reason behind stunted plant growth. Wind also carries seeds and aids in pollination.

Examples of Abiotic Components

- Wind
- Humidity
- Salinity
- Rain
- Temperature
- Latitude
- Elevation
- Radiation
- Pollution

Types of Ecosystems Based on Abiotic Factors

Based on abiotic factors, there are several types of ecosystems.

We will discuss the abiotic factors of these ecosystems in the following:

- **Desert Abiotic Factors:** Due to low rainfall, deserts develop ecosystems that are very distinguishable from other environments. IT covers 20% of the earth's surface and that includes Antarctica. Extreme temperature swings are often observed in deserts as open-air and water vapour stabilise the temperature.
- **Tropical Rainforest Abiotic Factors:** Tropical rain forests see the most rainfall on earth. Most rainforests have more than 100 inches of rain every year. It has warm and wet climates and the rainforests create a dense, lush, and complex ecosystem.
- **Tundra Abiotic Factors:** The tundra region receives less light and heat from the sun. A deep layer of soil called the subsoil is observed. And it can remain frozen for many years. Only grasses and small plants grow in this region.
- **Ocean Abiotic Factors:** The abiotic factors which play a part in the ocean's environment are salinity, heat, pollution, and many more. It is a truly unique environment. Because of its depth, the different zones receive a different amount of sunlight and heat. This creates a different ecosystem in each layer and it has its unique share of animals. The different ocean ecosystems are coral reef ecosystems, shoreline ecosystems, deep ocean ecosystems, etc.

Other Ranges of Ecosystems

- **Temperate Forests:** Abiotic factors include temperature, humidity, etc.

- **Freshwater Ecosystems:** The biotic factors are: light penetration, temperature, and pH of water. Examples are lakes, springs
- **Grasslands:** As the name says, this type of ecosystem is dominated by grass. The major abiotic factor is rainfall
- **Taiga Ecosystems:** It is the coldest region of the arctic. There is a presence of evergreen trees and you can notice mosses and mushrooms.

Responses to Abiotic Factors:

Living organisms respond to abiotic components in various ways. This list of abiotic factors includes:

1. Regulators: All organisms can maintain a constant internal environment called homeostasis. The organisms which can do this regulate homeostasis by physiological and behavioural means and it ensures constant body temperature and osmotic concentration. Humans maintain body temperature at 98.4 degrees Fahrenheit. They maintain homeostasis by sweating in the summer and shivering in the winter.

2. Conformers: These are organisms that cannot regulate internal body conditions, and their body condition changes as per the environment.

3. Migrate: For these organisms, when the weather in their habitat transforms into a stressful condition, they move to a habitat that has less stressful conditions. For example, Siberian birds fly from that region to Keoladeo National Park in Bharatpur, Rajasthan.

4. Suspend: Many organisms have different body mechanisms to survive in a stressful environment. There are many examples of this type of response. These are:

- **Sporulation:** Organisms produce thick-walled spores which help the organism to survive unfavourable conditions. When the conditions return to normal, the spore germinates. This type of response can be seen in certain types of bacteria, fungi, and lower plants.
- **Dormancy:** To survive periods of stress, seeds of higher plants reduce their metabolic activity and go into a state of dormancy. Under favourable conditions, the dormant seed germinates to grow to a new plant.
- **Hibernation and aestivation:** If organisms are unable to migrate, they avoid stressful conditions by escaping in time to a place where the organisms sleep in winter. It is called hibernation. If the organism or animal sleeps in summer, it is called aestivation. For example- bears sleep during winter and snails sleep during summer.

5. Diapause: It is a natural process that is observed in a certain animal. It causes the delay of development in these animals due to alterations in metabolic activity. Diapause is common in parasites, crabs, shellfish, snail insects, and certain groups of zooplanktons.

1) Environment consist of 2 factors such as ——–- and ———–.

A) Abiotic and biotic factors.

B) Autotrophs and herbivores

C) Decomposers and ecosystem

D) None of these.

2) The edaphic factors in abiotic components considered as characteristics of ———–.

A) Light B) Temperature

C) Soil D) Rainfall

3) Which of the following is considered as topographic factors?

A) Altitude B) Latitude

C) Mountain D) All of these

4) Which one of the following are abiotic factors?

A) Pollution and wind B) Soil and rainfall

C) Microorganism and temperature D) Both A and B.

5) Does human activity can produce abiotic factors?

A) Yes, Anthropogenic activities B) Yes, Pollution

C) No, humans cannot interfere D) Both A and B.

Answer: Answer is D, Human activities can produce the abiotic factors.

6) Which of the following are classes of abiotic factors?

A) Climatic factors B) Edaphic factors

C) Topographic factors D) All of these.

7) The most preferred and usable form of acetic acid is——–.

A) Vinegar B) Glacial acetic acid

C) Acetic anhydride D) Chloroacetic acid

8) The production of antibodies in response to antigen called as —— immunity.

A) Passive B) Active

C) Weak immunity D) Both A and B.

1.2. Plant Succession

- A Community or biocenose is an aggregate of organisms which form a distnict ecological unit. Such a unit May be defined in terms of floras, fauna, or both community units may be very small like the community of invertebrates and fungi in a decaying log. A different community occurs in each different habitat and environmental unit of larger size, and in fact the composition and character of the community is an excellent indicator of the type of environment that is present. Since plants and animals, bacteria and fingi all occurs together in the same habitat and have many, they can scarcely be considered independely of each other communities are not stable, but dynamic, changing more or less regularly over time and space. They are never found permanently in complete balance with their component species or with the physical environment. Environment always keep on changing over a period of time due to

  i. Variation in climatic and physiographic factors and.

  ii. The activating of the species of the communities themselves.

