S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper I - Fundamentals of Microbes and Non-vascular Plants
Name of the Topic	**Origin of life**
Topic Synopsis	▪ Origin of life ▪ Discovery of Microorganisms ▪ Viruses – shapes and symmetry ▪ Tobacco mosaic virus(TMV)
Hours Required	**6**
Learning Objectives	On completion of this topic students will be able to 1. Explain origin of life on the earth. 2. Illustrate diversity among the viruses and prokaryotic organisms and can categorize them.
Pre Knowledge to be reminded	• Life is coeternal with matter and has no beginning; life arrived on Earth at the time of Earth's origin or shortly thereafter. • Life arose on the early Earth by a series of progressive chemical reactions. • Such reactions may have been likely or may have required one or more highly improbable chemical events.

Topic Synopsis

Origin of life:

The origin of life on the earth has been the most attracting and complicated problem for the biologists.

Different views have been forwarded concerning the origin of life on earth.

Theory of Special Creation:

- Proposed by Hebrew and supported by Father Suarez. Living organisms were formed by some supernatural power called God or Creator. This idea has no scientific proof and it is a religious concept

Abiogenesis theory:

1. Life has originated from non living organic matter abiogenetically.

Cosmozoic theory:

2. Proposed by Arrhenius (1908 AD). The life reached earth in the form of spores or seeds from other planets.

Modern concepts:

3. A.I. Oparin (1923) suggested this proposal, and according to him origin of life is by process of evolution from organic matter.

Abiogenesis theory:

Origin of earth:

The earth is originated about 4.5-5 billion years ago. There are two hypotheses on earth origin.

1. **Planetesimal hypotheses** – Earth originated from broken part of sun
2. **Nebular hypothesis** – Proposed by Kent (1753), according to him the earth is originated by condensation of dust from entire solar system.
    - **Primitive Earth-** The primitive earth has hot gasses and vapours elements. Gradually the earth atmosphere was cooled for millions of years and forms atmosphere and seas.
    - **Formation of organic compounds:** After cooling of earth surface the molecules and minerals are combined by condensation and polymerisation to form amino acids, fatty acids and simple sugars.
    - **Formation of complex polymers:** Simple molecules frothier converted into complex molecules like polysaccharides, fats, nucleic acids and polypeptides. These complex polymers war synthesized abiotically.
    - **Formation of Protobionts / Protocells:** The synthesised complex molecules are come together and aggregated to form large colloidal cells called Protobionts. After that these Protobionts are increased in size and stared multiplication
    - **Formation of Eobionts / first cells:** The foregoing development of Protobionts turns in to cell like organisations. These are similar to Mycoplasma. These are common ancestors of Archaebacteria, Eubacteria and Eukaryotes.

Miller-Urey experiment:

- The Miller-Urey experiment was the first attempt to scientifically explore the origin of life.
- In 1953, Stanley Miller and Harold Clayton Urey conceived and built an experiment to simulate a putative primitive Earth environment to prove Abiogenesis theory.

R.H Whittaker Five Kingdom Classification:

- In 1969 R.H. Whittaker proposed five kingdom classification based on the Mode of nutrition, Cell Structure, Source of Nutrition and Body organisation.
    1) Monera
    2) Protista
    3) Fungi
    4) Plantae
    5) Animalia

Discovery of Microorganisms

- Micro organisms derived from Greek words micros (small) and orgonismos (organisms)
- Micro organisms first discovered by A.V. Leeuwen Hoek in 1674.
- Robert hook first illustrate micro organisms in his book MICRO GRAPHIA.

Louis Pasteur experiments:

- He is the first person who proved the biogenesis theory
- He believed each organism can came from pre existing organism.
- He proved that by using S shape flask with nutrient broth.

Germ theory of disease:

- States that diseases are caused by micro organisms

- Germ theory Proposed by G. Fracatoro in 1546 and replaced by miasma theory of Galen (1850) and Later replaced by L. Pasteur and R.K Postulates theory – "Germ Theory of Disease"

Virus:

- Obligate intracellular parasites, cont even microscope, need electron microscope
- M.V. Beijerink demonstrate they differ from other micro organisms
- Have only one type of nucleic acid i.e. DNA/RNA
- TMV is the first crystallised virus, and done by M. Stanly in 1935
- The size of viruses is from 20nm – 300nm.

Shape:

- They are in different shapes include rod shaped (TMV), Polyhedral (Polio virus), Rectangular (Vaccinia virus), Spherical (Adenovirus), Tadpole (Bacteriophage), and Filamentous (M-13 phage).

Structure:

- A virus consist a nuclear core and surrounded by protein coat called Capsid. Some are have tails and tail fibers (Bacteriophage).

Tobacco mosaic virus (TMV)

- Simple rod-shaped helical virus
- Centrally located single- stranded RNA, enveloped by a protein coat
- 3,000 Å in length and about 180 Å in diameter.
- The protein coat is made up of 2,130 sub-units, namely, capsomeres and 49 capsomeres on every three turns of the helix, about 130 turns per rod.
- RNA helix is about 80 Å, and have 7300 nucleotides, 25,000 daltons molecular weight

Multiplication:

The TMV life cycle for replication involves six steps

- Adsorption
- Penetration
- Replication
- Maturation
- Release
- Reinfection

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper I - Fundamentals of Microbes and Non-vascular Plants
Name of the Topic	**Virus**
Topic Synopsis	▪ **Gemini virus** ▪ **Bacteriophage** ▪ **Prions** ▪ **Viroids** ▪ **Disease symptoms of virus in plants** ▪ **Significances of viruses**
Hours Required	**6**
Learning Objectives	On completion of this topic students will be able to 1) Explain origin of life on the earth. 2) Illustrate diversity among the viruses and prokaryotic organisms and can categorize them.
Pre Knowledge to be reminded	• Life is coeternal with matter and has no beginning; life arrived on Earth at the time of Earth's origin or shortly thereafter. • Life arose on the early Earth by a series of progressive chemical reactions. • Such reactions may have been likely or may have required one or more highly improbable chemical events.

Teaching Synopsis

Gemini virus:

- Non enveloped, Icosahedral viriod consist Capsid
- Capsid is twinned or geminate i.e. have two subunits
- Have single stranded circular DNA, either segmented or not segmented
- Segmented DNA is 2500-3000 nucleotides and not segmented DNA have4800-5600.
- These are plant viruses and transmitted by insects

Bacteriophages:

- William Twort discovered Bacteriophage in 1915
- D'Hérelle termed them as 'Bacteriophage' in 1917, as they showed the ability to kill bacteria.
- It is made up of a protein coat known as a Capsid and encapsulates the genome
- It may be enveloped or nonenveloped and have different shapes such as rod-shaped, filamentous, isometric, etc.
- Genome consists of ss or ds DNA or RNA, which is linear or circular form.

Life cycles of Bacteriophage:

- **Lytic Cycle:** They induce complete lyses of the bacterial cell, which is known as a Lytic life cycle. The bacterial cell is completely destroyed immediately after replication.
- **Adsorption**- Anchoring of Bacteriophage to the bacterial cell wall with the help of tails fibres.

- **Penetration-** The phage DNA gets injected into bacteria.
- **Replication and synthesis-** The bacterial DNA is disrupted and the viral genome takes charge of bacterial machinery. It starts making proteins required for replication and other structural proteins.
- **Assembly-** Phage components are assembled into new viral particles.
- **Lysis and release-** Bacterial cells are lysed and new viral particles are liberated to infect other cells.

Lysogenic Cycle:

- The viral DNA gets integrated into the host genome and replicates along with the bacterial genome.
- It is relatively harmless and continues to remain in the position until the lytic cycle is triggered.

Prions:

- The term Prion means proteinaceous infectious particles.
- A Prion is a type of protein that can cause disease in animals and humans by triggering normally healthy proteins in the brain to fold abnormally.
- The proteins have 250 amino acids, and have self replication capacity within the presence of DNA or RNA.
- S.B. Prusiner discovered in 1983 while studying scrapio disease in sheep, and got Nobel Prize in1997.

Viroids:

- Viroids are small single-stranded, circular RNAs that are infectious pathogens.
- They have no protein coat, most cause diseases
- The first discoveries of viroids in the year 1892–1898 by Dmitri Iosifovich Ivanovsky and Martinus Beijerinck.
- Viroids only infect plants, and infectious viroids can be transmitted to new plant hosts by aphids, by cross contamination following mechanical damage to plants as a result of horticultural or agricultural practices,

Disease Symptoms:

- **Chlorosis** (Yellowing),
- **Mosaic** (Intermingling patches),
- **Vein banding, Leaf crinkle**, **Leaf curl** (leaves curl from the margins backward),
- **Enation** (leaf-like outgrowth from the veins),
- **Streak** (chlorotic streaks on leave),
- **Vein clearing** (Yellowing of veins),
- **Necrosis** (death of cell growing shoots),
- **Dwarfing** (decrease in overall size),
- **Rosette, Bunchy top, Twisting** etc. are produced in crop plants.

Significances of viruses:

- **Vaccines**
- **Biopesticides**
- **Cloning Vectors**

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper I - Fundamentals of Microbes and Non-vascular Plants**
Name of the Topic	**Special groups of Bacteria**
Topic Synopsis	▪ **Archaebacteria** ▪ **Actinomycetes** ▪ **Cyanobacteria**
Hours Required	**6**
Learning Objectives	On completion of this topic students will be able to 1. Illustrate diversity among the prokaryotic organisms and can categorize them. 2. Evaluate the ecological and economic value of microbes
Pre Knowledge to be reminded	• Bacteria are very small, Microscopic, Unicellular organisms. They were first observed by A. Van Leewenhoek and he called them animalcules • The term Bacteria are first used by Ehrenberg.

Topic Synopsis

Archaebacteria:

- Archaea constitute a domain of prokaryotes, single celled microorganisms, lacking of cell nuclei, their cell membrane including archaeols.
- These range from organic compounds, such as sugars, to ammonia, metal ions or even hydrogen gas.
- They reproduce by binary fission and budding, endospores formation is not known in them yet.
- Their morphological, metabolic, and geographical diversity permits them to play multiple ecological roles: carbon fixation; nitrogen cycling; organic compound turnover; and maintaining microbial symbiotic and syntrophic communities.

Cyanobacteria:

- Cyanobacteria consisting of free-living photosynthetic bacteria, they are prokaryotes and also called "blue - green algae and them obtain their energy through oxygenic photosynthesis.
- Fresh water or a terrestrial environment, they have flattened sacs like internal membranes called thylakoids help in the photosynthesis.
- They range from unicellular to filamentous and include colonial species,
- **Vegetative cells:** normal, photosynthetic cells that are formed under favourable conditions.
- **Akinetes:** climate-resistant spores that may form when conditions become harsh
- **Heterocysts:** contain the enzyme Nitrogenase, vital for nitrogen fixation in an anaerobic environment due to its sensitivity to oxygen.
- Sexual reproduction including gametes formation, fertilization and zygote formation is absent
- The cyanobacteria also reproduce asexually and the commonest mode of reproduction in them is transverse binary fission.

- Cyanobacteria produce a range of toxins known as cyanotoxins that can pose a danger to humans and animals.
- Cyanobacteria are arguably the most successful group of microorganisms on earth.

Actinomycetes:

- Actinomycetes is a heterogeneous group of bacteria that are gram-positive, filamentous, with a branched growth pattern
- They are prokaryotic and range in size from 1-2 µm in diameter, aerobic organisms but some can be anaerobic
- The mycelium of Actinomycetes sometimes breaks apart to form coccoid or rod-shaped colonies.
- Many members of Actinomycetes are also known to form spores with the sporangia or spore case being found on the aerial hyphae.
- The members of the group range from harmless bacteria to pathogenic species to extremely useful antibiotic producers.
- Reproduction in Actinomycetes is through hyphae fragmentation or spore formation
- They can degrade complex molecules such as cellulose and chitin
- The Actinomycetes are an important source of antimicrobial compounds; they produce up to two-thirds or about 61% of the total antibiotics.
- Ex. Streptomyces griseus, Streptomyces venezuelae, Micromonospora purpurea

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Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper I - Fundamentals of Microbes and Non-vascular Plants**
Name of the Topic	**Eubacteria**
Topic Synopsis	▪ **Eubacteria-Cell structure** ▪ **Nutrition** ▪ **Reproduction** ▪ **Gene transfer** ▪ **Economic importance** ▪ **Symptoms of plant diseases** ▪ **Citrus canker**
Hours Required	**6**
Learning Objectives	On completion of this topic students will be able to 1. Illustrate diversity among the prokaryotic organisms and can categorize them. 2. Evaluate the ecological and economic value of microbes
Pre Knowledge to be reminded	• Bacteria are very small, Microscopic, Unicellular organisms. They were first observed by A. Van Leewenhoek and he called them animalcules • The term Bacteria are first used by Ehrenberg.

Topic Synopsis

Eubacteria:

- Eubacteria are called true bacteria, these are single-celled prokaryotic cell, found in most of the habitats, don't have membrane-bound organelles, individual Eubacterium is 0.5-5 μm in diameter.
- Other than usual asexual reproduction methods, Eubacteria exhibit sexual reproduction methods like conjugation
- Eubacteria exhibit a variety of shapes and arrangements Cocci and bacilli are the major shapes. Vibrio, rods, filaments and spirochetes are the other shapes of Eubacteria

Cell structure

- Lacking a well defined nucleus, The cell wall is made up of peptidoglycans, either gram positive or gram negative bacteria
- The cell wall structure of gram negative bacteria is more complex than gram positive bacterial cell
- bacteria have cholesterol is present in the membrane, have plasma membrane, cytoplasm is composed of mainly water, do not have membrane-bound organelles, Ribosomes are present and Nuclear membrane is absent and have free floating bacterial DNA which is circular (Plasmid) or linear in shape.

Nutrition:

- Eubacteria, diversity in the modes of metabolism is also due to the wide variety of chemical compounds to produce energy in different environmental conditions.

- Some of the main nutritional modes of different species in the domain Eubacteria include Autotrophic, Heterotrophic bacteria.
- **Autotrophic:** Produce own food through photosynthetic processes.
- **Heterotrophic:** Obtain nutrients from their environment (unable to synthesize their own food).Depending upon the source of energy, heterotrophs are divided into three types,
    a) **Parasites:** Depending on living organisms like plants and animals for their food. They cause diseases in host cell, hence they called Pathogens.
    b) **Saprophytes:** Obtain their food from dead and decaying organic matter, and helps for decomposition.
    c) **Symbiotic:** Shows close resemblances with other organism like plants and animals, and don't shows any pathogenic activity on the host cell and they are mutually benefited each other. Ex. E.coli, Lactobacillus, Azitobactor

Reproduction:

- Bacteria can asexually reproduce through binary fission, fragmentation, budding and Endospore etc.
- **Endospore:** During the unfavourable condition, Eubacteria have the ability to become endospores. In this state, the bacteria can tolerate exceedingly high and low temperatures, acidic and basic conditions, and large amounts of radiation.

Gene transfer:

- Bacteria can't reproduce sexually, but they can exchange genetic information with each other.
- Bacterial Recombination is usually carried out in one of the three ways as follows
- **Transformation** – Here, the DNA from one bacterium is transferred to another bacterium.
- **Transduction –** Here, the DNA is transferred from one bacterial cell to a different bacterial cell through a bacteriophage virus. It is known to take place in different bacterial species, namely Escherichia, Micrococcus, Salmonella, etc.
- **Conjugation** – It is a direct transfer of the genome. Here, the genetic material of a bacterial cell of a specific strain is shifted from a donor or male into that of another bacterial cell recipient or female of a different strain. The donor cells have a sex factor or F factor, and the recipient cells do not possess this factor thereby, it is expressed as F- strain.

Economic importance:

The bacteria performs the two type of activities like Beneficial Activities and Harmful Activities

Beneficial Activities:

- **In Agriculture aspect**, they can act as decomposers, helps in maintaining Soil fertility, and nitrogen fixation and as a insecticides and bio pesticides.
- **In Industries aspect**, they can helps in fermentation process, In the Production of Vitamins, In Fiber Retting, In Butanol and Acetone Production, and in the Degradation of Petroleum;
- **In Medical aspects**, production of antibiotics, probiotics, drugs, vaccines, starter cultures, insecticides, medically-useful enzymes

Harmful Activities:

- Some bacteria can cause food Spoilage, Water Pollution, Reduction of Soil Fertility, and cause diseases in plants, animals, and humans.

Citrus canker:

- Citrus canker is a highly damaging disease caused by the bacterium Xanthomonas citri subsp.

- Citrus canker decreases fruit quality and yield, and leads to defoliation, twig dieback, blemished fruit and premature fruit drop
- The disease causes small, round blister-like formations on leaves, branches, stems, new shoots and fruit
- The canker lesions can develop within seven days of infection on leaves.
- The canker lesions ooze bacteria when wet, which can infect new growth, and be dispersed over short distances through wind, rain splash and overhead irrigation
- **Controlling methods:** There is no cure for the disease, so any infected trees have to be destroyed and replanted a new plant. It could be controlled by quarantine, and using resistant varieties.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper I - Fundamentals of Microbes and Non-vascular Plants**
Name of the Topic	**Fungi**
Topic Synopsis	▪ **Characteristics of fungi** ▪ **Ainsworth classification** ▪ **Rhizopus** ▪ **Puccinia** ▪ **Economic importances**
Hours Required	**8**
Learning Objectives	On completion of this topic students will be able to 1. Classify fungi, based on their structure, reproduction and life cycles. 2. Analyze and ascertain the plant disease symptoms due to fungi
Pre Knowledge to be reminded	• Fungi are eukaryotic organisms that include microorganisms such as yeasts, moulds and mushrooms. • These organisms are classified under kingdom fungi.. • The organisms found in Kingdom fungi contain a cell wall and are omnipresent. They are classified as heterotrophs among the living organisms.