1.2.1. Definition:

- Clements (1916) defined the succession as the natural process by which the same locality becomes successively colonized by different groups or communities of plants.E.P.Odem (1971) defined it as An orderly process of community change in a unit area.An orderly sequence of different communities over a period of time in some particular are.Sere:
- It is the sequence of developmental stages from pioneer to climax communities, e.g. litho sere or (rock), psamosere (on sanD), hydrosere (in water), and xerosere plants grow on dry conditions.

1.2.2. Basic types of succession:

1. Primary Succession
2. Secondary Succession
3. Autogenic Succession
4. Allogenic Succession
5. Autotrophic Succession
6. Heterotrophic Succession

i. Primary Succession:

- Primary Succession occurs on base life less substrate, such as rocks or in open water, where organisms gradually move in to an area and change its nature. On bare area mineral – poor soils, lichens grow first, forming small pockets of soil.

ii. Secondary Succession:

- If a wooded area is cleared and left alone, plants will slowly reclaim the area. Eventually, traces of the clearing will disappear and the area will again be woods. This kind of succession, which occurs in area where an existing community has been disturbed, is called secondary succession. Humans are often responsible for initiating secondary succession.

iii. Autogenic Succession:

- The succession taking place due to the influence of existing plant community it self, is known as autogenic succession.

iv. Allogenic succession:

- In some cases, however, the replacement of the existing community is caused largely by any other external condition and not by the existing vegetation it self.
- On the basis of successive changes in nutritional and every contents, successions are some times classified as.

v. Autotrophic succession:

- Photosynthetic organisms form dominant communities during the early stages of succession, and in organic substance are rich in this area. This kind of succession is called autotrophic succession.

vi. Heterotrophic Succession:

- Heterotrophic communities such as bacteria, fungi, actinomycetes, Protozoa and animals form dominant communities . Organic substances are rich in this area.

1.2.3. Patterns Of Succession

- Depending upon the types of habitant and varying amount of moisture, the succession are designated as below
  1. Hydro Sere
  2. Xero Sere

I) Hydrosere

- Plant succession occurring in the aquatic environment or starts on a wet area it is called hydro sere. It may be originating in a pond, starts with colonization of some phytoplankton's which ferns the pioneer community and finally terminates into a forest climax community. The various stages of hydrosere can be enumerated as below.

1. Phytoplankton Stage:

- Micro organisms like bacteria, blue green algae, diatoms first appear. In due course the number of these organisms increases. They constitute the pioneer community. The soils are very much reduced with a PH value of not more than 5.00 death and decay of phytoplanktons, organic matter is added to the water.

2. Rooted Submerged Stage:

- Most of the micro organisms perish away leaving humus along with the humus the dust particles and sand combine together forming clay due to the formation of clay at the substratum. Water depth at this stage is about 10 feet. As a result a soft mud is formed at the bottom of the pond. Hydrilla, Potamogeton and Najas form dense growth at bottom enriched with organic matter.

3. Rooted floating Stage:

- The water depth at this stage is much reduced to 2 to 5 feet. In the shallower regions appear plants with tuberous rhizomatous and creeping stems and leaves floating on the surface of water. Humus rich bottom begins to rise making water shallower rooted floating hydrophytes like Nymphaea, Nelumbo, Pistia, Azolla, Wolffia, Lemna etc.,

4. Reed Swamp Stage:

- The depth of water is very low 1to2 feet. In shallower water, amphibian plants are grow. They add more silt and humus at the bottom so that shoves built up. The plants of community are rooted but most parts of their shoots (assimilatory organs) remain exposed to air. Amphibious plants include scirpus, Typha, Sagittaria, Alisma, Phragmites etc.,

5. Sedge – Meadow Stage:

- Due to the deficiency of water plants like, carex, cyperus and juncos start growing. There plants increase in number. They form a mat like vegetation towards the centre of the pond with the help of their much branched rhizomatous systems. There is rapid rate of loss of water due to their high rate of transpiration. As a result the soil gets dried up and nutrients like ammonia, sulphites and so on some common vegetation are Eleocarpus cymbopogan, Cyprus, Eriophorum, Juncus, Themeda, Cicuta, Gallium etc.,

6. Woodland Stage:

- Due to high rate of transpiration by the plants and due to further lowering of water table, the soil becomes on favourable for the growth of the grass like plants. Subsequently the terrestrial plants invade this area, some of them are shrubs. And other are woody plants ex. Populus, Aluns, Terminalia, Cephalanthus, Salix, Cornus, Acacia, Casia etc.,

7. Climax Stage:

- New trees, shrubs and herbs appear which are in perfect harmony with the climate of the area. It is also called forest stage. This is the climax community of hydro sere succession. The wood land community is rapidly invaded by several trees.

II) Xerosere

- Xeric succession commonly occurs on bare rock surfaces resulting from glaciations from erosion by wind and water. The original substratum is deficient in water and lacks any organic matter, having only minerals in disintegrated un weathered state. The pioneer plants, to colonies this rocky substratum are crustose lichens. After a series of developmental stages a climax community develops on the substratum. The lichens secrete carbonic acid in excess. The carbonic acid react with the rocky materials and loosen the rock particles. Xerosere include various stages.

  1. Lichens Stage
  2. Moss Stage
  3. Annual Stage
  4. Shrub Stage
  5. Climax Stage

1. Lichens Stages:

- Bare rock is invaded first by crustose lichens e.g. graphics, Rhizocarpon. The reproduce by means of soredia. There soredia fall on the rocky substratum and grow into a thallus. The plant body very soft and sponge like. The corrode the rock at places causing foliose lichens e.g. parmelia, Dermatocarpon. Their body consist of a branched leaf like thallus with a foot.The death and decay of the lichens, more organic matter is added to the substratum. Thus the substratum becomes suitable for the growth of mosses. The weathering of rocks and its mixing with humus results into the development of a fine thin soil layer on rock surface and thus there is a change in the habitat.

2. Moss Stage:

- Mosses capable of tolerating drought invade the human rich holes created by foliose lichens. The formation of thin soil layer on the rock surface favours the growth of xerophytic mosses like Grimmia, Polytrichum etc., the erect leafy shoots of mosses shade out the fruticose lichens and replace them gradually. As a result of the death and decay of the mosses, still more amount of organic matter is added to the soil finally they create move humus and shade to eliminate lichens.

3. Annual Grass Stage :

- At first small herbaceous annual plants make their appearance. The roots of there herbs grow deeper into the crevices of rocks there by making the rock wither away. Annual grasses with runners and rhizome are slowly replaced by perennial grasses with runners and rhizomes e.g. Heteropogon, Cymbopogon, several, small animals begin to reside. Herbivorous animals visit the site.

4. Shrub Stage

- Xerophytes plants like Rhus, phyocarpus begin to grow and later they die. Shrubs begin to grow in area occupled by perennial grasses. They increases soil and humus contents besides moisture e.g. Rubus, Rhus, Capparis, Zizyphus. This intern increases the soil fertility.

5. Climax Stage

- At first small trees make their appearance. There are drought resistant plants. The rocks under goes withering and the amount of soil increase. Initially hardy, light demanding small trees invade the area. They make the habitat shadier and move moist. Ultimately, trees, shrubs and herbs representing the climax community begin to grow in the area. Xerophytic trees also form climax forest, if the climate of the area, is dry. Trees such as Acacia, Prosopis, Balanites, etc., may occur in the forests. This forests vegetation is more or less stable for several years with out much changes in its structure.

1. In ecological succession, the intermediate developmental phase is known as

A) ecesis B) climax

C) nudation D) sere

2. This is true about secondary succession

A) follows primary succession

B) takes place on a deforested site

C) is similar to primary succession except that it has a relatively slower pace

D) begins on a bare rock

3. Lithosphere serves as a reservoir for

A) nitrogen cycles B) carbon cycles

C) oxygen cycles D) phosphorus cycles

4. This is not a climax vegetation

A) grasses B) savannah C) forests D) hydrophytes

5. This about ecological succession is incorrect

A) food chain relationships become more complex

B) species diversity increases as succession proceeds

C) role of decomposers becomes all the more important

D) is a random process

6. An example of plants occupying the second stage of hydrosere is

A) Salix B) Vallisneria C) Azolla D) Typha

7. On the sand, ecological succession is

A) halosere B) xerosere C) hydrosere D) psammosere

8. Order of basic processes involved in succession is

A) invasion -> stabilization -> completion and coaction -> reaction -> nudation

B) nudation -> stabilization -> completion and coaction -> invasion -> reaction

C) invasion -> nudation -> completion and coaction -> reaction -> stabilization

D) nudation -> invasion -> completion and coaction -> reaction -> stabilization

9. Process of the successful establishment of species in a new area is known as

A) climax B) sere C) ecesis D) invasion

10. In ecological succession, the final stable community is known as

A) climax community B) ultimate community

C) final community D) seral community

1.3. Ecological Adaptations:

❖ Organisms try to adapt to the prevailing environmental conditions. thus adaptation may be defined as process by which the organism to cope with its environmental conditions in an attempt to cope with their environment organisms may have undergo changes in their morphology, and physiology thus showing structural and physiological and biochemical adaptation. Extreme desert is with out any vegetation and rainfall.

1.3.1. Hydrophytes

- Plant which grow in wet places or in water either partly or wholly submerged are called hydrophytes or aquatic plants. Examples are utricularia, Vallisneria, Hydrilla, Chara, Eichhornia, Wolfia lemna, etc. The plants readily fall into three categories viz, 1). Submerged Plant, 2). Floating Plants, 3). Amphibious Plants.

1. Submerged is a hydrophytes has following type.

a. Suspended. Eg. Utricularia, Hydrilla, ceratophyllum Najas.

b. Rooted E.g. Vallisnaria, Elodea, Isoetes, Potamogeton.

- The absorbing and conducting tissue are therefore reduced to minimum. The root are poorly or absent or not at all branches. In some of cases root are absent eg. wolffia, ceratophyllym. Salvinia, and utricularia. Some hydrophytes to grow and do not branch. Eg. Azolla, Lemna and often have root pockets that fit over the end of root. Plant which grow below the water surface and are not in contact with atmosphere are called submerged hydrophytes. Submerged hydrophytes has following types

2. Floating Hydrophytes:

- Plant that float on the surface or slightly below the surface of water are called floating hydrophytes. The plants are in contact with both water and air. They may or may not by rooted in the soil. This is following two types.

  i. Free floating hydrophytes

  ii. Floating but rooted hydrophytes.

i. Free floating hydrophytes:

- These plant float freely on the surface of water but are not rooted in the mud. Eg wolffia arhiza, wolffia microscopica, (a root less minutest duck weeD) Tapa bispinosa, Lymnathemym, Eichharnia.

ii. Floated but rooted hydrophytes.

- Submerged plants are rooted in muddy substrate of ponds, rivers, and lakes but their leaves and flowering shoots float on or above the surface of water.