Topic Synopsis

Characteristics of fungi:

- Fungi are eukaryotic, non-vascular, non-motile and heterotrophic (lack chlorophyll) organisms, fungi consist of long thread-like structures known as hyphae. These hyphae together form a mesh-like structure called mycelium.
- They may be unicellular or filamentous, reproduce by means of spores, and store their food in the form of starch. Fungi possess a cell wall which is made up of **chitin** and **polysaccharides**.
- They don't have embryonic stage, and the mode of reproduction is sexual (ascospores, basidiospores, and oospores) or asexual (conidia or zoospores, & sporangiospores), they are parasitic and can infect the host produce a chemical called pheromone which leads to sexual reproduction. Examples include mushrooms, moulds and yeast.

Classification:

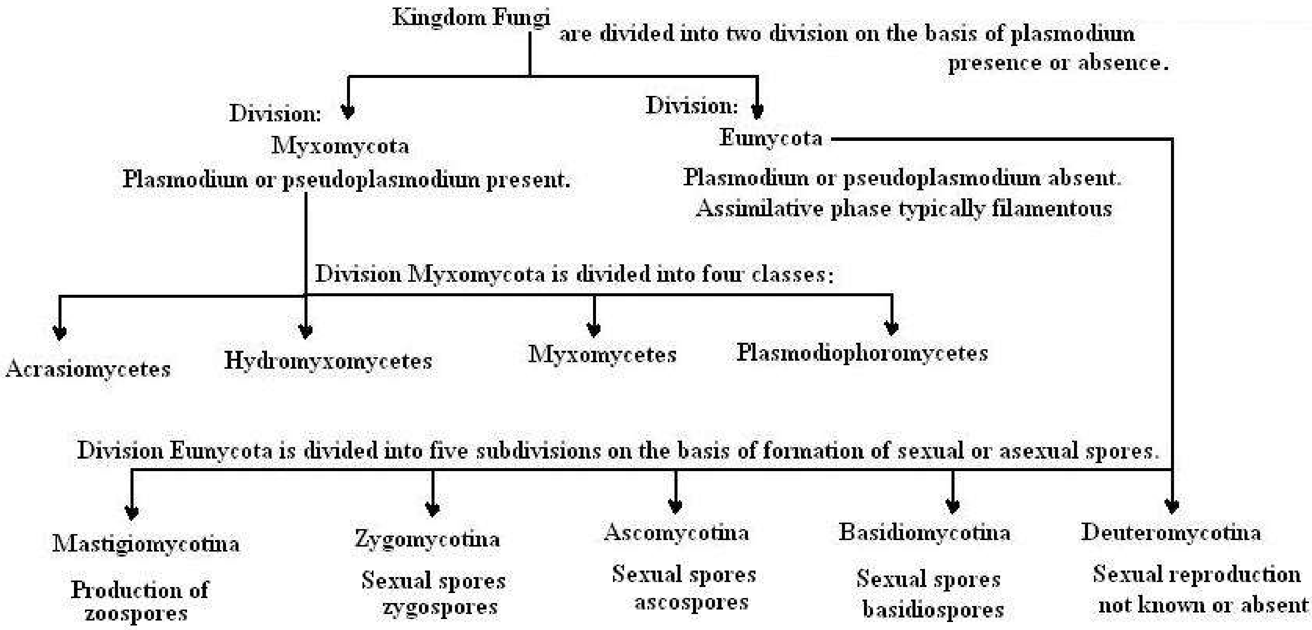
Kingdom Fungi are classified based on different modes

- **Based on Mode of nutrition:** Saprophytes, Parasitic and Symbiotic
- **Based on the formation of spores:** Zygomycetes, Ascomycetes, Basidiomycetes, and Deuteromycetes

Ainsworth classification

- Ainsworth G. C. (1966, 71, 73) proposed a more natural system of classification of fungi.

- This classification is based on morphology, especially of reproductive structure



Rhizopus:

- Rhizopus is a genus of saprophytic and parasitic fungi. They are found in moist or damp places.
- They are found on organic substances like vegetables, fruits, bread, jellies, etc. The vegetative structure is made up of coenocytic (multinucleated) branched hyphae.

Taxonomic position of Rhizopus

Mycota, Eumycotina, Zygomycetes, Mucorales, Mucoraceae, Rhizopus, Stolinifer

Structure

- They are fast-growing fungi and have a cottony appearance
- The body of Rhizopus consists of branched mycelium.
- The mycelium is coenocytic and composed of three types of hyphae; stolen, rhizoids and sporangiospores
- Rhizoids are formed where the stolen touches the substratum at nodes

Reproduction:

- **Vegetative reproduction:** Vegetative reproduction is by fragmentation and each of the fragments of a stolen develops separately making a complete mycelium
- **Asexual reproduction:** Asexual reproduction is by the formation of sporangiospores and chlamydospores
- **Sporangiospores:** Sporangiospores are formed terminally in sporangia of aerial mycelium called sporangiophores. They are formed under favourable conditions.
- **Chlamydospores:** Chlamydospores are formed during unfavourable conditions. An intercalary segment of mycelium develops due to the formation of septae and accumulation of protoplasm
- **Sexual reproduction:** Sexual reproduction is by fusion of two compatible hyphae. Most of the Rhizopus species (R. stolonifer) are heterothallic, i.e. having different mycelium for + and – mating strains.
- **Economic Importance:** Many Rhizopus species are commercially used to produce various chemicals and alcoholic products

Puccinia Graminis:

- **Habit and Habitat:** P. graminis is obligate parasite, polymorphic, macro cyclic and heteroecious rust, It affects wide range of hosts including wheat, barley, oats and rye.
- P. graminis tritici involves in its life cycle two distinct alternate host plants i.e., wheat (Triticum vulgare fam. Poacae) and Barberry (Berberis vulgaris fam. Berberidaceae).
- The wheat plant is called the primary host and the barberry plant is secondary or alternate host.
- **Symptoms of Puccinia on Wheat:** The symptoms of the disease appear as large, elongated and brown pustules (uredosori) on the stem, leaf, sheath and leaf, Later these brown pustules change into black coloured large pustules.
- **Symptoms of Puccinia on Barberry:** Infection first starts on the dorsal surface of the leaf in the form of minute, dark coloured and flask shaped pycnia which appear as yellow spots.
- **Vegetative Structure of Puccinia Graminis:** The mycelium is dikaryotic on primary host and monokaryotic on the secondary or alternate host. The monocaryotic mycelium is also called hapiomycelium or primary hyphae and the dikaryotic mycelium is called secondary hyphae.
- **Life Cycle of Puccinia Graminis:** Puccinia graminis is long cycled rust (macro cyclic). At the time of reproduction it produces five distinct stages in a regular sequence.
- **Stage 0:** Spermogonia bearing spermatia and receptive hyphae.
- **Stage I:** Aecia bearing aeciospores.
- **Stage II:** Uredia bearing uredospores.
- **Stage III:** Telia bearing teleutospores.
- **Stage IV:** Promycelia bearing basidiospores.
- Out of these five stages, Uredo stage, Teleuto stage are produced on the primary host (wheat) and remaining two stages, (spermogonial and aecial stages) are produced on the secondary host i.e., barberry

Economic uses of fungi:

Fungi are an important organism in human life. They play an important role in medicine by yielding antibiotics, in agriculture by maintaining soil fertility, are consumed as food, and form the basis of many industries. They help in controlling the population of pests as Biological Insecticides.

Signature of the Lecturer

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper I - Fundamentals of Microbes and Non-vascular Plants**
Name of the Topic	**Lichens**
Topic Synopsis	▪ **Structure** ▪ **Reproduction** ▪ **Ecological importance** ▪ **Economic importance**
Hours Required	**4**
Learning Objectives	On completion of this topic students will be able to 1. Classify fungi, lichens based on their structure, reproduction and life cycles. 2. Evaluate the ecological and economic value of Lichens
Pre Knowledge to be reminded	• Lichen is not a single organism but a symbiosis among different organisms like fungus and a cyanobacterium or algae.

Teaching Synopsis:

Lichens:

- Lichen is not a single organism but a symbiosis among different organisms like fungus and a cyanobacterium or algae. The fungal part is called mycobiont and non-fungal part is called phycobiont that contains chlorophyll.
- The species of Ascomycetes or Basidiomycetes are the most common fungi in lichens. The common algal partners are either green algae Chlorophyta or Cyanophyceae family of blue-green bacteria.
- **Types of lichens:** Hawks worth and Hill (1984) categorised the lichens into five main types or forms:
- **Leprose:** This is the simplest type, where the fungal mycelium envelops either single or small cluster of algal cells. The lichen appears as powdery mass on the substratum (Lepraria incana).
- **Crustose:** These are encrushing lichens where thallus is inconspicuous, flat and appears as a thin layer or crust on substratum like barks, stones, rocks etc (Graphis, Lecanora)
- **Foliose:** These are leaf-like lichens, where thallus is flat, horizontally spreading and with lobes (Ex. Parmelia, Physcia).
- **Fruticose:** These are shrubby lichens, where thalli are well developed, cylindrical branched, shrub-like, either grow erect (Cladonia) or hang from the substratum (Usnea).
- **Filamentous:** In this type, algal members are filamentous and well-developed. The algal filaments remain ensheathed or covered by only a few fungal hyphae (Racodium, Ephebe).

Structure of Thallus:

- Based on the distribution of algal member inside the thallus, the lichens are divided into two types. Homoisomerous or Homomerous and Heteromerous.
- **Homoisomerous or Homomerous:** Here the fungal hyphae and the algal cells are more or less uniformly distributed throughout the thallus. Ex. Crustose lichens

- **Heteromerous:** Here the thallus is differentiated into four distinct layers upper cortex, algal zone, medulla, and lower cortex. The algal members are restricted in the algal zone only. This type of orientation is found in foliose and fruticose lichens.
- **Breathing Pore:** In some foliose lichen the upper cortex is interrupted by some opening, called breathing pores, which help in gaseous exchange.
- **Cyphellae:** On the lower cortex of some foliose lichen (e.g., Sticta) small depressions develop, which appears as cup-like white spots, known as Cyphellae, help in aeration.
- **Cephalodium:** These are small warty outgrowths on the upper surface of the thallus.

Reproduction:

- Lichen reproduces by all the three means, vegetative, asexual, and sexual reproduction.
- **Vegetative Reproduction:** It takes place by Fragmentation and Death of Older Parts
- **Asexual Reproduction:** It takes place by Soredium, Isidium, and Pycniospore during unfavourable condition.
- **Soredium:** These are small grayish white, bud-like outgrowths developed on the upper cortex of the thallus composed of one or few algal cells loosely enveloped by fungal hyphae.
- **Isidium:** These are small stalked simple or branched, grayish- black, coral-like outgrowths, developed on the upper surface of the thallus. Under favourable condition the isidium germinates and gives rise to a new thallus.
- **Pycniospore:** Some lichen develops pycniospore or spermatium inside the flask-shaped pycnidium. They usually behave as gametes, but in certain condition they germinate and develop fungal hyphae.
- **Sexual Reproduction:** Only fungal partner of the lichen reproduces sexually and forms fruit bodies on the thallus. The nature of sexual reproduction in ascolichen is like that of the members of Ascomycotina, whereas in Basidiolichen is like that of Basidiomycotina members**.**

Economic Importance of Lichens:

- The lichens are useful as well as harmful to mankind. The useful activities are much more than harmful ones. They are useful to mankind in various ways: as food and fodder, as medicine and industrial uses.
- **As Medicine:** Lichens are medicinally important due to the presence of lichenin and some bitter or astringent substances. They have been used in the treatment of jaundice, diarrhoea, fevers, epilepsy, hydrophobia and skin diseases
- **Industrial Uses:** Lichens of various types are used in different kinds of industries like Tanning Industry, Brewery and Distillation, Preparation of Dye, Cosmetics and Perfumery.
- **Ecological importance:** Lichens have some ecological importance like, Pioneer of Rock Vegetation, Accumulation of Radioactive Substance, and Sensitivity to Air Pollutants i.e. as “pollution indicators.

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper I - Fundamentals of Microbes and Non-vascular Plants
Name of the Topic	**Algae**
Topic Synopsis	▪ Characteristics of Algae ▪ Fritsch classification ▪ Spirogyra ▪ Polysiphonia ▪ Economic importances
Hours Required	10
Learning Objectives	On completion of this topic students will be able to ▪ To know the history of phycology. ▪ To understand about the algal habitats, their cell organization and how they reproduce in nature to maintain their life on earth.
Pre Knowledge to be reminded	• The term "algae" was coined by Linnaeus in 1754 but he had used this term for the plants we know as bryophytes now a days.

Teaching Synopsis:

Algae

- Algae are an informal term for a large and diverse group of photosynthetic eukaryotic organisms.
- Algae are chlorophyll bearing thalloid plants with no differentiation into tissue or tissue system.
- All the algae (except few) are aquatic
- Sex organs are unicellular generally, when multicellular, each cell is capable to reproduce
- Sex organs are never surrounded by sterile jacket layer.
- No embryo is formed after gametic fusion.
- Sporophytic and gametophytic generations are independent when represented in life cycle.
- Reproduction in algae takes place by vegetative, asexual and sexual modes

Classification:

F.E. Fritsch (1935, 1945) in his book "The Structure and Reproduction of the Algae" proposed a system of classification of algae. He treated algae giving rank of division and divided it into 11 classes based upon characters of pigments, flagella and reserve food material.

- **Chlorophyceae:** (Chlorophyll b and carotenoids) (starch)
- **Xanthophyceae:** (xanthophylls) (fat)
- **Chrysophyceae:** (Phycocyanin) (leuosin)
- **Bacillariophyceae:** (Diatomin)
- **Cryptophyceae**
- **Dinophyceae:** (yellow or brown or red coloured) (oil or starch)
- **Chloromonadineae:** (Xanthophyll) (Fat)
- **Euglenineae** (Chlorophyll) (Starch)
- **Phaeophyceae:** (Fucoxanthin) (laminarian, mannitol)
- **Rhodophyceae:** (Phycocyanin, chlorophyll-a, carotene and xanthophyll)(floridean starch)
- **Myxophyceae:** (phycocyanin, phycoerythrin and allophycocyanin) (myxophycean starch)

Thallus organization:

The thallus of algae ranges from simple unicellular to the highly organized one having differentiation of tissues yet lack vascular tissues.

1. **Unicellular motile form:** Unicellular motile algae can move with the help of flagella
2. **Unicellular non-motile forms:** These unicellular forms don't have flagella.
3. **Multicellular colonial forms:** Many cells come together and forms colony and each cell of colony is capable of doing life processes.
    - **Motile coenobial colony:** A colony formed of definite number of cells arranged in a specific manner is known as coenobium.
    - **Non-motile coenobial colony or coccoid form:** Definite numbers of cells are closely attached together in specific manner and do not have flagella as locomotory organ.
    - **Palmelloid form:** cells are aggregated together in a gelatinous matrix of indefinite shape but the number of cells are not fixed as in the case of coenobium
    - **Dendroid form:** This is also a non motile colony of unfixed number of cells but differs from palmelloid form in having attachment of cells to the substratum
4. **Filamentous form:** Filamentous thallus may be of indefinite length. The cells are attached end to end in a linear fashion and form a filament.
    - **Unbranched filament**
    - **Branched filament**
    - **False branching**
5. **Siphonaceous form:** The thallus is coenocytic non-septate, multinucleate siphon like structure.
6. **Heterotrichous form:** This is a highly advanced type of thallus which is characterized by the differentiation of plant body into prostrate and erect system.
7. **Pseudo parenchymatous form:** thallus which looks like parenchymatous but not a true parenchymatous form.
8. **Parenchymatous Form:** Parenchymatous thallus organization is a modification of the filamentous habit; in which cell division occur in various directions to form parenchymatous structure.

Life cycle:

- In plants, both haploid and diploid cells can divide mitotically and proliferate to produce gametophyte (n) and sporophyte (2n), respectively. Plants that undergo sexual reproduction, alternate between the haploid and diploid stages. This is known as alternation of generations.
- Based on the dominant stage of their life cycle, they are categorized into three types:
- **Haplontic Life Cycle** – The dominant stage is the haploid gametophyte. The diploid sporophyte is only represented by the zygote, which is diploid. e.g. Volvox, Spirogyra, Chlamydomonas, etc
- **Diplontic Life Cycle –** The diploid sporophyte is the dominant stage. It shows gametic meiosis. Examples for diplontic life cycle: Brown algae *Fucus*, etc.
- **Haplodiplontic Life Cycle –** Here both haploid and diploid stages are multicellular. In some, the gametophyte is dominant and free-living and the sporophyte is a small and short-lived phase, which is dependent on gametophytes, e.g. Bryophytes.