  Eg. Nymphaea, Nelumbium, Victoria Regia, Ceratopteris

3. Amphibious hydrophytes:

- This plant are adapted to both aquatic and terrestrials modes of life. Amphibious plant grow either in water or on the muddy substratum. Amphibious plants which grow in marshy places are termed as “halophytes” the aerial parts of these amphibious plant shows mesophytes or some times xerophytes feature, while submerged parts develop true hydrophytic characters.

  Eg. Oryza sativa, Marsilea, Sagittaria , Alisma, Jussiaea, Neptunia, Commelina, Polygonum, Ranunculus.

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UNIT-10

PLANT BIOTECHNOLOGY, BIOINFORMATICS, MOLECULAR BIOLOGY

Your Success is Our Goal....

INDEX

10. PLANT BIOTECHNOLOGY, BIOINFORMATICS, MOLECULAR BIOLOGY

1.PLANT BIOTECHNOLOGY

1.1 HISTORY OF PLANT TISSUE CULTURE

- Gottlieb Haberlandt is regarded as the Father of plant tissue culture as he predicted the totipotency of plant cells and attempted in vitro culture of plant mesophyll cells as early as 1902. Totipotency is the ability of a plant cell to multiply, differentiate and grow into a complete plant. The first embryo culture was attempted by Hanning in 1904 . In 1925, Laibach recovered hybrid progeny from an interspecific cross in Linum by using zygotic embryos of seeds as explant.
- The first plant growth hormone indoleacetic acid (IAA) was discovered in 1930s by F. Kogl et al. In 1934, Professor Philip White successfully cultured tomato roots on the medium, later called as White's medium. In 1939, Gautheret successfully cultured carrot tissues and the possibility of cultivating plant tissues for an unlimited period was independently endorsed by Gautheret, White and Nobecourt in 1939. In 1955 Miller and Skoog published their discovery of the hormone kinetin, a cytokinin. The first plant from a mature plant cell was regenerated by Braun in 1959.
- The focus of the scientists later shifted to preparation of single cell cultures. Muir (1953-54) demonstrated that, callus tissues in liquid medium when subjected to shaking, broke into single cells. In 1960, Bergmann developed the method for cloning of these single cells by filtering suspension cultures. This technique called Plating technique is widely used for cloning isolated single protoplasts.
- In 1962, Toshio Murashige and Skoog published the composition a plant tissue culture medium known as MS medium, which became the most widely used medium for tissue culture now.
- For the first time in the world, haploid plants from anthers of Datura were first produced by the Indians, Guha, S and Maheshwari, S.C. (Nature, 204:497 (1964) & Nature, 212:97-98 (1966)). This discovery received significant attention since, plants recovered from doubling of haploids are homozygous and express all recessive genes thus making them ideal for pure breeding lines.
- The classical work of Steward (1966) on induction of somatic embryos from free cells in carrot suspension cultures finally demonstrated totipotency of somatic cells, thereby validating the ideas of Haberlandt. Morel utilized this application for

rapid propagation of orchids and Dahlias. He was also the first scientist to develop virus free orchid and Dahlia plants by cultivation of the shoot meristem of infected plants.

- Protoplast (a cell without cell wall) was produced by Cocking in 1960 by using cell wall degrading enzymes. The first somatic hybrid plants by fusing the protoplasts of N. glauca x N. langsdorfli was produced by Carlson et al. in 1972.

1.1.1 DEVELOPMENT OF BIOTECHNOLOGY IN INDIA

- The promote biotechnology in India the Department of Biotechnology (DBT) was started in 1986. It was initially started as National Biotechnology Board (NBTB) in 1982 under Department of Science and Technology. Later, the International Center of Genetic Engineering and Biotechnology (ICGEB) was established by the United Nations to help the developing countries like India. ICGEB has two centers, one in New Delhi and the other in Trieste (Italy).

1.1.2 TIME LINES OF PLANT BIOTECHNOLOGY

1838 - Cell theory, indicating towards totipotentiality of cells by Schleiden and Schwann.

1902 - First but unsuccessful attempt of tissue culture using monocots by **Haberlandt.** He also explained the concept of cell totipotency.

1904 - First attempt in embryo culture of selected Crucifers by Hannig.

1922 - A symbiotic germination of orchid seeds by Knudson.

1922 - In vitro culture of root tips by Robbins.

1924 - Callus formation on carrot root explants by use of lactic acid by Meyer.

1934 - Identification of the first plant hormone, IAA, leading to cell enlargement by Kogl.

1941 - Coconut Milk used for growth and development of very young Datura embryos by Overbeek.

1942 - Observation of secondary metabolites in plant callus cultures by Gautheret.

1943 - Tumor-inducing principle of crown gall tumors identified by Braun.

1944 - First In vitro culture of tobacco used to study adventitious shoot formation by Skoog.

1946 - First whole plants of Lupines and Tropaeolum from shoot tips by Ball.

1948 - Formation of adventitious shoots and roots in tobacco by Skoog.

1957 - Discovery that root or shoot formation in culture depends on auxin: cytokinins ratio by Skoog and Miller.

1958 - In vitro culture of excised ovules of Papaver somniferum by Maheshwari.

1958 - Regeneration of somatic embryos from nucleus of Citrus ovules by Maheshwari and Rangaswamy.

1962- Development of MS medium by Murashige and Skoog.

1964 - First haploid plants from Datura androgenesis by Guha and Maheshwari.

1973- Cytokinins found to be capable of breaking dormancy in Gerberas by Pierik

1978 - Somatic hybridization of tomato and potato resulting pomato by Melchers.