Spirogyra

- Spirogyras are free-floating green algae present in freshwater habitats such as ponds, lakes, etc. Spirogyra is commonly known as "water silk or pond silk".
- The vegetative structure of Spirogyra is an unbranched filamentous thallus
- The thallus is multicellular with each cylindrical cell joined end to end
- They are 10-100 µm in width and may grow several centimetres in length
- They are present as a slimy mass due to the presence of mucilage sheath around the filament
- The cell wall is made up of two layers, inner cellulose and outer pectose. The slimy mucilage sheath is due to the dissolution of pectose in water
- In each cell, there is a nucleus, cytoplasm, a large central vacuole and spiral chloroplasts
- Chloroplasts are ribbon-shaped and arranged spirally. There may be 1-16 chloroplasts present in a cell

Reproduction

- Spirogyra undergoes vegetative, asexual and sexual reproduction. The life cycle of Spirogyra is haplontic, i.e. the dominant stage is free-living haploid (n) gametophyte and the sporophyte is represented only by the diploid zygote (2n)
- **Vegetative reproduction:** Vegetative reproduction is by fragmentation. Under favourable conditions, vegetative reproduction is the preferred mode of reproduction.
- **Asexual reproduction**: found in few of the species of Spirogyra. Asexual reproduction is by the formation of Azygospores, Akinetes or aplanospores.
- Sexual Reproduction: Sexual reproduction in Spirogyra is isogamous, i.e. male and female gametes of similar size fuse together in the sexual reproduction. It is done by conjugation and is of two types
- **Scalariform Conjugation: Two** filaments of Spirogyra sp come together and lie side by side. The structure formed looks like a ladder, so it is named as scalariform conjugation
- Lateral Conjugation: Adjacent cells of a Spirogyra sp function as male and female gametes. Conjugation tubes are formed between cells of the same filament. Life cycle of Spirogyra is "Haplontic type".

Polysiphonia

General features

- Polysiphonia is a red algae, marine, lithophyte or epiphyte, attached to the substrate by small flattened disks;
- Laterally or dichotomously Branched, lateral branches are two kind : the ordinary branches and the trichiblasts
- **The ordinary branches** are polysiphonous with unlimited growth, similar to main axis,
- **The tricoblasts** are uniseriate, usually colourless, and bear the sex organs, They are attached by rhizoids,
- The thallus consists of fine branched filaments each with a central axial filament supporting pericentral cells, and Sexual reproduction is advanced Oogamy.

Life-cycle

- The life-cycle of the red algae has three stages i.e. gametangial, carpospoangial and tetrasporangial phases.
- Male gametophytes produce spermatia and the female gametophytes produce the carpogonium which remains attached to the parent female plant. After fertilization the diploid nucleus migrates and fuses with an auxiliary cell.
- These spores settle and grow to become the male and female plants thus completing the cycle.

Economic importance of algae:

- Food source, Medicines, Biological indicator and Pisciculture

Signature of the Lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper I - Fundamentals of Microbes and Non-vascular Plants**
Name of the Topic	**Bryophytes**
Topic Synopsis	▪ **Characteristics of Bryophytes** ▪ **Classification** ▪ **Marchantia** ▪ **Funaria** ▪ **Evolution of saprophyte**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to ▪ To know the Evolution of bryophytes. ▪ Classify bryophytes based on their structure, reproduction and life cycles. ▪ Recall and explain the evolutionary trends among amphibians of plant kingdom for their shift to land habitat
Pre Knowledge to be reminded	• The term "algae" was coined by Linnaeus in 1754 but he had used this term for the plants we know as bryophytes now a days.

Teaching Synopsis:

Bryophytes

- The term Bryophyta came from the word 'Bryon' which means moss and python means plants. Bryophyta includes embryophytes like mosses, hornworts, and liverworts.
- These are the plants that grow in shady and damp areas and are small in size. They lack vascular tissues. They reproduce through spores instead of producing flowers and seeds.

General Characteristics

- Plants occur in damp and shaded areas, the plant body is thallus-like, i.e. prostrate or erect, attached to the substratum by rhizoids(unicellular or multicellular)
- Plants lack the vascular system (xylem, phloem), the dominant part of the plant body is the gametophyte which is a haploid,
- The gametophyte bears multicellular sex organs antheridium and archegonium and photosynthetic.
- The antheridium produces antherozoids (flagellated) and archegonium is produces one egg.
- The antherozoids fuse with an egg to make a zygote, and the zygote develops into a multicellular sporophyte which is semi-parasitic and dependent on the gametophyte for its nutrition.
- Cells of sporophyte undergo meiosis to form haploid gametes which form a gametophyte. The sporophyte is differentiated into foot seta and capsule.

Classification of Bryophytes

- According to the newest classification, Bryophyta is split into three classes:

- **Hepaticopsida (Liverworts):** The gametophyte plant is either thalloid or foliose, lobed, and dichotomously branched, unicellular, branched, and septate Rhizoids, Sex organs are borne dorsally embedded in gametophytic tissues

- **Anthocerotopsida (Hornworts):** The gametophytic body is flat, dorsiventral, simple thalloid, and has no internal differentiation and each cell has one chloroplast with a pyrenoid. Sporogenous tissues develop from amphithecium, and Pseudoelaters are present in the capsule.
- **Bryopsida (Mosses):** The gametophyte is divided into protonema and foliose gametophores, and leaves without a midrib, Sex organs are borne apically on the stem, Sporogenous tissues develop from endothecium.

Marchantia

- Habitat- moist and shady places, Morphology- thalloid dorsiventral, flat and dichotomously branched, and the gametophyte is the dominant phase of plant life.
- The dorsal surface contains diamond-shaped markings and the ventral surface contains scales and rhizoids,
- The reproductive bodies are present on the dorsal surface; Sexual reproductive organs are born on the stalks called antheridiophore and archegoniophore.
- Asexual reproduction in Marchantia is by fragmentation or by forming specialised structures known as gemmae.
- Sexual Reproduction- Marchantia is dioecious, both sex organs develop on different thalli
- The antheridium produces antherozoids (Bi flagellated) and archegonium is produces one egg, they need water for fertilization,
- The archegonia swells after absorbing water neck canal cells and the ventral canal cell disintegrate and form a mucilaginous mass, which oozes out.
- The antherozoids get attracted and swim towards archegonia, by triggering the chemotactic response of archegonia.
- The male and female nuclei fuse together to form a diploid cell called the zygote.
- The diploid zygote does not undergo meiosis immediately; it rather divides mitotically and develops into a multicellular structure called the sporophyte it is not the free-living stage, it is dependent on the gametophyte for nourishment

Funaria

- Funaria is divided into two stages: leafy gametophyte and sporophyte, and the gametophyte is the main plant body that is represented by a juvenile and an adult stage
- The haploid plant body is divided into stem, leaves and rhizoids, stem is erect, branched, green and photosynthetic, leaves are sessile and almost ovate in shape and have a distinct midrib and arranged spirally on the stem.
- The stem is fixated on the substratum by rhizoids, which is branched, multicellular and appear like root hairs.
- The male reproductive organ or antheridium and the female reproductive organs or the archegonium are borne on different branches of the same plant.
- The sporophyte is attached to the archegonium in parasitic nature and is divided into a foot, seta and capsule.
- Funaria reproduces by both vegetative and sexual methods.
- **Vegetative Reproduction:** done by protonema, Bulbils (small resting buds that arise from the rhizoids), Gemmae, and Apospory (development of gametophyte from sporophyte without spore formation)

- **Sexual Reproduction:** sexual reproduction is of oogamous type; the main shoot of the gametophyte bears the antheridium in clusters and acts as the male branch. The female branches arise as lateral outgrowth from the base of the male branches and bears archegonia
- **Antheridium:** club shaped structure that has a short and stout multicellular stalk and the apex of the antheridium has a few layered thick walls called opercular cells. The androcyte mother cells are present below the wall layer and mother cell divides to form two androcytes which further gives rise to biflagellated and elongated sperm or spermatozoid.
- **Archegonium:** The archegonium is a flask shaped structure, and consists of swollen venter and a narrow neck, attached to the female branch by a stalk. The neck consists of an axial row of 8-12 neck canal cells and venter cavity contains a ventral canal cell and an egg. On maturity, the neck canal cells and ventral canal cells disorganise to form mucilage which helps in chemotactic response.
- The spermatozoids reach the archegonium by pollination by wind or splashing raindrops.
- Spermatozoid fuses with the egg cell to form a zygote which later develops into a sporophyte.
- **Sporophyte:** Sporophyte is the diploid plant of Funaria is attached to the gametophyte like a parasite, and has Foot, Seta, and Capsule. Capsule is the body of the sporophyte where spores are developed the Capsule consists of three parts namely Apophysis, Theca and Lid.
- As the capsule matures, the operculum is thrown off by the rupture of annulus, exposing the peristome teeth to the air.
- The spores produced by sporophytes are called meiospores. The haploid spores are produced in the capsule by reductional division, absorbs moisture and swells up, rupturing the exine and intine grows into a germ tube and later into a branched filamentous structure called protonema.
- The protonome grows on the substratum by fixing itself with rhizoids. Many lateral buds are produced from the grown protonema which gives rise to gametophytes.

Evolution of sporophyte

- There are mainly two theories regarding the evolution of sporophytes
- **Theory of progressive evolution:** According to this theory, the early sporophyte of bryophytes was uncomplicated and almost all of the sporogenous tissue was fertile (e.g., Riccia) and from this type of sporophyte, the more complex sporophytes (e.g., mosses) are said to have evolved by the process of progressive sterilisation of potential sporogenous tissue known by the name of "Theory Of Sterilisation"
- **Theory of regressive evolution:** According to this theo-ry, the simplest sporophyte of Riccia (which is composed of a simple capsule) is the most advanced kind which is said to have evolved by the simplifica-tion or progressive reduction of the more complicated sporophytes (foliose with complex assimilatory tissue and functional stomata) of mosses (e.g. Funaria, Pogonatum, Polytrichum etc.) This theory is also known as "Retrogressive Theory".

Signature of the Lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper II - Basics of Vascular plants and Phytogeography
Name of the Topic	**Pteridophytes**
Topic Synopsis	▪ **General characteristics** ▪ **Smith classification** ▪ **Lycopodium** ▪ **Marsilea** ▪ **Stelar evolution** ▪ **Heterospory and seed habit**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Classify and compare Pteridophytes based on their Morphology, anatomy, reproduction and life cycles. 2. Justify evolutionary trends in tracheophytes to adapt for land habitat.
Pre Knowledge to be reminded	• Before the flowering plants, the landscape was dominated with plants that looked like ferns for hundreds of millions of years. Pteridophytes show many characteristics of their ancestors. • Unlike most other members of the Plant Kingdom, Pteridophytes don't reproduce through seeds, they reproduce through spores instead.

Topic Synopsis

Pteridophytes:

- Pteridophytes are considered as the first plants to be evolved on land.
- They are cryptogams, seedless and vascular.
- The plant body has true roots, stem and leaves.
- Spores develop in sporangia- They are usually homosporous some are heterosporous.
- Sporangia are produced in groups on sporophylls - Leaves that bear the sporangia are termed as sporophylls and the tip of the leaves tends to curl inwards to protect the vulnerable growing parts.
- Sex organs are multicellular and the male sex organs are called antheridia, while the female sex organs are called archegonia
- They show true alternation of generations - the sporophyte generation and the gametophyte generation are observed in Pteridophytes. The diploid sporophyte is the main plant body

Classification

According to Smith (1955) Pteridophytes are classified into four divisions, such as Psilopsida, Lycophyta, Sphenophyta, and Pterophyta.

- **Psilopsida:** Most primitive, Root less and have rhizoids, dichotomously branched, photosynthetic stem, leaves often absent, protostele and homosporous, ex. Rhynia, Horneophyton.
- **Lycophyta:** Differentiated plant body, microphyllous leaves, have protostele or siphanostele, sporophylls are aggregate and form cone or strobili, and homosporous or heterosporous, gametophyte depends on fungus for food.
- **Sphenophyta:** All are fossils expect Equisitum, differentiated plant body, stem jointed with nodes and inter nodes, scaly leaves seen as whorl around the node, sporangia formed strobili or cone and homosporous.
- **Pterophyta:** Most widely distributed vascular cryptograms, well differentiated plant body, mostly rhizomatous, microphyllous leaves called fronds, young leaves show circination, protostele and siphanostele or dictyostele, sporangium from sori on the aboxial side of the leaf, sporocarp in marseliya, indusium may be true or false, homosporous or heterosporous, and antherozoids are multi flagellated.

Lycopodium

- **Morphology** the plant has creeping stem with erect tips, dichotomously branched, smaller and erect branches bear cone or strobili at the tips containing spores, rhizome remains completely or partially subterranean, Stems are densely covered with small moss like leaves that are spirally arranged and are simple, sessile, with serrate margins, pointed tip and single median vein.
- **Strobilus** are distinct, yellowish to cream in colour when mature, 2.5-5.0 cm long, compact and are borne at the tips of special erect shoots, he sporophylls possess a small flange on ventral side and protects the sporangium.
- **Sporangium** arises on the dorsal (adaxial) surface of the sporophylls, spores become mature, central axis of strobili elongates.
- The exposed sporangia become dry, wall splits and disseminate the spores.
- **Spores** are light yellow in colour, homosporous, unicellular with single nucleus, filled with oil and fat, etrahedral in shape with a rounded or semicircular base.
- Spores take about 3-8 years to germinate under moist conditions to form prothallus.
- **Prothallus** is top shaped, tuberous, yellowish brown in colour and about 15 mm long
- The lower conical region bearing numerous rhizoids and upper broad generative region several archegonia on the margins and antheridia on the centre.
- **Antheridia** produce biflagellate spermatozoids, and one spermatozoid reaches the egg and effect fertilization forming oospores.
- **Oospore** is converted into embryo by cell division which later becomes young plant.

Marsilea

- Marsilea is commonly known as "water clover" or "water fern", they grow rooted in mud or marshes and shallow pools or are completely submerged.
- Plant body is Sporophytic and herbaceous plant. The plant body is differentiated into rhizome, leaves and roots. Root is protostelic.
- Rhizome which creeps on or just beneath the soil surface. It is slender, dichotomously branched with distinct nodes and internodes. Rhizome is protostelic in nature.
- Leaves are borne alternately on upper side of rhizome at nodes show circinate venation and submerged plants, lamina floats over the surface of water
- The roots are adventitious, arising from the underside of the node of rhizome,
- Marsilea reproduces by two methods i.e. Vegetative/Asexual reproduction and Sexual Reproduction
- **Vegetative/Asexual reproduction:** It takes place by means of tubers which are produced in unfavourable conditions from the rhizome.
- **Sexual Reproduction:** Marsilea is heterosporous i. e., it produce two types of spores microspores and megaspores.
- These sporangia are borne in special type of spore producing organ called sporocarp which is born laterally on the base of the petiole.
- The development of micro and megasporangia is of lepto-sporangiate type.
- The decaying of the wall of the sporocarp takes place due to bacterial action and thus the sporangia and spores are liberated.
- The gelatinuous ring absorbs water and extends greatly through the open margins of the sporocarp thus dragging out sori along with it. The gelatinous ring bears two alternating rows of sori.
- The microspores and the megaspores are the unit of male and female gametophytes respectively.
- The microspore is developing into male gametophyte, later it produces antherozoids.
- The megaspore is developing into female gametophyte, later it produces oosphere or egg.
- Within the antherozoids only one enters the egg's cytoplasm and fuses with the egg nucleus to form zygote.
- The zygote is the mother cell of the next Sporophytic generation

Stelar Evolution in Pteridophytes

- Stele is the central cylinder or core of vascular tissue in higher plants.
- The stele consists of xylem, phloem, pericycle and medullary rays and pith.
- The term stele was first time used by Van Tieghem and Douliot in 1886 on their "Stelar theory"
- On the basis of ontogeny and phylogeny there are three types of steles are present, i.e. Protostele, Siphono stele and Solenostele.
- **Protostele:** Within this stele a solid core of xylem and it is surrounded by phloem, pericycle and endodermis is called protostele. Hear the pith is absent and it is the simplest Stelar organisation. It shows five variations on their organization.
- **Haplostele:** Smooth central xylem surrounded by phloem. Ex. Rhynia and Lygodium

- **Actinostele:** Star shaped xylem and separate the phloem in to separate portions. Ex. Lycopodium, Serratum.
- **Plectostele:** phloem and xylem are arranged in plate or disk like manner. Ex. L. Clavetum.
- **Mixedprotostele:** Xylem appears as patches in phloem. Ex. L. Sernum
- **Mixedprotostele with pith:** xylem and phloem have pith like organisation at centre of stele but the pith is not real, but appear as a pith. Ex. Hymeno phyllum
- **Siphonostele:** Protostele organisation with centrally located pith is called Siphonostele. Hear three types of steles are present.
- **Ectophloic Siphonostele**: Xylem was surrounded by phloem from outside and pith from inside. Ex.Ormunda
- **Amphiphloic Siphonostele:** Xylem was surrounded by phloem from both sides means outside and inner side of the stele. Ex. Marsilea.
- **Cladosiphonostele:** Etactosiphonostele with leaf traces. Ex. Selaginella.
- **Solenostele:** It treated as a type of Siphonostele, hear stele have leaf gaps in their organisation is called as Solenostele.
- **Ectophloic Solenostele:** Solenostele with only single layer of phloem with leaf gaps.
- **Amphiphloic Solenostele:** Solenostele with two layers of phloem and leaf gaps. Ex. Adianatum
- **Dictyostele:** Solenostele have number of vascular bundles arranged in circular ring. Ex. Pteris.
- **Polycyclic stele:** Many vascular bundles arranged in more than one ring. Ex. Pteridium auilinium.
- **Eustele:** Vascular bundles are arranged in broken ring manner. Ex. Dicots
- **Atacto stele:** vascular bundles are arranged in scattered manner. Ex. Monocots

Heterospory and Seed Habit

- **Heterospory:** Some Pteridophytes produce two different types of spores (differing in size, structure and function). Such Pteridophytes are known as heterosporous and the phenomenon is known as Heterospory.
- The two types of spores are microspores and megaspores. Microspores are smaller in size and develop into the male gametophyte while the megaspores are large and develop into female gametophyte.
- The origin of Heterospory can be better discussed on the basis of evidences from paleobotany, developmental and experimental studies.
- **Palaeobotanical evidences:** Palaeobotanical evidences show that the earlier vascular plants wart all homosporous and the heterosporous condition appeared subsequently in the lowermost upper Devonian. A number of heterosporous genera belonging to the Lycopsida, Sphenopsida and Pteropsia were known in the late Devonian and early Carboniferous periods.
- **Developmental Studies:** The development of micro and megasporangia follow the same pattern. They have identical organization but for their size. While in megasporangia most of the spore mother cells degenerate but in microsporangia only a few mother cells are

disorganize. The phenomenon of Heterospory becomes distinct either before or after meiosis.