1981 - Introduction of the term somaclonal variation by Larkin.

1981 - Isolation of auxotroph by cell colony screening in haploid protoplasts of Nicotiana plumbaginifolia treated with mutagens by Sidorov.

1985 - Infection and transformation of leaf discs with Agrobacterium tumefaciens and regeneration of transformed plants by Horsch.

1985 - Development of disarmed Ti-plasmid vector system for plant transformation by Fraley.

1. Who is known as the Father of tissue culture?

(a) Bonner (b) Laibach (c) Haberlandt (d) Gautheret

2.What is plant tissue culture?

a) The technique of in vitro maintaining and growing cells

b) The technique of in vivo growing cells

c) The technique of growing plants in gardens

d) The technique of cutting plants

3.Tissue culture technique was first practised by _____________

a) White b) Haberlandt c) Halperin d) Skoog

4.Which of the following scientist was not responsible for developing somatic hybrids?

a) Steward b) Halperin c) Wetherell d) Skoog

1.2 SCOPE AND APPILACTION OF BIOTECHNOLOGY

Application and Important Role of Biotechnology in Agriculture

One can define agricultural biotechnology as a set of scientific techniques which can improve plants, micro-organisms, and animals based on DNA and its concepts.

Arguably the use of biotechnology in agriculture is deemed to be more effective than that of agrochemicals. The latter is believed to be responsible for causing environmental distress and is also somewhat unfeasible for farmers.

The following highlight the few ways in which biotechnology has found its way in agriculture –

- **Genetic engineering / rDNA technology**

  It is a technology in which one or more genes are modified deliberately in the lab. This is achieved by the process of using recombinant DNA (rDNA) technology, thereby altering the genetic makeup of an organism.

- **Tissue culture**

  Tissue culture involves nurturing fragments of plant or animal tissue in a controlled environment where they survive and continue to grow. For this tissue has to be isolated first.

- **Embryo rescue**

  It is a form of in-vitro culture technique for plants. Here an immature embryo is nurtured in a controlled environment to ensure its survival. This can help in the preservation of species of seeds that are nearing extinction. This can include heritage seeds, local grains of cultural significance, etc.

- **Somatic hybridisation**

  It is a process through which the cellular genome is manipulated through the process of protoplast fusion.

- **Molecular-gene markers**

  In genetic engineering, Molecular-gene markers are specific segments of DNA that are associated with a particular location within the genome.

- **Molecular diagnostics**

  Molecular diagnostics is a set of techniques used to analyse biological markers in the genome and proteome. It helps in determining how their cells express their genes as proteins

- **Vaccine**

  It is a formulation that is injected into a host body to stimulate a desired immune response. It helps in preventing various diseases such as polio. Its production is carried out widely currently to fight against covid.

- **Micropropagation**

  It is a clonal propagation of plants in a closed vessel under aseptic and controlled conditions.

1.Which of the following is not an application of tissue culture?

a) Rapid Clonal Propagation b) Soma clonal Variations

c) Embryo rescue d) Transgenic plants

2.Which of the following is not related to embryo culture?

a) Growth of embryos on culture medium

b) Developing seedlings

c) Multiplication of rare plants

d) Making virus-free plants

3.Which of the following plant's meristem has not been successfully cultured?

a) Banana b) Apple c) Sugarcane d) Potato

4.What is Dimethyl sulfoxide used for?

(a) A gelling agent (b) Cryoprotectant

(c) Chelating agent (d) An Alkylating agent

1.3 . BIOFERTILIZERS

"A biofertilizers is a substance which contains **living cells** or **microorganisms** that help crop plants uptake of nutrient by their interactions in the **rhizophere** when applied through seed or soil".

- ⇨ They are often known as microbial fertilizers or microbial inoculants.
- ⇨ The use of chemical / synthetic fertilizers is the common practice to increase crop yields.
- ⇨ Besides the cost factor, the use of fertilizers is associated with environmental pollution.

- ⇨ The term biofertilizers is used to refer to the nutrient inputs of biological origin to support plant growth.
- ⇨ This can e achieved by the addition of microbial inoculants as a source of biofertilizers.
- ⇨ Biofertilizers broadly includes the following categories.

1. Symbiotic nitrogen fixers.
2. Asymbiotic nitrogen fixers.
3. Phosphate solubilising bacteria.
4. Organic fertilizers.

Advantages:

- ⇨ Biofertilizers reduce the use of chemical fertilizers in agriculture.
- ⇨ They never cause pollution in **air**, **water**, & **land**.
- ⇨ They secrete plant growth hormone to increase the plant growth.
- ⇨ They reduce the attack by soil-borne pathogens.
- ⇨ They improve the quality of soil for more productivity.
- ⇨ They can be mass produced by using renewable wastes.
- ⇨ No special care is required while using biofertilizers.
- ⇨ The farmers themselves can grow BGA biofertilizers & Azolla biofertilizers in their own lands.

1.3.1 AZOLLA

- ➢ Azolla is an aqualli heterosporous firm which contains an endophyli cyanobacterium, (Anabaena azollai in its lead cavity. The significance of Azolla as 'BJ' in rise field was realized in vietnam, recently used in china, India, Bangladesh, Phillipines.