- **Experimental Studies:** Experimental studies on Selaginella (Goebel, 1905) and Marsilea (Shattuck, 1910) suggest that nutritional factors mainly govern the Heterospory. Under conditions of low light intensity, the photosynthetic activity of Selaginella was retorted and it produced microsporangia. By sudden lowering of the temperature, the size of the microspores in the sporocarp of Marsilea increases by six times.
- **Seed Habit in Pteridophytes:** The adoption of Heterospory and the retention and germination of a single megaspore within megasporangium to form a female gametophyte, led to the phenomenon of "seed habit", a characteristic feature of the spermatophytes. A seed is that ovule which contains an embryo developed as a result of fertilization.

Signature of the lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper II - Basics of Vascular plants and Phytogeography
Name of the Topic	**Gymnosperms**
Topic Synopsis	▪ General characteristics ▪ Sporne classification ▪ Cycas ▪ Gnetum ▪ Geological time scale ▪ Cycadeoidea
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Classify and compare Gymnosperms based on their Morphology, anatomy, reproduction and life cycles. 2. Explain the process of fossilization and compare the characteristics of extinct and extant plant.
Pre Knowledge to be reminded	• Gymnosperms are non-flowering plants belonging to the sub-kingdom Embophyta • The seeds are not enclosed in an ovary or fruit. They are exposed on the surface of the leaf-like structures of the gymnosperms. • Gymnosperms are found in boreal and temperate forests.

Topic Synopsis

Gymnosperms

The word “Gymnosperm” comes from the Greek words “gymnos” (naked) and “sperma”(seed), hence known as “Naked seeds.” Gymnosperms are the seed-producing plants, but unlike angiosperms, they produce seeds without fruits. These plants develop on the surface of scales or leaves, or at the end of stalks forming a cone-like structure.

- They do not produce flowers.
- Seeds are not formed inside a fruit. They are naked.
- They are found in colder regions where snowfall occurs.
- They develop needle-like leaves.
- They are perennial or woody, forming trees or bushes.
- They are not differentiated into ovary, style and stigma.
- Since stigma is absent, they are pollinated directly by the wind.

- The male gametophytes produce two gametes, but only one of them is functional.
- They form cones with reproductive structures.
- The seeds contain endosperm that stores food for the growth and development of the plant.
- These plants have vascular tissues which help in the transportation of nutrients and water.
- Xylem does not have vessels and the phloem has no companion cells and sieve tubes.
- The life cycle of gymnosperms is both haploid and diploid, i.e., they reproduce through the alternation of generations. They have a sporophyte-dominant cycle.

Classification (Sporne)

- K.R. Sporne(1965) was classified entire gymnosperms into three classes, such as Cycadopsida, Coniferopsida and Gnetopsida
- **Cycadopsida:** It includes fossils and living forms, stem is unbranched and stumpy, leaves are large and pinnately compound, male cones are large and compact with simple microsporophylls. Female cones are loose / pinnate and megasporophylls are simple and the ovules are large. This class further divided into four orders namely Bennettitales, Pentoxylales and Cycadales.
- **Coniferopsida:** The plants are large and profusely branched and appear as cone hence these are called Coniferales. Leaves are simple pith is small and xylem is dense and massive, wood is Pycnoxylic type, cones are compact and contain complex sporophylls. It further divided into four orders namely Cordaitales, Coniferales, Taxales and Gynkgoales.
- **Gnetopsida:** they are shrubs and woody climbers and morphologically similar to Angiosperms. Leaves are opposite; wood shows vessels in their organisation. Resin cannals are absent and the act as a bridge between angiosperms and gymnosperms. It contains only one order Gnetales.

Cycas

It is the only living genus identified in the family Cycadaceae. It contains more than 100 species. It is mainly distributed in the eastern and south-eastern Asian regions. Many Cycas species are native to China, Australia and India.

- Cycas are perennial evergreen trees. They appear like a palm tree.
- They are characterised by the presence of naked seeds, i.e. ovules are not enclosed within the ovary. The main body part is the diploid sporophyte.
- Cycas are dioecious, i.e. the male and female plants are separate.
- It possesses two kinds of roots, tap root and coralloid root.
- The coralloid roots develop from the normal roots. The coralloid roots are associated with cyanobacteria that perform biological nitrogen fixation.
- The surface of the stem is rough due to persistent leaf bases.
- Leaves form a crown at the top of the stem. There are two types of leaves found in *Cycas*, foliage leaves and scaly leaves.
- The leaves have circinate venation and have a midrib without lateral veins.
- The foliage leaves are not permanent and fall off, leaving leaf bases.

- Xylem contains tracheids and xylem parenchyma but lacks vessels.
- Phloem consists of sieve tubes and phloem parenchyma. Companion cells are absent.
- They show secondary growth
- The megaspores and microspores are produced in the megasporangia and microsporangia, respectively. The sporangia are borne on spirally arranged megasporophylls and microsporophylls.
- The megasporophyll does not form a cone or strobili.
- Cycas shows vegetative as well as sexual reproduction.
- **Vegetative reproduction** occurs through bulbils or adventitious buds. Sexual reproduction occurs through the formation of seeds.
- **Sexual Reproduction:** It produces two kinds of spores. It is dioecious, i.e. male and female reproductive parts are borne on different plants. The sexual reproduction is oogamous, i.e. the egg is quite large in size and non-motile compared to male gametes.
- Fertilisation: Pollen grains are carried towards the ovule by air. The pollen tube grows towards the archegonia in the ovules and discharges its contents, i.e. male gametes, near the mouth of the archegonia. The male gamete fuses with the egg nucleus to form a diploid zygote. The zygote gives rise to the embryo and the ovule develops into a seed. The seeds are naked (not covered), which is the characteristic of gymnosperms.

Gnetum

- Most Species are climbers except few being shrubs & trees.
- Branches 2 types: Branches of limited growth Branches of unlimited growth
- Climbing Species have branches of limited growth (short shoots) and unbranched with foliage leaves.
- Leaves: Dicot like large & oval with entire margins 9-10 in pairs arranged in decussate fashion with reticulate venation.
- Leaves shows resemble with a Dicot leaf, and bounded by a layer of thickly circularized epidermis, Stomata are distributed all over the lower surface; mesophyll is differentiated generally into a single-layered palisade and a well-developed spongy parenchyma.
- Several vascular bundles in the form of an arch or curve are present in the prominent midrib region. A ring of thick-walled stone cells is present just outside the phloem. Each vascular bundle is conjoint and collateral.
- The xylem of each vascular bundle faces towards the upper surface while the phloem faces towards the lower surface. The xylem consists of tracheids, vessels and xylem parenchyma while the phloem consists of sieve cells and phloem parenchyma.
- The male flowers are arranged in definite rings above each collar on the nodes of the axis of male cone; the male flowers in the rings are arranged alternately.
- Two unilocular anthers remain attached on a short stalk enclosed within the perianth. At maturity, when the anther's are ready for dehiscence, the stalk elongates, and the anthers come out of the perianth sheath
- The female cones resemble with the male cones except in some definite aspects, a single ring of 4-10 female flowers or ovules is present just above each collar.
- Only a few of the ovules develop into mature seeds.

- ovule consists of a nucellus surrounded of three envelopes, nucellus contains the female gametophyte
- The inner envelope elongates beyond the middle envelope to form the micropylar tube or style
- At the time of fertilization, the pollen tube pierces through the membrane of the female gametophyte just near to a group of densely cytoplasmic cells. The tip of pollen tube bursts and the male cells are released. One of the male cells enters the egg cell.
- The male and female nuclei lying side by side for some time, fuse with each other and form the zygote.
- In all gymnosperms, except Gnetum, a cellular endosperm develops before fertilization. In Gnetum, the cell formation, although starts before fertilization, a part of the gametophyte remains free-nuclear at the time of fertilization.
- Gnetum seeds (Fig. 13.26) are oval to elongate in shape and green to red in colour. It remains surrounded by a three-layered envelope which encloses the embryo and the endosperm.
- Germination of seed is of epigeal type.

Geological time scale

- Earth's history is approximately 350 million years old.
- Geologists have used two major units for subdividing the geological history of the earth these are- time and strata.
- On the basis of time the geological history of earth has been divided into five Eras namely Archaeozoic, Proterozoic, Palaeozoic, Mesozoic and Coenozoic.
- Eras have been divided into periods and periods into epochs.
- Similarly on the basis of strata, the geological history of the Earth is divided into system, series, stage and zone.
- **Precambrian Era**
- **Palaeozoic Era**
- **Mesozoic Era**
- **Coenozoic Era**

Cycadeoidea

- Cycadeoidea is the only genus of family Cycadeoidaceae, represented by thirty species.
- They are entirely extinct and resemble cycads in the outward stumpy appearance of trunk and an apical crown of pinnate compound leaves.
- This fossil group of plants flourished during the Triassic to Cretaceous periods of the Mesozoic era. They are reported from various places in the world;
- In India the Cycadeoidales are found in Rajmahal Hills in Bihar.
- Cycadeoidea had a short, branched, or unbranched spherical, conical, or irregular trunk.
- These trunks are covered by rhomboidal leaf bases having multicellular hairs in between. Crown of 10 ft long pinnate compound leaves are present at the top.
- The pinnules show xerophilous structure. The upper and lower epidermis is heavily cutinized and thick-walled. The mesophyll cells are distinguished into palisade and spongy parenchyma. The vascular bundles are mesarch and surrounded by bundle sheath.

- The epidermis is not very distinct due to the presence of heavy armour of leaf bases. The cortex is parenchymatous and traversed by mucilage canals and numerous leaf traces.
- The primary vascular structure consists of a ring of endarch, collateral, conjoint, and open vascular bundles encircling the pith. Pith is wide and parenchymatous.
- The secondary wood encircles the primary xylem and consists of tracheids with scalariform and bordered pits.
- The secondary medullary rays traverse the secondary xylem and secondary phloem.
- The C-shaped leaf traces arise singly from the primary vascular strand and entering the cortex divides into several masarch strands and enters straight into the leaf.
- The reproductive structure is represented by **flowers.** In most of the **species,** the flowersare **bisexual** and arise in the **axil** of each leaf.
- The flowers are bisporangiate, stalked, and partially sunken in the leaf base armor.
- From the base of such flowers about 100 to 150 hairy bracts arise in close spiral little below the apex. These bracts formed a perianth like structure and protect the megasporangiate and microsporangiate parts of a flower.
- The microsporophyll or androecium forms a whorl united at the base into a sheath.
- The megasporophyll or gynaecium consists of numerous stalked ovules born around a central receptacle.
- The liberated microspores or pollens are oval, measures up to 68µ that represents the male gametophytes. Pollen grains of Cycadeoidea are multicellular.
- The gynaecium consists of a spherical or conical receptacle that bears numerous stalked orthotropous ovules and interseminal scales.
- Each ovule is about 1 mm long and consists of the single integument that fused with the nucellus except at its apex.
- The seeds are somewhat elongated or oval and possessed two cotyledons.

Signature of the lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper II - Basics of Vascular plants and Phytogeography
Name of the Topic	**Basic aspects of Taxonomy**
Topic Synopsis	▪ **Aim and scope of taxonomy** ▪ **Species concept** ▪ **Taxonomic hierarchy** ▪ **Plant nomenclature (Botanical)** ▪ **Herbarium and its techniques** ▪ **Bentham and Hooker system of classification** ▪ **Annonaceae** ▪ **Curcurbitaceae**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Critically understand various taxonomical aids for identification of Angiosperms. 2. Analyze the morphology of the most common Angiosperm plants of their localities and recognize their families. 3. Evaluate the ecological, ethnic and economic value of different tracheophytes and summarize their goods and services for human welfare.
Pre Knowledge to be reminded	• Before the flowering plants, the landscape was dominated with plants that looked like ferns for hundreds of millions of years. Pteridophytes show many characteristics of their ancestors. • Unlike most other members of the Plant Kingdom, Pteridophytes don't reproduce through seeds, they reproduce through spores instead.

Topic Synopsis

Aim and scope of taxonomy

- Taxonomy is the practice and science of classification.
- The word finds its roots in the Greek "Taxis" meaning 'order' or 'arrangement) and Nomo's means 'law' or 'science'.
- The word Taxonomy was first used by the great Botanist A.P.De. Condolle in 1813.
- "The science of classifying plants, animals, and microorganisms into increasingly broader categories based on shared features."

Scope of taxonomy:

- In establishing the Phylogenetic relationship that exists naturally b/w many groups of plants
- Using nomenclature principles and rules all plants are named.
- It has a great value in Forestry because all forest trees have been named and classified.
- It has wide importance in Agriculture, Horticulture, etc

Objectives or aims of taxonomy:

- Inventory of world's fauna
- To provide a method for identification and communication
- To produce a coherent and universal system of classification
- To demonstrate the evolutionary implications of plant diversity
- To provide single Latin "Scientific name" for every group of plants in the world, both living and extinct.
- To arrange plants in such a way as to give us an idea about the sequence of their evolution from simpler, earlier and more primitive type to more complexes, more recent, more advanced type in different periods of history.

Species Concept

- The Biological Species Concept defines a species taxon as a group of organisms that can successfully interbreed and produce fertile offspring.
- According to that concept, a species' integrity is maintained by interbreeding within a species as well as by reproductive barriers between organisms in different species.
- Species are often defined as a group of individuals with similar characteristics, where they can interbreed to produce fertile offspring's.
- Typological Species Concept: In this concept, there is a finite number of varieties of living organisms that exist on earth. These types do not exhibit any relationship with each other. Such varieties are termed as species. This inequality is regarded as an unimportant and irrelevant phenomenon. Aristotle and Plato stated this concept in their philosophies.
- **Nominalistic Species Concept:** The nominalistic species concept is the concept of Occam and his followers, of the belief that nature only produces individuals. Species are the creation of man. In nature, they lack definite exis-tence. These concepts do not have any scientific basis.
- **Biological Species Concept:** K. Jordan was the first to formulate this concept in 1905. Later in 1940, Mayr supported this concept. As per this concept, "a species is a group of interbreeding natu-ral population that is reproductively iso-lated from other such groups". Mayr described that the members of a species exhibit these attributes.
- **Reproductive community:** For the purpose of reproduction the individuals of a species recognize one another as potential mates.

- **Ecological Unit:** The species' members differ from each other due to many attributes, but all the members cooperatively form a unit. They interact with other species as a unit in any environment.

- **Genetical unit:** Species comprises a large, inter-communicating gene pool, although the individual is simply a non-permanent vessel comprising a small part of the contents of the gene pool for a shorter duration.

Taxonomic hierarchy

- Taxonomic hierarchy is the process of arranging various organisms into successive levels of the biological classification either in a decreasing or an increasing order from kingdom to species and vice versa.
- In this system of classification, kingdom is always ranked the highest followed by division, class, order, family, genus, and species.
- **Kingdom:** The kingdom is the highest level of classification, which is divided into subgroups at various levels.
- **Phyla:** This is the next level of classification and is more specific than the kingdom.
- **Class:** Class was the most general rank in the taxonomic hierarchy until phyla were not introduced.
- **Order** is a more specific rank than class. The order constitutes one or more than one similar families.
- **Family:** This category of taxonomic hierarchy includes various genera that share a few similarities.
- **Genus:** A group of similar species forms a genus. Some genera have only one species and are known as monotypic, whereas, some have more than one species and is known as polytypic.
- **Species:** It is the lowest level of taxonomic hierarchy. There are about 8.7 million different species on earth. It refers to a group of organisms that are similar in shape, form, reproductive features. Species can be further divided into sub-species.

Botanical Nomenclature

- Binomial nomenclature is the biological system of naming the organisms in which the name is composed of two terms, where, the first term indicates the genus and the second term indicates the species of the organism.
- The system of binomial nomenclature was introduced by Carl Linnaeus.
- According to it, each and every organism would have one scientific name which would be used by everyone to identify an organism. This process of standardized naming is called as Binomial Nomenclature.
- There are international codes which are agreed upon by all the biologists over the entire world for the naming protocol.
- International Code of Botanical Nomenclature (ICBN) – Deals with the biological nomenclature for plants.