Sources (6)

A. Carolinarta	*A. Pinnata*	*A. Mexicana*
A. Nilolica	*A. rubra*	*A. Microphyllaa*

Filiculoide:

The global collections are maintained of CRRI (Cuttack)

Mass cultivation:

Microplots 20m^2 are prepared in nurseries in which sufficient water (15-10cm) is added for good growth of Azolla. 4 –20 kg/ha is also amended,pH – 8.0 Temp (14-30 degree C)

Microplots inoculated with fresh Azolla (0.5 to 0.4 Kgm^2)

↓

Insecticides furadon used to check the insect attack

↓

3 weeks after growth mass formed by Azolla

↓

same plot is inoculated with fresh Azolla to repeat the cultivation.

↓S

Azolla mass is drived, used as green manure.

Methods of Application:

1. Incorporation of Azolla in soil prior to rice plantation
2. Transplantation of rice followed by H_2O drawning and incorporation of Azolla Yield 30Kg N/ha:

Characteristic Feature:

1. Tolerance against heavy metals (As, Hg, Pb, Ca, Cd, Cr)
2. Tolerates low conin, but a7 high levels a set bear in biochemical pathway is caused.
3. A pinnota absorbs heavy metals into cell walls and vacuoles thro' evovation of specific metal resistant enzymes.
4. Inoculated into the field where heavy metal conee'n is about 0.01 + 1.5 mg/ lit.
5. Damodhar valley project (distributed vegetation due to heavy metal pollution)

1.3.2 AZOSPIRILLUM

Gram negative, motile, vibrioids in shape, and contains PHB granules.on semisolid malate medium white dense and undulating thin pellicles is characteristics of Azospirillum.

Sources: Azospirillum amazonense, A.seropedicae

Isolation of Azospirillum:

- ♣ Collected root washed with tap water to remove adhering soil.
- ♣ Cut the roots to small bits 1cm size with help of razer.
- ♣ The root bits are surface sterilized by 1% chloranium T solution for 2-5 times or 0.1% mercuric chloride for 1min, followed by washing with sterile distilled water and phosphate buffer[pH 7]
- ♣ The root bits are inoculated into a semisolid malic medium.
- ♣ Incubate the tubes at room temperature for 3 to 5days.
- ♣ Observe development of pellicles and colour change of medium form yellow to blue.

Carriers:

Soil and farmyard manure in ratio 1:1

Mass production of Azospirillum:

Purified strains of Azospirillum

↓

From agar slant to large flask, ammonia containing medium

↓

Incubate 3-10 days at 28°C

↓

Starter culture transfer to production fermentor

↓

Incubate 3-5 days

↓

Obtain 2x109 cells / ml of medium

↓

Check purity

↓

Mixed with carrier

↓

Adjusted the moisture content to 40%

↓

Packed in polythene bags expelling the air

Application techniques:

- ♣ For nurseries Azospirillum is to be mixed with water and seeds should be sown over night 2kg Azospirillum mixed with 25kg FYM + 25 kg soil and broad caster over field before transplantation.
- ♣ Another method is to prepare slurry of 1 kg Azospirillum in 4 lts of water and dip roots of rice stand for 15 to 30 mins before seedling.

1.3.3 RHIZOBIUM (bacterial biofertilizer)

There are number of steps involved in production of bacterial fertilizers. They are

1. Isolation of rhizobium from root nodules
2. Preparation of culture broth
3. Preparation of carrier
4. Mixing
5. Curing
6. Packaging

1. Isolation of rhizobium from root nodules:

- ✓ Healthy leguminous plants are uprooted, root system is washed with water & nodules which are healthy are selected and preferably on the taproot.
- ✓ Nodules are separated by giving incision from two sides of nodules so as to cut nodule along with root portion.
- ✓ Nodules are washed thoroughly with the running water and then transferred to the sterile beaker & surface sterilized with 0.1% mercuric chloride & 70% ethyl alcohol for 3 minutes & 30 seconds respectively.
- ✓ The alcohol is then decanted & washed with sterile water atleast 6 times.
- ✓ The nodules are then placed in small vial containing sterile water or on porcelain cavity plate & then crushed with sterile glass rod.
- ✓ These suspensions are then plated on CRYEMA plate & incubated at 28°C till small, round, colorless or white colony with central red dot & entire margins develop.
- ✓ Isolated colonies are then transferred to fresh CRYEMA plate for purification.

- ✓ The pure cultures are maintained in YEMA (yeast extract mannitol agar) slants till further use.

2. Preparation of culture broth:

It involves 3 stages:

(a) Preparation of medium:

As stated here YEMA medium is prepared and sterilized.

composition of YEMA medium:

Mannitol	– 10 gm
Yeast extract	– 1 gm
K_2HPo_4	– 0.5 gm
$MgSo_4$	– 0.2 gm
NaCl	– 0.1 gm
Distilled water	– 1000ml
Agar	– 18 gm
pH	– 7.00

Add Congo red (1: 400 aqueous solution) 10 ml to make Congo red YEMA (CRYEMA)

b) Preparation of mother culture:

- ✓ The isolated strain i.e. the master culture is taken & loop full of master culture is transferred into the medium in the flask aseptically.
- ✓ It is kept in shaking incubator for atleast 5-6 hrs daily & the flask is kept in BOD incubator at 27°C for 5-6 days.

c) Preparation of culture broth:

- ✓ With the help of mother culture, the sterilized medium flask are inoculated & incubated at 27°C on a rotary shaker for 5-6 days.
- ✓ This starter culture from the flasks is transferred aseptically to the fermenters containing sterilized medium at rate of 4% by volume.
- ✓ Aeration of the fermenters is done as per the size of the fermenters.
- ✓ At the end of the fermentation, the broth culture should be tested for purity.

3. Preparation of carrier:

- ✓ Carrier is the most important ingredient in biofertilizers formulation.