Rules:

- These codes make sure that each organism gets a specific name and that name is globally identified.
- The naming follows certain conventions. Each scientific name has two parts: Generic name and Specific epithet.
- All the scientific names of organisms are usually Latin. Hence, they are written in italics.
- When the names are handwritten, they are underlined or italicized if typed. This is done to specify its Latin origin.

- The name of the genus starts with a capital letter and the name of the species starts with a small letter.

ICBN

- It is an international code or deed for writing the name of world flora.
- The naming of plants is following according to the rule of ICBN after its establishment.
- The ICBN only deals and control to the naming of plants but does not do any work on taxonomy.
- The head office of ICBN is situated at Atrect in the Netherlands.

Principles

- **Principle 1**: Botanical nomenclature is independent of zoological and bacteriological nomenclature.
- **Principle 2:** The application of names of taxonomic groups is determined by means of nomenclatural types.
- **Principle 3:** The nomenclature of a taxonomic group is based upon priority of publication.
- **Principle 4:** Each taxonomic group with a particular circumscription, position, and rank can bear only one correct name, the earliest that is in accordance with the Rules, except in specified cases.
- **Principle 5:** Scientific names of taxonomic groups are treated as Latin regardless of their derivation.

Herbarium

- A herbarium is a collection of preserved plant specimens that are systematically organized, catalogued, and stored for scientific study. It serves as a valuable resource for botanical research, species identification, documentation, and conservation efforts.
- Herbarium techniques: a) Specimen Collection, 2) Pressing and Drying, 3) Mounting, 4) Labelling, 5) Storage and Organization, and 6) Digitization.

BSI Herbarium (Botanical Survey of India Herbarium):

- The BSI Herbarium is one of the prominent herbaria in India and is managed by the Botanical Survey of India (BSI), an organization dedicated to the documentation and conservation of India's plant biodiversity.
- Established in 1890, the BSI Herbarium is located in the Botanical Garden of the BSI headquarters in Kolkata.

Kew Herbarium:

- The Kew Herbarium, also known as Herbarium of the Royal Botanic Gardens, Kew, is one of the world's largest and most renowned herbaria.
- It is an integral part of the Royal Botanic Gardens, Kew, located in London, United Kingdom.
- The herbarium's history dates back to the 18th century, and it is recognized as a global center for botanical research and conservation.

Digital herbarium:

- It is a virtual repository or online database that hosts digitized versions of plant specimens and associated information.
- It provides a platform for users to access, search, and study plant specimens remotely, without the need to physically handle the physical specimens themselves.
- Digital herbaria typically include high-resolution images of specimens, along with accompanying data such as taxonomic information, collection details, locality data, and annotations.

Bentham and Hooker classification

- It was a widely used plant classification system developed by George Bentham and Sir Joseph Dalton Hooker in the 19th century.
- It aimed to organize plant diversity based on natural affinities and shared characteristics.

Key features-

- Hierarchical Classification, Natural Grouping, Emphasis on Flowering Plants, Morphological Descriptions.
- In the Bentham and Hooker classification system, the plant kingdom is divided into several divisions.
- **Thallophytae**: It includes plants that lack differentiation into distinct organs (Algae),
- **Bryophyta**: It includes non-vascular plants, commonly known as mosses,
- **Pteridophyta**: It includes vascular plants that reproduce through spores,
- **Gymnospermae**: This division comprises seed-bearing plants that do not produce flowers,
- **Angiospermae**: This is the largest division and includes the flowering plants. They are further divided into two subclasses: **Monocotyledonae** (monocots) and **Dicotyledonae** (dicots).

Annonaceae:

- **Habit:** The plants are shrubs, trees, or climbers.
- **Leaves:** Simple, alternate, and have entire margins (smooth edges), may have elliptical leaves or lanceolate or ovate leaves.
- **Inflorescence:** Borne in clusters or solitary, they may have axillary or terminal inflorescences
- **Flower structure:** The flowers are usually trimerous; borne singly or in compound inflorescences; bisexual and rarely unisexual and have valvate (overlapping) or imbricate (non overlapping)
- **Calyx:** Sepals 3, sepaloid, polysepalous, connate at the base, valvate.
- **Corolla:** Petals 6 in two whorls of 3 each, valvate or slightly imbricate.
- **Androecium:** Stamens numerous spirally arranged on the axis, filament short and thick, anthers long, extrose, truncate connective, bithecous.
- **Gynoecium:** Carpels numerous or a few, usually free, spirally arranged on the raised receptacle, apocarpous, superior, unicarpellary, unilocular; ovules one to many, anatropous; style short or none, stigma small, parietal placentation.
- **Fruit:** An aggregate of berries, united to form a single compound fruit
- **Example:** Annona squamosa.

Floral formula:

$\oplus ⚥ K_3 C_{3+3} A_\alpha G_{\underline{\alpha}}$ or $(\underline{\alpha})$

Curcurbitaceae:

- **Habit:** The plants have long, thin, and flexible stems that crawl along the ground or climb onto surrounding structures with the help of tendrils.
- **Leaves:** Leaves are large, broad, and palmately veine, alternate, rough texture & deeply lobed, with five to seven lobes and provide a dense canopy of foliage.
- **Tendrils:** The plants are characterized by the presence of tendrils and these tendrils are slender, coiled structures that arise from modified leaf or stem structures that aid in climbing and provide support to the plants.
- **Inflorescence:** Inflorescence is cymose type. It may be axillary and bears a solitary female flower. The male flowers may be solitary or in the form of racemes, corymbs or panicles. The plants are monoecious or sometimes dioecious.
- **Flower:** The flowers are yellow or white, unisexual (rarely bisexual), actinomorphic, pentamerous and epigynous (rarely perigynous). The thalamus forms a cup above the ovary.
- **Calyx:** The calyx is of 5 sepals forming a tube, which is wholly adnate to the ovary in female flowers and aestivation is imbricate or valvate.
- **Corolla:** The corolla consists of 5 petals which are united to form a tube or nearly free. The corolla is campanulate, rotate or salver form. The lobes are imbricate or induplicate valvate. Petals are white or yellow in color. The petals are free in Luffa, Trichosanthes.
- **Androecium:** The Androecium present in male flowers only and shows much variation. The simplest condition is where 5 free stamens are present with dithecous/monothecous anthers.
- **Gynoecium:** The gynaecium in the female flowers and consists of 3 syncarpous Carpels with inferior or half-inferior ovary. The ovary is unilocular with three intruding and bifurcating placenta which often meet at the center and ovary becomes three loculed, consists of many anatropous ovules in the placenta.
- **Fruit:** The fruit is fleshy-berry with soft or hard pericarp. This type of fruit is called **Pepo**. It is usually indehiscent, but rarely dehiscent in Mimordica.
- **Seed:** The seeds are compressed and non-endospermic with straight embryo. They are dispersed by explosive opening of the fruit. Viviparous germination is seed Sechium.
- **Example**: **Coccinia indica/cardifolia**

Floral Formula:

Male Flower

Br/Ebr, $\oplus$, ♂, $K_{(5)}, C_{(5)}, A_{(2)+(2)+1}, G_0$

Female Flower

Br/Ebr, $\oplus$, ♀, $K_{(5)}, C_{(5)}, A_0, G_{(3)}$

Signature of the lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper II - Basics of Vascular plants and Phytogeography
Name of the Topic	**Systematic Taxonomy**
Topic Synopsis	▪ **Asteraceae** ▪ **Asclepiadaceae** ▪ **Amaranthaceae** ▪ **Euphorbiaceae** ▪ **Arecaceae** ▪ **Poaceae** ▪ **Angiosperm Phylogeny Group**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 4. Classify and compare Gymnosperms based on their Morphology, anatomy, reproduction and life cycles. 5. Explain the process of fossilization and compare the characteristics of extinct and extant plant.
Pre Knowledge to be reminded	• Taxonomy is a science that deals with naming, describing and classification of all living organisms including plants. • Classification is based on behavioural, genetic and biochemical variations. Characterization, identification, and classification are the processes of taxonomy. Organisms are classified into similar categories namely kingdom, phylum, class, order, family, genus and species.

Topic Synopsis

Asteraceae:

- **Habitat:** Members of this family are mostly mesophytes and some xerophytes are also known in this family.
- **Habit:** Mostly annual or perennial herbs, rarely shrubs (Helianthus annus) and trees (Veronia). Occasionally marsh plants (Caesulia) also occur in this family.
- **Root system:** Generally the root system is branched taproot system. Tuberous are present in Dhalia. The roots and stem may contain oil passages.
- **Stem:** Herbaceous or woody, erect, branched. Helianthus tuberoses produces stem tubers. Many species have milky white sap. Stems are often covered by trichomes.

- **Leaf:** Leaves are simple, alternate or opposite (Helianthus) or whorled (Eupatorium), exstipulate, petiolate, hairy, reticulate venation. They are simple or pinnately or palmately lobed.
- **Inflorescence:** The primary inflorescence is a racemose head or capitulum. It is terminal or axillary in position. In some species several heads aggregate to form compound head or umble or panicle. Each head is subtended by an involucre of green membranous bracts which are protective in function.
- **Flower:** Flowers are bracteates, sessile, bisexual (sometimes unisexual or neutral), pentamerous, epigynous and they maybe homogamous or heterogamous.
- **Homogamous:** All the florets are alike in structure and function. They are bisexual and either regular (Veronica) or liguate (Cichorium).
- **Heterogamous:** Florets in heterogamous heads are of two types described below,

Disc florets:

- They are centripetally arranged complete florets. The florets are bracteate, actinomorphic and bisexual, tubular and epigynous. They do not possess any extra-appendage. So, this floret is illinguate.
- **Calyx:** Absent or modified into pappus
- **Corolla:** Sepals 5 in number, Gamosepalous, tubular
- **Androecium:** Stamens 2, epipetalous, syngenesious dithecous
- **Gynoecium:** Bicarpellary, Syncarpous, unilocular, one ovule, on basal placentation style single, stigma bifid.

Floral formula: Br ⊕ ⚥ $K_{2\text{-}3\ (pappus)}\ C_{(5)}\ A_5\ \overline{G}_{(2)}$

Ray florets

- They are peripherally placed incomplete florets. The florets are zygomorphic and unisexual or neutral. This helps in increasing the attraction of the flower. They possess extra appendages called ligule. So, this floret is ligulated.
- **Calyx:** Absent or hairy pappus or scaly persistent
- **Corolla:** Petals 5 in number, polypetalous, ligulate
- **Androecium:** Absent
- **Gynoecium:** Bicarpellary, syncarpous, unilocular, one ovule, the locule, basal placentation, style narrow and stigma branched, ovary inferior.

Floral formula: Br % ♀ $K_{(2\text{-}3)\ (pappus)}\ C_{(3\text{-}5)}\ A_0\ \overline{G}_{(2)}$

- **Fruit:** The fruit is a Cypsela which is dispersed by pappus hairs (Taraxacum). In Xanthium the fruits are dispersed by animals due to presence of hooks.
- **Seed:** Non-endospermic with straight embryo.
- **Importance:** The Asteraceae family plays a significant role in horticulture, medicine, food production, pollinator support, soil conservation, and cultural practices. Its diverse range of species contributes to human well-being, ecological balance, and cultural heritage.

Asclepiadaceae:

- **Habitat:** Plants belonging to this family are commonly mesophytes, and some are also xerophytes.
- **Habit:** Few of the plants in this family are perennial herbs, Shrubs, or even woody climbers. Some plants of this family are also epiphytic climbers and succulents.
- **Root system:** Their root system consists of the taproot system.
- **Stem:** Lower parts of the stem are erect, branched, and woody. Bi-collateral vascular plants, which contain whitish liquid similar to milk, are present in branching laticiferous tubes.
- **Leaf:** Their leaves are intersected and non-stipulated leaves. Xerophytes have leaves that are transformed into spines with a thick waxy covering on them.
- Floral Characteristics
- **Inflorescence:** It is primarily dichasial cyme, occurring from the leaf hypocotyl. Racemose or Umbellatus inflorescence.
- **Flower:** Flowers belonging to this family are hermaphrodite, bracteates, hypogynous, bracteolate, actinomorphic, and pentamerous.
- **Calyx:** It comprises five sepals that join together to form a small tube. It shows imbricate or valvate aestivation.
- **Corolla:** It has 5 petals merged, which may be rotated or funnel-shaped. It displays valvate or twisted aestivation.
- **Androecium:** It comprises five epipetalous stamens inserted at the foot of the corolla tube. Free or joined filaments form a tube around the style.
- **Gynoecium:** Ovaries of the two Carpels of the gynaecium are free. The ovary of each carpel has a single locus with a single placenta and marginal placentation.
- **Pollination:** The flowers show Entomophily or pollination by insects. This family has a unique pollination mechanism.
- **Fruit:** Two sacs that are either close together or divergent are present. They may vary in shape and texture.
- **Seed:** The family has flat seeds with a terminal cluster of white long silky hair. They have dense endosperm and a large embryo.

Floral formula: Br, Brl, $\oplus$, ⚥, K_5, $\overparen{C_{(5)}, A_5}$, $G_{(2)}$

Amaranthaceae:

- **Habit:** Mostly herbs, rarely shrubs or under shrubs (Deeringia), annual or perennial.
- **Root:** A branched tap root
- **Stem:** Aerial, herbaceous or woody, erect or straggling, cylindrical, or angular, branched, solid,
- hairy, green or striped green.
- **Leaves:** Simple, alternate or opposite, petiolate, exstipulate, reddish in colour, unicostate reticulate venation.

Floral characters

- **Inflorescence:** Axillary or terminal spikes (Achyranthes, Digera). Some times in cymose panicles.

- **Flower:** Bracteate, sessile or sub-sessile, bracteolate, bracteoles two, actinomorphic, hermaphrodite or unisexual hypogynous, small inconspicuous, green or variously coloured.
- **Perianth:** Usually five tepals, free or united, sometimes two or three (Amaranthus), dry membranous, valvate or twisted, sometime, hairy, green or coloured, persistent, inferior.
- **Androecium:** Stamens 5 or 3 (Amaranthus), free or united, staminodes sometimes present, introrse, dithecous or monothecous (Alternanthera). In Achyranthes 5 fimbriated scales alternate with 5 fertile stamens.
- **Gynoecium:** Bicarpellary, or tricarpellary; syncarpous, ovary superior, unilocular, usually one Campylotropous ovule; basal placentation; style short or filiform; stigma 2 or 3.
- **Fruit:** Dry one seeded achene or several seeded capsule or one to several seeded berry.

Floral formula:

$$\oplus \; ☿ \;\; P_{3-5 \text{ or } (3-5)} \; A_5 \; G_{\underline{(2-3)}}.$$

- **Economic Importance:** The Amaranthaceae family contributes to agriculture, nutrition, traditional medicine, horticulture, and ecological sustainability. Its diverse range of species offers both economic and cultural benefits, making it an important plant family.

Euphorbiaceae:

- **Habitat:** Generally, plants belonging to this family are Mesophytic or xerophytic in habitat
- **Habit:** This family shows a great range of characteristics in vegetative and floral structures. Members of this family are mostly shrubs or trees and rarely herbs.
- **Root system:** These plants show tap root system. Exceptionally, Manihot has tuberous roots which are rich in starch. Few species of Manihot are edible.
- **Stem:** Several species of Euphorbia are cactus-like in habit with thick and fleshy stems and leaves reduced to spines. These plants often contain milky latex with special laticiferous vessels
- **Leaf:** The leaves are usually alternate or rarely opposite (Choriophyllum) or whorled (Mischodon), simple, entire or deeply palmately lobed (Ricinus and Jatropa) or compound (Bischofia).
- **Inflorescence:** Euphorbiaceae plants have diverse inflorescence structures. The inflorescence types can be racemes, panicles, spikes, or solitary flowers. Observe the inflorescence arrangement and the overall shape and size.
- **Flowers:** Study the individual flowers within the Euphorbiaceae inflorescence. The flowers can be unisexual (separate male and female flowers on the same or different plants) or bisexual (flowers with both male and female reproductive parts).
- **Perianth:** Perianth is mostly in one whorl, green or rarely petaloid (Manihot). Rarely perianth is in two whorls as in Jatropa or absent as in Euphorbia.

- **Androecium:** The Androecium show variable number of stamens. In male flowers they range from one to many arranged in one to ten whorls. Filaments are free or united. The anthers are monothecous or dithecous, erect and dehisce longitudinally or transversely.
- **Gynoecium:** The gynaecium is tricarpellary, syncarpous with superior, trilocualr ovary. One or two collateral, pendulous, anatropous ovules in each locule in axile placentation are present. At the base of the ovaries nectarines are present.
- **Pollination:** Unisexual flowers necessitate cross pollination and here pollination is entomophilous taking place with the help of insects.
- **Fruit:** Fruit is usually three chambered, schizocarpic splitting into three one-seeded cocci. Rarely drupe (Phyllanthus) or berry (Bischofia).

Floral Formula:

$$Br, Ebrl, \oplus, ♂, K_{(5)}, C_{(5)}, A_{\infty}, G_{0}$$
$$Br, Ebrl, \oplus, ♀, K_{(5)}, C_{(5)}, A_{0}, G_{(3)}$$

Arecaceae:

- **Habitat:** They are mostly mesophytes and some xerophytes are also found in this family.
- **Habit:** These plants are generally woody shrubs or trees or sometimes vines (Calamus) with usually unbranched, slender to stout stem to over 30 meters tall. Leaves often form a terminal cluster on the tall stem.
- **Root system:** Fibrous and adventitious root are seen in this family which arise from the base of the stem.
- **Stem:** Stem is variable in different forms such as very short with leaves appearing to arise from ground, thin and slender with long internodes and tall, stout, pillar-like covered by persistent leaf-bases and terminal cluster of leaves. Stems are rarely branched.
- **Leaf:** Leaves are palmate (fan palms) or pinnate (feather palms) and rarely simple. Leaves are usually large with petiole base sheathing the stem. Leaf is usually terminal cluster. Petiole is large and venation is parallel type.
- **Inflorescence:** Inflorescence is usually large, much branched, paniculate or spadix. The inflorescence often reaches up to 1 meter and is covered by boat shaped woody bracts.
- **Flower:** Flowers are ebracteate, sessile, actinomorphic usually unisexual and monoecious but sometimes even dioecious. They are rarely bisexual, trimerous, cyclic (usually), or partially acyclic, hypogynous. The male flowers are usually smaller than the female flowers.
- **Perianth:** Perianth is 6 in number free or united in 2 whorls of 3 each. They are usually tough, leathery and usually persistent.
- **Pistillodes and staminodes:** A pistillode is usually present in the centre of each male flower. Staminodes may or may not be present in the female flowers.
- **Gynoecium:** The gynaecium is present only in pistillate or bisexual flowers. Ovary is tricarpellary, unilocular, apocarpous or syncarpous or Carpels are completely or partially free. The ovary is unilocular (Single ovule is place on sub-apical or basal placentation), apocarpous or syncarpous, may or may not have style Stigma is dry-type.

- **Pollination:** Pollination is usually anemophilous and the flowers are protandrous.
- **Fruit**: Fruit is a berry with fleshy or non-fleshy exocarp or a drupe with fibrous epicarp. Fruit is always single seeded with small embryo and abundant endosperm.
- **Seed:** Seeds endospermic (ruminate, or not ruminate); oily (usually), or not oily. Seeds are usually without starch.

Floral Formula:

Male Flower : $Br, Ebrl, \oplus, ♂, P_{(3)+3 \text{ or } 3+3}, A_{3+3}, G_0$ Female Flower: $Br, Ebrl, \oplus, ♀, P_{(3)+3 \text{ or } 3+3}, A_0, G_{\underline{(3)} \text{ or } \underline{3}}$

- **Importance:** The Arecaceae family encompasses a wide range of species that contribute to agriculture, forestry, horticulture, cultural practices, and environmental conservation.

Poaceae:

- **Habit:** Annual or perennial herbs; rarely tree (bamboos.
- **Roots:** Fibrous and adventitious.
- **Stem:** Herbaceous; cylindrical; jointed, hollow at internodes. Sometimes, forms rhizome or runner.
- **Leaves:** Sessile with long sheathing base; alternate; simple; ligulate; parallel venation.
- **Inflorescence:** Spike of spikelets or panicles of spiklets. Each spiklet is composed of 2-5 flowers. It is enclosed by a pair of bracts called glumes.
- **Spike of spikelets:** The spiklets form dense clusters in sessile manner on main axis as in wheat.
- **Panicles of spikelets:** The spiklets are arranged on a branched axis panicle as in oat.
- **Flower:** Pedicillate; bracteate, two bracts **palea** and **lemma** enclose flower or floret; lemma contain bristle like awns zygomorphic; incomplete; unisexual or hermaphrodite; hypogynous.
- **Perianth:** Represented by two or three scale like lodicules.
- **Androecium:** 3 stamens, sometimes 1,2 or 6; polyandrous; anther versatile.
- **Gynoecium:** Monocarpellary; unilocular; ovary superior; stigma usually 2; feathery; basal placentation.
- **Fruits:** Caryopsis
- **Seed:** Endospermic.
- **Floral formula:**

$$Br. \% ⚥ P_2(\text{lodicules}) A_3 \underline{G_1}$$

- **Importance:** The Poaceae family's importance extends to agriculture, animal husbandry, environmental conservation, landscaping, and cultural practices.

Angiosperm Phylogeny Group

- The Angiosperm Phylogeny Group (APG) is an international group of botanists who work collaboratively to establish a standardized and updated classification system for flowering plants (angiosperms).

- The APG was formed in 1998 and has since published several influential papers that have significantly influenced the understanding and classification of angiosperms.
- The primary goal of the APG is to develop a phylogenetic classification system for angiosperms based on evolutionary relationships, using molecular data and other evidence.
- The Angiosperm Phylogeny Group (APG IV) is a renowned international group of botanists that published an influential classification system for flowering plants (angiosperms) in 2016. The APG IV classification provides an updated framework for understanding the evolutionary relationships and classification of angiosperms like Monocots and Eudicots, major groups within monocots and Eudicots, Family-Level Classification, Phylogenetic Relationships, and Updates and Revisions of angiosperms.

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper II - Basics of Vascular plants and Phytogeography
Name of the Topic	**Phytogeography**
Topic Synopsis	▪ **Principles of Phytogeography** ▪ **Distribution** ▪ **Endemism** ▪ **Phytogeographic regions of World** ▪ **Phytogeographic regions of India** ▪ **Vegetation types in Andhra Pradesh**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Evaluate the ecological, ethnic and economic value of different tracheophytes and summarize their goods and services for human welfare 2. Locate different phytogeographical regions of the world and India and can analyze their floristic wealth.
Pre Knowledge to be reminded	• Phytogeography is the study of the distribution of plants or taxonomic groups of plants and its focus is to explain the ranges of plants in terms of their origin, dispersal, and evolution • To observe changes in abundance and distribution of plants, most often is longer than the career or life span of a geographer, palaeo ecological data and their understanding are of great importance

Topic Synopsis

Principles of Phytogeography

- Phytogeography is the study of the distribution patterns of plants across different geographic regions.
- It seeks to understand the factors and processes that shape the distribution of plant species and communities.
- The principles of phytogeography help explain these patterns and provide insights into the ecological and evolutionary processes that influence plant distributions.
- **Floristic Regions-** divide the world into distinct floristic regions;
- **Biogeographic Boundaries-** identifies and studies the boundaries between different floristic regions;

- **Endemism-** the occurrence of plant species in a specific geographic area and nowhere else in the world;

Distribution:

- Distribution refers to the spatial pattern of plant species across geographic regions.
- It involves studying the presence, abundance, and range of plant species in different areas and understanding the factors that shape their distributions.
- Distribution in phytogeography encompasses several aspects such as **Range**, **Dispersal**, **Endemism** and **Ecological Preferences.**
- Distribution is explored by
- **Widespread Species-** Widespread species have a broad geographic range and can be found across multiple regions or continents.
- **Endemic Species:** Endemic species have a restricted distribution and are found in a specific geographic area or habitat type.
- **Discontinuous Species:** Discontinuous species have a fragmented distribution with isolated populations occurring in different geographic regions.

Endemism

- Endemism can arise due to various factors, and it can be categorized into two main types i.e.
- **Regional Endemism-** Regional endemism refers to species that are restricted to a particular geographic region or area;
- **Local Endemism-** Local endemism, also known as micro endemism, refers to species that are restricted to very small geographic areas.

Causes of endemism:

- Geographic Isolation, Geological and Tectonic Events, Ecological Specialization, Climate and Environmental Factors, Long-Term Evolutionary History, Dispersal Limitations and Anthropogenic Factors.

Phytogeographic regions of World

Phytogeographic regions are broad geographical areas characterized by distinct plant communities and vegetation types.

- **Neoarctic Region** (North America, including parts of Greenland, northern Mexico, and the northernmost portions of Central America),
- **Neotropical Region** (Central and South America, as well as the Caribbean islands),
- **Palaearctic Region** (Europe, North Africa, and most of Asia), Afrotropical Region (sub-Saharan Africa and the associated islands),
- **Indo-Malayan Region** (Indian subcontinent, Southeast Asia, and the associated archipelagos),
- **Antarctic Region** (Antarctica and the surrounding sub Antarctic islands),

- **Oceania Region** (the islands of the Pacific Ocean, such as Hawaii, Fiji, Samoa, and the Marquesas Islands).

Phytogeographic regions of India:

India, with its diverse topography and varied climatic conditions, is home to several distinct Phytogeographic regions.

- **Trans-Himalayan Region,**
- **Western Himalayan Region,**
- **Eastern Himalayan Region,**
- **Indo-Gangetic Plain,**
- **Western Ghats,**
- **Eastern Ghats,**
- **Deccan Plateau**
- **Northeast India**

Vegetation types in Andhra Pradesh:

Andhra Pradesh, located in south-eastern India, exhibits a range of vegetation types due to its diverse topography, climate, and soil conditions.

- **Tropical Rainforests,**
- **Deciduous Forests,**
- **Scrublands,**
- **Mangrove Forests,**
- **Grasslands,**
- **Wetlands and Plantations**

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper III - **Anatomy and Embryology of Angiosperms, Plant Ecology and Biodiversity**
Name of the Topic	**Anatomy of Angiosperms**
Topic Synopsis	▪ **Organization of apical meristems** ▪ **Tissue systems** ▪ **Anomalous secondary growth in Boerhaavia** ▪ **Anomalous secondary growth in Dracaena** ▪ **Economic importance of Timber yielding plants**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants. 2. Various aspects of growth, development of the tissues and differentiation of various plant organs. Knowledge of basic structure and organization of plant parts in angiosperms.
Pre Knowledge to be reminded	• A tissue is a group of cells with a common origin. The cells of tissue usually perform a common function. • The plant tissues are broadly classified into Meristematic Tissues (apical, lateral and intercalary) Permanent Tissues (simple and complex).

Topic Synopsis

Organization of apical meristems

- Meristems are small populations of rapidly proliferating cells that produce all the adult organs of a flowering plant.
- **Apical meristems** give rise to the primary plant body and are responsible for the extension of the roots and shoots.
- **Lateral meristems** are known as secondary meristems because they are responsible for secondary growth, or increase in stem girth and thickness.
- The apical meristem consists of a population of meristematic cells that have the ability to divide and differentiate into various specialized cell types.

- The apical meristem is protected by surrounding layers of cells, such as the root cap in root apical meristems and the leaf primordia in shoot apical meristems.
- The apical meristem gives rise to three main types of primary meristems, such as **Protoderm:** The protoderm is the primary meristem that gives rise to the epidermis, which is the outermost layer of cells covering the plant's surface.

  Ground meristem: The ground meristem gives rise to the ground tissues of the plant, including the cortex, pith, and other parenchyma cells that make up the bulk of the plant's body.

  Procambium: The procambium is the primary meristem that differentiates into the vascular tissues, including the xylem and phloem, which are responsible for transporting water, nutrients, and sugars throughout the plant.
- The organization of apical meristems in plants is described by two main theories: the **Tunica-Carpus** theory and the **Histogen** theory.

Tunica-Carpus theory:

- The tunica-carpus theory, proposed by Ernst Munch in the 1920s, describes the organization of the apical meristem into two distinct layers: the tunica and the corpus.
- **Tunica:** The tunica refers to the outermost layer of the apical meristem. It consists of one or more layers of cells that divide anticlinally and contribute to the formation of the epidermis and other outer tissues of the plant.
- **Corpus:** The corpus is the central core of the apical meristem, located beneath the tunica. It consists of cells that divide in various planes, including anticlinal and periclinal divisions (parallel to the surface), giving rise to the inner tissues of the plant, such as the cortex, pith, and vascular tissues.

Histogen theory:

- The histogen theory, proposed by Johannes von Sachs in the late 19th century, describes the organization of the apical meristem into three distinct layers called histogens.
- **Dermatogen:** The dermatogen is the outermost layer of the apical meristem and gives rise to the epidermis and other outer protective tissues of the plant.
- **Periblem:** The periblem is the middle layer of the apical meristem, located between the dermatogen and the plerome. It gives rise to the cortex, endodermis, and some lateral root tissues.
- **Plerome:** The plerome is the innermost layer of the apical meristem, located at the core. It gives rise to the vascular tissues (xylem and phloem), pith, and sometimes the pericycle.
- Both the tunica-carpus theory and the histogen theory provide different perspectives on the organization of apical meristems.

Tissue systems

- There are three primary tissue systems that contribute to the overall structure and function of the plant body.

- These tissue systems are known as the dermal tissue system, ground tissue system, and vascular tissue system.

Dermal Tissue System:

- The dermal tissue system is the outermost layer of cells in plants, covering the entire plant body.
- It serves as a protective barrier against physical damage, pathogens, and excessive water loss.
- The dermal tissue system consists of two main types of cells Epidermis (single layered, tightly packed cells), Periderm (It replaces the epidermis in older stems and roots, and preventing water loss).

Ground Tissue System:

- The ground tissue system is the tissue system located between the dermal and vascular tissues.
- The ground tissue system consists of different types of cells such as Parenchyma, Collenchyma and Sclerenchyma.

Vascular Tissue System:

- The vascular tissue system is responsible for the transport of water, nutrients, and sugars throughout the plant.
- It consists of two main types of tissues such as Xylem (conducts water and minerals, composed of tracheids and vessel elements and fibers) and Phloem (transports sugars, organic molecules, and nutrients, it is composed of sieve elements and phloem fibers).

Anomalous secondary growth in Boerhaavia

Boerhaavia is a genus of plants that includes several species, some of which exhibit anomalous secondary growth.

- Anomalous secondary growth refers to a type of secondary growth that deviates from the typical pattern seen in most woody plants, where secondary growth occurs in a cylindrical manner. In Boerhaavia, secondary growth occurs in a scattered or irregular manner.
- In plants that undergo anomalous secondary growth, the vascular cambium, which is responsible for the production of secondary xylem (wood) and secondary phloem, does not form a continuous cylinder as it does in most woody plants. Instead, the vascular cambium forms patches or strands that are scattered within the stem or root.

Anomalous secondary growth in Dracaena:

- Dracaena is a genus of plants that includes several species commonly used as ornamental houseplants. Some species within the Dracaena genus exhibit anomalous secondary growth, also known as "dracaenoid" or "dracaena-type" secondary growth.

- The secondary growth does not follow the typical pattern seen in most woody plants with continuous cylindrical growth. Instead, it occurs in a scattered or irregular manner.
- The irregular secondary growth in Dracaena is characterized by the formation of secondary xylem (wood) in patches or strands, rather than in a continuous ring.
- These patches or strands of secondary xylem are scattered throughout the stem, resulting in an irregular arrangement and distribution of wood.
- The anomalous secondary growth in Dracaena is often attributed to the presence of localized cambial activity or the formation of isolated vascular bundles.
- This irregular growth pattern can lead to the development of irregular wood structure and may result in the stem appearing swollen or "bumpy" in some species.

Economic importance of timber yielding plants:

Teak:

- Teak (Tectona grandis) is highly valued for its durability, natural resistance to decay, and attractive appearance. It is one of the most sought-after timbers in the world.
- Teak timber has a golden-brown color, rich grain patterns, and excellent strength properties, making it suitable for a wide range of applications, like Furniture, Flooring and decking, Construction and joinery and Boatbuilding.
- The high demand for teak timber has led to significant commercial plantations of teak in many countries, contributing to the economic livelihoods of communities involved in its cultivation and trade.

Red Sanders:

- Red Sanders (Pterocarpus santalinus), also known as Red Sandalwood, is a highly prized timber with a rich, deep red color.
- It is known for its attractive appearance, hardness, and ability to retain its color over time.
- Red Sanders timber has various uses, including High-end furniture and cabinetry, Musical instruments and Traditional and cultural uses like making religious artefacts', carvings, and decorative items.
- Due to overexploitation and illegal logging, Red Sanders has become a protected species in many countries, leading to restrictions on its harvesting and trade.

Rosewood:

- Rosewood timber is used in various applications, including making High-quality furniture, Musical instruments, jewellery boxes, ornamental carvings, and other decorative objects.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper III - Anatomy and Embryology of Angiosperms, Plant Ecology and Biodiversity
Name of the Topic	**Embryology of Angiosperms**
Topic Synopsis	▪ **Structure of anther** ▪ **Development of male gametophyte** ▪ **Structure of ovule** ▪ **Development of embryosac** ▪ **Pollination and fertilization** ▪ **Endosperm** ▪ **Development of Dicot embryo**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Illustrate and interpret various aspects of embryology. 2. Knowledge regarding embryology make them understand how reproduction play significant role in defining population structure, natural diversity and sustainability of ecosystem in a better way
Pre Knowledge to be reminded	• The science of the origin and formation of new plants. In a broader sense, plant embryology studies not only embryonic development but also the formation of the generative sphere, the formation of sex cells in the generative sphere, and fertilization. • The embryo sac or female gametophyte is an oval structure present in the ovule of flowering plants

Topic Synopsis

Structure of anther

- The anther is the male reproductive organ of angiosperm plants. It produces pollen grains, which contain the male gametes or sperm cells.
- The anther consists of several structural components, including the anther wall, microsporangia, and the tapetum.
- **Anther Wall:** The anther wall consists of several layers of cells, including the outer epidermis, middle layers, and the innermost endothecium. The anther wall surrounds the microsporangia, which are responsible for the production of pollen grains.
- **Microsporangia:** The microsporangia, also known as pollen sacs, are located within the anther. The microsporangia contain diploid cells called sporogenous cells or microsporocytes.
- **Tapetum:** The tapetum is a specialized layer of cells found within the anther. It surrounds the developing microsporangia and plays a crucial role in the development of pollen grains. The tapetum provides nourishment and support to the developing microspores.
- There are typically three types of tapetum based on their staining characteristics and function such as **Secretary Tapetum** (secretes substances), **Plasmodial Tapetum** (characterized by multinucleate cells that form a large, amoeboid mass), **Ubisch's Tapetum** (remains intact even after the release of mature pollen grains).