- ✓ It carries the live microorganisms which function as biofertilizers.
- ✓ The shelf-life of biofertilizers also depends on the quality of the carrier.
- ✓ Most widely used carriers are peat, lignite, charcoal.
- ✓ The qualities of a good carrier material are,
  - High absorptive & easy to process
  - Non-toxic to microorganisms
  - Easy to sterilize
  - Available in adequate amount and inexpensive
  - Provide good adhesion to seed
  - Have pH buffering capacity

Preparation of the carrier involves various steps like,

a) Drying & grinding of the carrier:

Carrier is sun dried up to a moisture level of 5% & ground in grinder, preferably to pass through 100-200 mesh sieve. Particles coarser than this cause 'balling up' when welted and adhere poorly to the seed coat at the time of inoculation & the survival of Bacteria is also poor.

b) Pretreatment of the carrier:

The carriers with finely powdered calcium carbonate (15%) to be neutralized to pH of 6.5 -7.0 & the moisture is maintained.

c) Sterilization of the carrier:

- ✓ The pretreated carrier is filled upto 2/3 of capacity of the container & autoclaved at 126°C for 1-2 hrs. After 3 days, the same lot is resterilized.
- ✓ Gamma irradiation (5 mega radiations) is the preferred method for carrier sterilization over autoclaving.
- ✓ The sterilized carrier is spreaded in trays of appropriate size and cooled down before using.

4. Mixing:

- ✓ Sterilized carrier containing 15% moisture & the broth are mixed under aseptic condition either manually or mechanically in a clean & sterilized room.
- ✓ After mixing also the moisture should be maintained around (35 – 40%). thus, about 20-25 lit culture broth is mixed in 100 kg of carrier.

5. Curing:

- ✓ The mixture is now strained through a sieve and kept overnight covered with thin muslin cloth. This is known as curing.
- ✓ This process will allow complete absorption of culture broth by the carrier to allow the heat of wetting generated by the mixing process to dissipate without elevating the temperature of inoculant to the point where all viability declines.
- ✓ Re growth of culture to higher viable cell count levels will begin during curing process & should continue for several weeks, even after packaging of inoculants.

6. Packaging:

- ✓ Next day, cured culture is filled in LDPE bags (200 gm capacity)
- ✓ Sealing is done after removal of air within the packet.
- ✓ These are then packed with respective duplex boxes with printed instructions.
- ✓ Then further it is packed in units of 100 packets of 200 gm each in corrugated card transportation.

1.3.4 VAM-FUNGAL BIOFERTILIZER

- ✓ The **vesicular arbuscular mycorrhizal** fungi (VAM fungi) are a group of symbiotic, endotrophic mycorrhizal fungi found in roots of higher plants.
- ✓ They are included in the family Endogonaceae of Zygomycetes.
- ✓ VAM fungus infects a plant root & forms vesicles & arbuscles in the roots cortex & a permanent many crop plants like rice, maize, potato, soybean, tobacco, sugarcane, tomato, rubber, papaya & so on.

Morphology of VAM

VAM has 3 distinct regions.

1. External hyphae. 2. Arbuscles. 3. Vesicles.

- ✓ The **external hyphae** are aseptate, dimorphic, thick walled & closely appressed on the root's surface. It extends upto about 1cm from the root's surface. At the point of contact with the plant root, it bears an appresorium.
- ✓ An **arbuscle** is a dichotomously branched, brush-like haustorium produced at the top of fungal hupha in cortical cell. It gets digested as the host cell matures.
- ✓ The **vesicle** is a spherical or oval, thick-walled structure produced at the tip of hypha in the intracellular space or intracellular space. It is rich in fat droplets & hence serves as a storage organ.

- ✓ The spore germinates into a **hypha** called **permanent hypha** on the root surface. This hypha is aseptate & thick-walled.
- ✓ Thin-walled short-lived hyphae arise from the permanent hypha & penetrate root hairs or epidermis to reach the cortex. In the cortex, they grow through the intracellular spaces between the cells.
- ✓ Tips of these hyphae enter the cells & form arbuscles & vesicles. Some of these thin-walled hyphae come out of the plant root & produce spores called chlamydospores.

Isolation of VAM Spores

VAM spores are isolated from the soil in 2 ways. They are

1. Sieving method. 2. Floatation method.

1. Sieving Method

- ✓ In this method, a small amount of soil is treated with hot water (40-45°C) & stirred well to disperse the soil aggregates.
- ✓ The soil particles are allowed to settle down & then the suppression is passed through a series of sieves with the size of 719micrometer, 250micrometer & 75 micrometer.
- ✓ The resulting filtrate is passed through a 45micrometer sieve to collect the VAM spores on the sieve. The spores are dried in shade for mass production.

2. Floatation Method

- ✓ In this method, a small amount of soil is blended well & passed through a sieve to remove large particles.
- ✓ The sieving so obtained is centrifuged in sucrose density gradient at 300rpm for 3minutes.
- ✓ As a result, VAM spores get reached between 20% & 60% sucrose concentrations. The spores are collected & dried to use as inoculum.

Mass Production of VAM:

- ✓ VAM can be produced on a large scale by pot culture technique.
- ✓ The VAM spores are immersed in a solution containing chloramin-T & streptomycin (200ppm) for 15minutes & then washed with distilled water.
- ✓ The spores are mixed with sterilized soil. The soil is filled in pots & seedlings of a host plant are transplanted in the pots.
- ✓ The pots are kept in a green house for 3-4months.

- ✓ Finally, the soil in the pots along with roots of host plants in macerated & dried till it attains 5% moisture. The dried soil-inoculant mixture is used for field application.