Microsporogenesis and Development of Male Gametophyte:

Microsporogenesis is the process of microspore formation within the microsporangia of the anther.

- **Microsporocyte Division:** Within the microsporangia, the diploid sporogenous cells undergo meiosis to produce haploid microspores. Each microspore typically undergoes two rounds of meiotic divisions, resulting in the formation of four haploid microspores.
- **Microspore Development:** Each microspore undergoes further development to form mature pollen grains.
- **Pollen Grain Maturation:** The developing pollen grain is nourished and supported by the tapetum. As the pollen grain matures, it undergoes changes in its size, shape, and internal structures.
- Once the pollen grain reaches maturity, the anther dehisces (splits open), allowing the pollen grains to be released and dispersed. The mature pollen grains are then capable of pollinating the female reproductive structures of the flower, leading to fertilization and the formation of seeds.

Structure of the Embryosac:

- The mature embryo sac, also known as the female gametophyte, is the structure within the ovule of flowering plants where fertilization and seed development take place.
- It is formed through the process of megasporogenesis and subsequent differentiation of the megaspore.

- The mature embryo sac typically consists of several distinct cell types, each with specific functions.
- Egg Cell
- Synergids
- Central Cell
- Antipodal Cells

Structure of the Ovule (Female Gametophyte):

The ovule is the female reproductive structure found within the ovary of flowering plants. It contains the megasporangium, which houses the megaspore mother cell or megasporophyte, and eventually develops into the female gametophyte or embryo sac.

- **Integuments:** The integuments are protective layers that surround the central region of the ovule. They enclose and protect the developing female gametophyte.
- **Micropyle:** The micropyle is a small pore or opening at the tip of the ovule. It allows the entry of pollen tubes during pollination.
- **Nucellus:** The nucellus is the central region of the ovule. It contains the megasporangium, which houses the megaspore mother cell.

Megasporogenesis:

- Megasporogenesis is the process of megaspore formation within the ovule. It involves the development and differentiation of the megasporocyte.
- The different types of embryo sacs are based on the number of functional megaspores produced during megasporogenesis.

Monosporic Embryo Sac (Polygonum type):

- In plants with a monosporic embryo sac, only one of the four megaspores produced during megasporogenesis becomes functional.
- The remaining three degenerate. This type is exemplified by Polygonum (a genus of flowering plants).

Bisporic Embryo Sac (Allium type):

- In plants with a bisporic embryo sac, two of the four megaspores produced during megasporogenesis become functional.
- One megaspore develops into the egg apparatus (synergids and egg cell), while the other megaspore develops into the central cell.
- This type is exemplified by Allium (the genus that includes onions, garlic, and other related plants).

Tetrasporic Embryo Sac (Peperomia type):

- In plants with a tetrasporic embryo sac, all four megaspores produced during megasporogenesis become functional.
- The megaspores divide and differentiate into specific cells within the embryo sac.

- This type is exemplified by Peperomia (a genus of plants).

Pollination:

- Pollination is the transfer of pollen grains from the anther to the stigma of a flower.
- **Self-pollination:** Pollen is transferred from the anther to the stigma of the same flower or a different flower on the same plant.
- **Cross-pollination:** Pollen is transferred from the anther of one flower to the stigma of another flower on a different plant of the same species.

Pollen-Pistil Interaction:

The pollen grains land on the stigma, a series of interactions occur between the pollen and the pistil to facilitate successful fertilization.

- **Pollen germination:** Upon landing on the stigma, the pollen grain absorbs moisture and germinates, forming a pollen tube. The pollen tube grows through the stigma and style, reaching the ovary.
- **Pollen tube growth:** The pollen tube penetrates the style and grows towards the ovules inside the ovary. It is guided by various chemical and molecular signals produced by the pistil.
- **Recognition and compatibility:** The pollen tube must be compatible with the female reproductive structures for successful fertilization. Molecular recognition and compatibility mechanisms help ensure that the correct pollen tubes reach the appropriate ovules for fertilization.

Agents of pollination:

- There are various organisms or elements that facilitate the transfer of pollen from the male reproductive organs to the female reproductive organs of flowering plants.

- **Abiotic agents:** Anemophily (Pollination by air/ wind), Hydrophily (Pollination by water).

- **Biotic agents:** Entomophily (pollination by Insects), Ornithophily (pollination by birds), Chiropteriphily (pollination by bats) and Malacophily (pollination by slug and snail).

Fertilization:

Fertilization involves the fusion of male and female gametes, resulting in the formation of a zygote and the initiation of seed development.

- **Double fertilization:** It involves the fusion of one sperm cell with the egg cell, forming a diploid zygote that develops into the embryo. Simultaneously, the other sperm cell fuses with the polar nuclei in the central cell, forming a triploid nucleus that develops into the endosperm, a nutritive tissue that supports embryo development.

- **Embryo development:** The zygote undergoes cell division and differentiation, leading to the development of the embryo within the seed.

- **Endosperm development:** The endosperm develops and provides nutrients to the growing embryo, ensuring its proper growth and development.

- **Seed formation:** The fertilized ovule develops into a seed, which contains the embryo, endosperm, and protective seed coat. The mature seed can disperse and germinate to give rise to a new plant.

Endosperm:

- Endosperm is a nutritive tissue found in the seeds of flowering plants. It provides nourishment to the developing embryo and supports seed germination and early seedling growth.

- Endosperm can vary in its cellular organization, and different types of endosperm have distinct characteristics and biological importance. Here are some types of endosperm.

Types of endosperm:

- **Free Nuclear Endosperm:** cell divisions occur without cell wall formation, resulting in a multinucleate syncytium or coenocyte.

- **Cellular endosperm:** Cellular endosperm is characterized by the formation of cell walls between the dividing nuclei, resulting in distinct individual cells within the endosperm.

- **Helobial endosperm:** Helobial endosperm is a combination of free nuclear and cellular endosperm.

- **Ruminate endosperm:** Ruminate endosperm is characterized by the presence of large, irregularly shaped, interconnected cells with invaginations and projections. This gives the appearance of ruminate or pitted texture.

- Biological Importance of Endosperm is following Nutrient Storage, Embryo Development, Germination and Seedling Growth and Reproductive Success.

Development of Dicot embryo:

The development of a Dicot embryo, such as in the case of Capsella bursa-pastoris (Shepherd's purse), follows a general pattern that can be described in several stages.

- **Fertilization** occurs when a pollen grain lands on the stigma and germinates to form a pollen tube. The pollen tube grows down through the style and reaches the ovary. The male gametes (sperm cells) are released from the pollen tube and fertilize the egg cell located in the ovule.

- **Zygote Formation:** The fertilization event results in the formation of a zygote. The zygote is the first cell of the new sporophytic generation and is formed by the fusion of the male and female gametes.

- **Embryo Formation:** The zygote undergoes division and differentiation to form the embryo. The zygote divides asymmetrically to produce two cells: the terminal cell and basal cell. The terminal cell gives rise to the apical meristem, which will form the shoot system (stem and leaves) of the plant. The basal cell gives rise to the suspensor, a structure that anchors the embryo to the endosperm and aids in nutrient uptake.

- **Cotyledon Formation:** As the embryo develops further, it forms one or two cotyledons, which are embryonic leaves. In Capsella bursa-pastoris, two cotyledons are formed. The cotyledons play a role in nutrient storage and are involved in seedling establishment after germination.

- **Radicle Formation:** The radicle, which is the embryonic root, develops at the lower end of the embryo. It elongates and eventually emerges from the seed during germination to establish the root system of the new plant.

- **Maturation:** During maturation, the embryo undergoes further growth and development within the seed. The embryo becomes fully differentiated and acquires the ability to withstand desiccation and remain dormant until favourable conditions for germination are present.

- The mature embryo is then enclosed within the seed, which also consists of protective seed coats and the endosperm or nutritive tissue. The embryo is quiescent until the appropriate cues trigger germination, leading to the emergence of the seedling.

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Program	B. Sc - BZC
Course (Paper)	Paper III - Anatomy and Embryology of Angiosperms, Plant Ecology and Biodiversity
Name of the Topic	**Basics of Ecology**
Topic Synopsis	▪ **Ecology** ▪ **Ecosystem** ▪ **Ecological pyramids** ▪ **Plants and environment** ▪ **Ecological succession**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Discuss the basic concepts of plant ecology, and evaluate the effects of environmental and biotic factors on plant communities. 2. Appraise various qualitative and quantitative parameters to study the population and community ecology.
Pre Knowledge to be reminded	• Ecology is the study of the relationships among living organisms, including humans, and their physical environment. • Ecology considers organisms at the individual, population, community, ecosystem, and biosphere level.

Topic Synopsis

Ecology:

- Ecology is the scientific study of the interactions between organisms and their environment.

- It explores the relationships and interdependencies between living organisms, including plants, animals, and microorganisms, and their physical surroundings, such as air, water, soil, and other organisms.

Branches of Ecology:

- **Organismal Ecology:** Examines the physiological, morphological, and behavioral adaptations of individual organisms to their environment.

- **Population Ecology:** Studies the dynamics and characteristics of populations of the same species, including their growth rates, distribution patterns, and interactions with other species.

- **Community Ecology:** Focuses on the interactions between different species in a particular geographic area and the processes that influence species diversity and community structure.

- **Ecosystem Ecology:** Investigates the flow of energy and nutrients through ecosystems, including the interactions between organisms and their physical environment.

- **Landscape Ecology:** Analyzes the spatial arrangement of different ecosystems and the ecological processes that occur at larger scales, such as habitat fragmentation and connectivity.

- **Global Ecology:** Examines ecological patterns and processes at a global scale, including the influence of climate change and human activities on ecosystems worldwide.

Significance of Ecology:

- Helps in Understanding Ecosystem Functioning, Conservation
- Biodiversity,
- Sustainable Resource Management,
- Understanding Environmental Change
- Human Health protection

Ecosystem:

Ecosystems are self-sustaining communities of organisms that interact with each other and their physical environment. They can range in size from small ponds to vast forests or even the entire planet.

Components of an Ecosystem:

- **Biotic Components:** These include all living organisms within an ecosystem, such as plants, animals, fungi, and microorganisms.

- **Abiotic Components:** These refer to the non-living factors that influence the ecosystem, such as temperature, sunlight, water, soil, air, and minerals.

- **Interactions:** Ecosystems are characterized by complex interactions between the biotic and abiotic components. Organisms rely on abiotic factors for survival, reproduction, and other vital processes, while their activities and behaviours shape the environment.

Energy Flow in Ecosystems:

- Sunlight: The primary source of energy in most ecosystems is sunlight. Plants and some other organisms, known as autotrophs or producers, capture sunlight through photosynthesis and convert it into chemical energy.

- Energy Transfer: Energy flows through the ecosystem as organisms consume other organisms. This energy transfer occurs through feeding relationships, allowing energy to move from one tropic level to another.

- Laws of Thermodynamics: The laws of thermodynamics govern energy flow in ecosystems, stating that energy cannot be created or destroyed but only transferred or transformed. Energy is lost as heat at each tropic level, resulting in a decrease in available energy as you move up the food chain.

Food Chain:

- A food chain is a linear sequence that illustrates the transfer of energy and nutrients from one organism to another.

- It represents a series of feeding relationships, where each organism occupies a specific tropic level. For example, a simple food chain in a grassland ecosystem could be: grass → grasshopper → bird → hawk.

Food Web:

- A food web is a more complex representation of feeding relationships in an ecosystem.

- It consists of interconnected food chains and illustrates the multiple interactions and tropic levels within a community.

- In a food web, organisms can occupy multiple positions or tropic levels, reflecting their diverse diets and interactions.

Ecological Pyramids:

- Ecological pyramids are graphical representations that depict the relative amounts of energy, biomass, or number of individuals at each tropic level within an ecosystem.

- **Energy Pyramid:** Shows the flow of energy through the tropic levels, with energy decreasing as you move up the pyramid. The base represents the primary producers, and the successive levels represent the primary consumers, secondary consumers, and so on.

- **Biomass Pyramid:** Represents the total biomass or weight of living organisms at each tropic level. Biomass decreases at higher tropic levels due to energy loss.

- **Pyramid of Numbers:** Represents the number of individuals at each tropic level. The number of organisms generally decreases as you move up the pyramid.

Plants and environment:

Plants are influenced by various factors in their environment, including climatic factors (light and temperature), edaphic factors (soil), and biotic factors (other living organisms). These factors play crucial roles in determining the distribution, growth, and survival of plants.

Climatic Factors:

- **Light:** Light is essential for photosynthesis, the process by which plants convert sunlight into energy. Light availability affects plant growth, development, and flowering. Different plant species have varying light requirements, ranging from full sun to shade tolerance.

- **Temperature:** Temperature influences plant growth, metabolism, and development. Plants have specific temperature ranges in which they can thrive. Cold temperatures can limit plant growth and cause frost damage, while high temperatures can lead to heat stress and affect plant physiology.

Edaphic Factors:

- **Soil Composition:** Soil composition, including its texture (proportion of sand, silt, and clay), organic matter content, and nutrient levels, affects plant growth. Different plants have specific soil preferences and adaptability to different soil types.

- **Soil pH:** Soil pH influences nutrient availability to plants. Some plants thrive in acidic soils, while others prefer neutral or alkaline soils. pH levels also affect the availability of certain minerals and can influence plant nutrient uptake.

Biotic Factors:

- **Competition:** Plants compete for resources such as light, water, nutrients, and space. Competition can influence plant growth and survival, as individuals better adapted to resource acquisition may out compete others.

- **Herbivore:** Herbivores, including insects, mammals, and other animals, feed on plants. Herbivore can influence plant growth, reproduction, and defence mechanisms. Plants have evolved various strategies to deter herbivores, such as thorns, toxins, or chemical signals to attract predators of herbivores.

- **Mutualism:** Some plants form mutualistic relationships with other organisms, such as pollinators or Mycorrhizal fungi. These relationships benefit plant and the other organism involved, facilitating pollination, nutrient uptake, or protection from pathogens.

- **Predation and Pathogens:** Plants can be subject to predation by animals or attacked by pathogens such as fungi, bacteria, or viruses. These interactions can have significant impacts on plant health, productivity, and survival.

Ecological succession:

Ecological succession refers to the process of sequential and predictable changes in the species composition and community structure of an ecosystem over time.

- It occurs in response to environmental changes, such as the colonization of a new habitat, disturbances, or the gradual modification of environmental conditions.

- There are various types of ecological succession, including hydrosere and xerosere.

Hydrosere:

- Hydrosere is a type of ecological succession that occurs in aquatic or waterlogged environments. It begins in bodies of water, such as ponds, lakes, or wetlands.

- The process typically involves the gradual filling of water bodies with sediment, organic matter, and debris, leading to the formation of new land areas.

- The stages of hydrosere are as follows, Pioneer Stage, Submerged Stage, Reed swamp Stage and Woodland Stage.

Xerosere:

- Xerosere is a type of ecological succession that occurs in dry or arid environments, such as deserts or rocky terrains.

- It involves a series of changes in plant and animal communities in response to increasing water availability or modifications in other environmental factors.

- The stages of xerosere are as follows, Pioneer Stage, Herbaceous Stage, Shrub land Stage, Woodland Stage.

Signature of the Lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper III - Anatomy and Embryology of Angiosperms, Plant Ecology and Biodiversity
Name of the Topic	**Population, Community and Production Ecology**
Topic Synopsis	▪ **Population ecology** ▪ **Community ecology** ▪ **Concepts of productivity** ▪ **Secondary production**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Discuss the basic concepts of plant ecology, and evaluate the effects of environmental and biotic factors on plant communities. 2. Appraise various qualitative and quantitative parameters to study the population and community ecology.
Pre Knowledge to be reminded	• Ecology is the study of the relationships among living organisms, including humans, and their physical environment. • Ecology considers organisms at the individual, population, community, ecosystem, and biosphere level.

Topic Synopsis

Population ecology:

- Population ecology is a branch of ecology that focuses on the study of populations of organisms and their interactions with the environment.
- Population ecology provides insights into the factors that influence population dynamics, such as birth rates, death rates, immigration, and emigration.
- It helps in understanding the processes and mechanisms that regulate population growth, distribution, and interactions with the environment.
- It involves the examination of various population parameters, dynamics, and processes.

Natality:

- Natality refers to the birth rate or the rate at which new individuals are added to a population through reproduction. It is typically measured as the number of births per unit of time or per unit of population size.

Mortality:

- Mortality refers to the death rate or the rate at which individuals die in a population. It is often measured as the number of deaths per unit of time or per unit of population size.

Growth Curves:

- Growth curves are graphical representations of the population size or density over time. They depict the changes in population size as a result of birth, death, immigration, and emigration. Two commonly observed growth curve patterns are exponential growth curve (J-shaped curve), logistic growth curve (S-shaped curve).