Field Application:

There are 2 methods of using the inoculum.

1. VAM fungal inoculant is diluted with water & mixed with seeds to make a pellet of inoculant on them. The seeds are then sown in the main field as usual.
2. In another method, the inoculant is spread uniformly all over the field before ploughing & then crops are transplanted or seeds are sown in that field as usual.

Application of Fungi

- ✓ VAM fungi play the following important role in agriculture.
- ✓ VAM fungi help the plants to intake more Zn, S, Cu, P, Ca, K, Fe, Mn & Br from the soil.
- ✓ VAM fungal infection increases the growth rate in plants. Eg: citrus, maize, wheat, barley etc.
- ✓ VAM fungal infection increases the absorption of water by plants from the soil. It helps to overcome the water stress in the soil while drought prevails.
- ✓ VAM fungal infection increases the concentration of cytokinins & chlorophylls in the plants.
- ✓ It reduces sensitivity of crops towards high level of salts & heavy metals in the soil.
- ✓ It improves the hardiness of transplant stocks by serving as extra root hairs. Eg: pine.
- ✓ VAM provides resistance to plants against various soil borne plant pathogens causing root diseases.
- ✓ In fumigated soils plants show stunted growth. VAM fungal infection reduces the stunting of the plants in such soils.
- ✓ VAM fungal infection increases the yield in crops like potato, maize, barley, etc.
- ✓ When the infected plant is starving for food, VAM gives the plant its own food & protect the plant.

1. Which of the following is incorrectly matched?

(a) Alnus – *Frankia* (b) Alfalfa – *Rhizobium*

(c) Nitrogen fixer – *Anabaena* (d) Mycorrhiza – *Rhodospirrilum*

2. Which of the following nitrogen fixers is found in rice fields associated with *Azolla*?

(a) *Tolypothrix* (b) *Frankia* (c) *Anabaena* (d) *Spirulina*

3. Which of the following is not a biofertilizer?

(a) Mycorrhiza (b) *Rhizobium* (c) *Agrobacterium* (d) *Nostoc*

4. Which of the following is used as a biofertilizer for soybean crop?

(a) *Nostoc* (b) *Azospirillum* (c) *Rhizobium* (d) *Azotobacter*

5. Which of the following is commonly used as a nitrogen fixer in paddy fields?

(a) *Frankia* (b) *Oscillatoria* (c) *Azospirrilum* (d) *Rhizobium*

6. This is not used in organic farming

(a) snail (b) earthworm (c) *Oscillatoria* (d) *Glomus*

7. Which of the following is a nitrogen fixer in the root nodules of *Alnus*?

(a) *Clostridium* (b) *Bradyrhizobium* (c) *Azorhizobium* (d) *Frankia*

8. Which of the following is a pair of biofertilizers?

(a) *Salmonella* and *E.coli* (b) *Rhizobium* and grasses

(c) *Nostoc* and legume (d) *Azolla* and BGA

9. Which of the following fern is a biofertilizer?

(a) *Salvinia* (b) *Azolla* (c) *Pteridium* (d) *Marsilea*

10. Which of the following is an endomycorrhiza?

(a) *Rhizobium* (b) *Agaricus* (c) *Glomus* (d) *Nostoc*

1.4 BIOPESTICIDES

- The word "biopesticides" refers to compounds that, as opposed to general chemical pesticides, are used to control agricultural pests through specialised biological effects. Used to manage pests, biopesticides refer to products containing biocontrol agents, natural entities or chemicals produced from natural materials (such as animals, plants, bacteria, or specific minerals). These agents may also include their genes or metabolites.
- The FAO defines biopesticides as passive biocontrol agents, compared to those that actively seek out the pest, such as parasitoids, predators, and numerous types of entomopathogenic nematodes.

- Large numbers of greenhouse farmers in Michigan are learning that biopesticides can be employed in their integrated pest management (IPM) programs in addition to naturally occurring enemies that can be bought commercially. Growers can benefit from several advantages provided by biopesticides such as lower employee risk, negligible (or no) re-entry and pre-harvest intervals, and compatibility with biocontrol programs.

1.4.1 Importance of Biopesticides

Most farmers attempting to establish a sustainable farming system know that the chemical shed is not their first line of defence against unwanted pests. A “softer” biopesticide or a conventional, synthetic treatment are the farmer’s two options when a pest infestation gets too serious, and a chemical application is required. The Integrated Pest Management (IPM) program combines cultural measures, biological controls (such as predatory insects), and chemical control to keep pest populations under control.

Biopesticides are more environmentally friendly and do not harm the soil, water supply, or wildlife, including beneficial insects, which is one of the main advantages of introducing them into a sustainable agriculture system.

Biopesticides are typically used in rotation with conventional products rather than as a replacement, which reduces the amount of synthetic chemicals used. Insects and diseases develop resilience to synthetic chemicals over time. The effectiveness of the synthetic chemical is increased by alternating it with biopesticides.

- Some inoculants with bacteria are made using the fermentation method. Before planting, these inoculants are sprayed on the seeds, and some of them are released into the plants.
- In organic farming, a solution of *Azotobacter* and synthetic nitrogenase is used to control different insects, weeds, and nematodes.
- The use of biopesticides protects against fluoroacetamide and other chemicals from contaminating the soil. Additionally, they are less likely to affect both human and animal skin.
- Biotechnology enables the direct incorporation of bacterial and fungi toxins that can kill infections and pests into plants. Similar to bacteria, some fungus and virus species have pesticide properties. A biopesticide called spinosad is produced during fermentation.