Ecotypes:

- Ecotypes are distinct subpopulations within a species that have adapted to specific ecological conditions or habitats. They exhibit unique physiological, morphological, or behavioural characteristics that allow them to thrive in their specific environment. Ecotypes can arise due to natural selection acting on genetic variation within a species.

Ecads:

- The term "ecads" is not a commonly used term in population ecology or ecological literature. It does not have a recognized definition or specific meaning within the context of ecology.

Community ecology:

- Community ecology is a branch of ecology that focuses on the study of the interactions between species within a community, including their abundance, distribution, and diversity.
- Several concepts are commonly used in community ecology to describe and analyze communities.

Frequency:

- Frequency refers to the proportion of sampling units (e.g., quadrates or plots) in which a particular species or trait is present. It provides an estimate of the occurrence or presence of a species within a community.

Density:

- Density refers to the number of individuals of a species per unit area or volume. It provides an estimate of the abundance or population size of a species within a community.

Cover:

- Cover is a measure of the area occupied by a species relative to the total area being considered. It is typically estimated visually by measuring the proportion of ground or vegetation covered by a particular species.

Life Forms:

- Life forms categorize plant species based on their growth form, structure, and ecological characteristics. Common life form classifications include trees, shrubs, herbs, grasses, and vines.

Biological Spectrum:

- The biological spectrum, also known as the Raunkiær's spectrum, is a classification system that categorizes plants based on their growth forms and adaptations to environmental conditions. The spectrum includes categories such as phanerophytes, chamaephytes, hemicryptophytes, and therophytes.

Concepts of productivity:

Productivity is a fundamental concept in ecology that refers to the rate at which energy is captured and stored in an ecosystem or the rate at which biomass is produced.

- There are several key concepts related to productivity, including **Gross Primary** Productivity (GPP), Net Primary Productivity (NPP), and Community Respiration**.**
- These productivity concepts provide insights into the flow of energy and biomass through ecosystems, the efficiency of energy transfer between tropic levels, and the overall productivity and functioning of ecosystems.

Gross Primary Productivity (GPP):

- Gross Primary Productivity is the total amount of energy captured by primary producers (usually plants) through photosynthesis in an ecosystem over a given period of time.
- It represents the total rate of carbon fixation or the total amount of energy converted from sunlight into chemical energy by photosynthesis.

$$\mathbf{GPP = NPP + R}$$

Net Primary Productivity (NPP):

- Net Primary Productivity is the amount of energy or biomass remaining after subtracting the energy used by primary producers for their own respiration
- NPP represents the rate at which organic matter is accumulated as plant biomass and is available as a food source for consumers.

$$\mathbf{NPP = GPP - R}$$

Community Respiration (CR):

- Community Respiration is the total amount of energy released by all living organisms within an ecosystem through cellular respiration over a given period of time.
- It represents the metabolic activity and energy consumption of all organisms in the ecosystem, including primary producers, consumers, and decomposers.

Secondary production:

- Secondary production refers to the production of biomass by heterotrophic organisms in an ecosystem.
- It represents the energy stored in the form of biomass by consumers (herbivores, carnivores, omnivores) through their consumption of primary producers (plants) or other consumers.

Production to Respiration ratio (P/R ratio):

- Production to Respiration ratio is a measure that compares the primary production (P) of an ecosystem to the amount of energy consumed by respiration (R).
- It represents the efficiency of energy transfer within an ecosystem.

$$\mathbf{P/R\ ratio = NPP/\ CR}$$

- P/R ratio greater than 1 indicates that more energy is being stored through primary production, P/R ratio less than 1 indicates that respiration is consuming more energy than is being produced through primary production.

Ecosystems:

- Ecosystems are defined by the interactions and interdependencies of organisms within them.
- Ecosystems are complex systems consisting of living organisms and their physical environment. They encompass interactions between biotic (living) and abiotic (non-living) components. Ecosystems vary in size, characterized by the cycling of energy and nutrients through the components of the ecosystem.
- They can be classified into different types based on their dominant vegetation and climate, such as forests, grasslands, deserts, or aquatic ecosystems.

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S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper III - Anatomy and Embryology of Angiosperms, Plant Ecology and Biodiversity

Name of the Topic	**Basics of Biodiversity**
Topic Synopsis	▪ **Biodiversity** ▪ **Value of Biodiversity** ▪ **Biodiversity Hot spots in India** ▪ **Principles of conservation** ▪ **Role of NBPGR and NBA**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Correlate the importance of biodiversity and consequences due to its loss. 2. Enlist the endemic/endangered flora and fauna from two biodiversity hot spots in India and assess strategies for their conservation.
Pre Knowledge to be reminded	• Biodiversity is all the different kinds of life you'll find in one area—the variety of animals, plants, fungi, and even microorganisms like bacteria that make up our natural world. • Each of these species and organisms work together in ecosystems, like an intricate web, to maintain balance and support life.

Topic Synopsis

Biodiversity:

Biodiversity refers to the variety and variability of life on Earth. It encompasses the diversity of species, ecosystems, and genetic variation within species.

Components of Biodiversity:

- **Species Diversity**
- **Ecosystem Diversity**
- **Genetic Diversity**

The Convention on Biological Diversity:

- Conservation of Biodiversity aims to conserve and sustainably use biodiversity. It recognizes the intrinsic value of biodiversity and the importance of maintaining ecological processes and essential services provided by ecosystems.
- The objectives of the Convention on Biological Diversity are threefold; they are Conservation of Biodiversity, Sustainable Use of Biodiversity and Fair and Equitable Sharing of Benefits.

Earth Summits:

Earth Summits, also known as the United Nations Conference on Environment and Development (UNCED), are international conferences held to address global environmental issues and promote sustainable development.

- **Earth Summit 1992 (Rio Summit):** Held in Rio de Janeiro, Brazil. The main outcomes of the summit were the adoption of the Convention on Biological Diversity.
- **World Summit on Sustainable Development 2002 (Johannesburg Summit):** Held in Johannesburg, South Africa. The summit focused on key themes such as poverty eradication, sustainable consumption and production, water and sanitation, energy, and biodiversity.
- **United Nations Conference on Sustainable Development 2012 (Rio+20):** Held in Rio de Janeiro, Brazil. The summit focused on two main themes: green economy in the context of sustainable development and poverty eradication, and the institutional framework for sustainable development.
- **United Nations Climate Change Conference (COP21) 2015 (Paris Agreement):** Although not officially an Earth Summit, the COP21 held in Paris, France and aimed at limiting global warming to well below 2 degrees Celsius above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 degrees Celsius.

Levels of Biodiversity:

- **Species Diversity:** Species diversity refers to the variety and abundance of different species within a given area or ecosystem.
- **Ecosystem Diversity:** Ecosystem diversity refers to the variety of different ecosystems includes forests, grasslands, wetlands, coral reefs, and many other types of habitats.
- **Genetic Diversity:** Genetic diversity refers to the variation in genes within a species.

Value of Biodiversity:

- Biodiversity holds immense value, both intrinsic and instrumental, for the planet and human societies.
- **Ecosystem Services**
- **Food Security**
- **Medicine and Pharmaceuticals**
- **Cultural and Aesthetic Value**

Threats to Biodiversity:

- Biodiversity is facing numerous threats, primarily caused by human activities. Some key threats to biodiversity include Habitat Loss and Degradation, Climate Change, Pollution, Overexploitation of Resources, Invasive Species and Land and Water Use Changes.

Biodiversity Hot spots in India:

The major biodiversity hotspots in India is following

- **Western Ghats:** The Western Ghats is a mountain range that runs parallel to the western coast of India.
- **Indo-Burma Region:** The Indo-Burma region covers parts of north eastern India, including the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura.
- **Sunderland:** Sunderland is a biodiversity hotspot that extends to parts of India, including the Andaman and Nicobar Islands.
- **Himalayas:** The Himalayas, including the eastern and western Himalayas, are recognized as a biodiversity hotspot.
- **Nicobar Islands**: The Nicobar Islands, part of the Andaman and Nicobar Islands group, are considered a distinct biodiversity hotspot.

North Eastern Himalayas:

- The North Eastern Himalayas is one of the 36 globally recognized biodiversity hotspots.
- It spans across the eastern part of the Indian states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, as well as parts of Bhutan and Nepal.
- This region is characterized by its diverse topography, ranging from the high mountains of the Eastern Himalayas to the plains of the Brahmaputra Valley.

Western Ghats:

- The Western Ghats is another important biodiversity hotspot in India.
- It stretches along the western coast of India, covering the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala, and Tamil Nadu.
- This region is a UNESCO World Heritage site and is known for its exceptional biological diversity.

Principles of conservation:

The principles of conservation encompass a set of guiding principles and approaches aimed at the protection, preservation, and sustainable management of biodiversity and natural resources.

- These principles are based on scientific knowledge and ethical considerations and provide a framework for effective conservation strategies.
- The key principles of conservation as like Biodiversity Preservation, Ecosystem Approach, Sustainable Use, Integrated Conservation Planning, Collaboration and Participation, Education and Awareness and Adaptive Management.

IUCN Threat Categories:

The International Union for Conservation of Nature (IUCN) has developed a system of threat categories to assess the conservation status of species.

The IUCN threat categories include:

1. **Extinct (EX):** Species that are no longer found in the wild or have gone extinct.
2. **Extinct in the Wild (EW):** Species that are only found in captivity or cultivation.
3. **Critically Endangered (CR):** Species facing an extremely high risk of extinction.
4. **Endangered (EN):** Species facing a very high risk of extinction.
5. **Vulnerable (VU):** Species facing a high risk of extinction.
6. **Near Threatened (NT):** Species that are close to qualifying for a threatened category.
7. **Least Concern (LC):** Species that are widespread and have a low risk of extinction.
8. **Data Deficient (DD):** Species with insufficient information to determine their conservation status.
9. **Not Evaluated (NE):** Species that have not yet been evaluated.

RED Data Book:

The RED (**Reduction of Endangered Species**) data book is a compilation of comprehensive information on endangered and threatened species.

- It serves as a valuable reference for assessing the conservation status of various species and understanding their distribution, population trends, threats, and conservation measures.
- The RED data book plays a crucial role in prioritizing conservation actions, developing conservation strategies, and monitoring the status of endangered species.

Role of NBPGR and NBA:

- Both the NBPGR and the NBA work in close collaboration with each other and other governmental and non-governmental organizations to conserve and sustainably manage biodiversity in India.
- Their efforts contribute to the protection of plant genetic resources and the conservation of biodiversity at the national level.
- **Role of National Bureau of Plant Genetic Resources (NBPGR):**Conservation of Plant Genetic Resources, Gene bank Management, Research and Documentation, Capacity Building.
- **Role of National Biodiversity Authority (NBA):** Regulation and Policy, Biodiversity Conservation, Access and Benefit Sharing and Documentation and Database.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper IV - Plant Physiology and Metabolism**
Name of the Topic	**Plant-Water relations**
Topic Synopsis	▪ **Importance of water** ▪ **Absorption and transport of water** ▪ **Transpiration** ▪ **Mechanism of phloem transport**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Comprehend the importance of water in plant life and mechanisms for transport of water and solutes in plants. 2. Evaluate the role of minerals in plant nutrition and their deficiency symptoms.
Pre Knowledge to be reminded	• 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.

Topic Synopsis

Importance of water

- Water is crucial for the growth and survival of plants due to its numerous essential roles. It is required for photosynthesis, the process by which plants convert sunlight, carbon dioxide, and water into energy-rich sugars and oxygen.
- Water also serves as a medium for the uptake and transport of vital nutrients from the soil to various parts of the plant.
- It is involved in regulate plant temperature metabolic processes, including the synthesis and breakdown of essential compounds. Adequate water availability is necessary for successful seed germination, and it acts as a carrier for the transport of sugars within plants.

Physical properties of water:

- The physical properties of water, such as its high specific heat capacity, cohesion, and ability to exist in three states (solid, liquid, and gas), make it unique and essential in various natural processes.
- These properties enable water to regulate temperature, support life through its cohesive and adhesive properties, and play a crucial role in Earth's water cycle.

- Water's ability to dissolve many substances also allows it to act as a universal solvent, facilitating chemical reactions and serving as a medium for transport in biological systems.

Diffusion:

- Diffusion is the passive movement of particles or molecules from an area of higher concentration to an area of lower concentration.
- In the context of water, it refers to the movement of water molecules across a semi-permeable membrane or through a permeable material, such as soil or plant tissues, until equilibrium is reached.

Imbibition:

- Imbibition is the process by which substances, such as water, is absorbed and swells into the pores or spaces within a solid material, typically a hydrophilic substance like cellulose or gel-like substances.
- This process is commonly observed in seeds, where water absorption causes them to swell and initiate germination.

Osmosis:

- Osmosis is the movement of water molecules across a semi-permeable membrane from an area of lower solute concentration to an area of higher solute concentration.
- It is driven by the need to equalize the concentration of solutes on both sides of the membrane, resulting in the movement of water towards the more concentrated solution.

Water Potential:

- Water potential is a measure of the potential energy of water in a system, specifically in relation to its tendency to move from one area to another.
- It is influenced by various factors, including solute concentration, pressure, and gravity.
- Water always moves from an area of higher water potential to an area of lower water potential.

Osmotic Potential:

- Osmotic potential, also known as solute potential, is a component of water potential that relates to the effect of solute concentration on water movement.
- It represents the amount of pressure required to prevent the net movement of water through osmosis.
- The more negative the osmotic potential, the higher the concentration of solutes and the lower the water potential.

Pressure Potential:

- Pressure potential is another component of water potential that accounts for the physical pressure exerted on water in a system.

- It can be positive or negative, depending on whether the pressure is exerted on or by the system.
- Positive pressure potential, such as turgor pressure in plant cells, can increase water potential, while negative pressure potential, like tension in xylem vessels, can decrease water potential.

Ascent of Sap:

The upward movement of water in plants is known as the ascent of sap.

The transport of water in plants occurs through the xylem, which is a complex tissue composed of specialized cells that form tubes for water movement.

- **Cohesion-Tension Theory:** This theory explains the primary mechanism behind the upward movement of water in the xylem. It relies on the cohesion (attraction between water molecules) and adhesion (attraction between water and cell walls) properties of water.
- **Transpiration Pull:** Transpiration, the process of water loss from the aerial parts of the plant (mainly leaves), generates tension or negative pressure within the xylem. This transpiration pull facilitates the movement of water upwards through the xylem vessels.
- **Capillarity:** Capillary action, the phenomenon of water rising in narrow tubes, can also contribute to the ascent of sap in some plants with very narrow xylem vessels.

Factors Influencing Ascent of Sap:

- Transpiration Rate
- Environmental Conditions
- Xylem Structure

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper IV - Plant Physiology and Metabolism
Name of the Topic	**Mineral nutrition, Enzymes and Respiration**
Topic Synopsis	▪ **Essential macro and micro mineral nutrients** ▪ **Absorption of mineral ions** ▪ **Enzymes** ▪ **Respiration**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Interpret the role of enzymes in plant metabolism. 2. Evaluate the role of minerals in plant nutrition and their deficiency symptoms.
Pre Knowledge to be reminded	• Mineral Nutrition is defined as the naturally occurring inorganic nutrient found in the soil and food that is essential for the proper functioning of animal and plant body. • Minerals are vital elements necessary for the body. Both the plants and animals require minerals essentially.

Topic Synopsis

Essential macro and micro mineral nutrients:

- Plants require a range of macro and micro mineral nutrients for their growth, development, and overall physiological functions.
- For plants, essential nutrients can be categorized into two groups such as macronutrients and micronutrients.

Macronutrients:

- Macronutrients are elements that plants require in relatively large quantities, as they are essential components of plant biomass.
- **Nitrogen (N):** Essential for protein synthesis, chlorophyll production, and overall plant growth. Due to the deficiency of this may leads to stunted growth, yellowing of older leaves (chlorosis), and reduced protein content.
- **Phosphorus (P):** Involved in energy transfer processes (ATP), nucleic acid synthesis, and root development. Due to the deficiency of this may leads to poor root development, purple or reddish leaves, and delayed flowering.
- **Potassium (K):** Essential for enzyme activation, water uptake, and osmoregulation in plant cells. Due to the deficiency of this may leads to Weak stems, scorched leaf edges, and poor fruit development.

- **Calcium (Ca):** Important for cell wall structure, cell division, and membrane integrity. Due to the deficiency of this may leads to Poor root growth, leaf deformation, and blossom end rot in fruits.
- **Magnesium (Mg):** An essential component of chlorophyll and involved in enzyme activation. Due to the deficiency of this may leads to Interveinal chlorosis in older leaves and reduced chlorophyll content.
- **Sulphur (S):** Essential for the synthesis of amino acids, proteins, and some vitamins. Due to the deficiency of this may leads to Yellowing of new leaves, similar to nitrogen deficiency, but occurs in young tissues.

Micronutrients:

- Micronutrients, also known as trace elements, are elements that plants need in smaller quantities but are equally important for their growth and development.
- **Iron (Fe):** Essential for chlorophyll synthesis, enzyme functions, and electron transport in photosynthesis. Due to the deficiency of this may leads to Interveinal chlorosis in young leaves.
- **Manganese (Mn):** Involved in photosynthesis, enzyme activation, and nitrogen metabolism. Due to the deficiency of this may leads to Interveinal chlorosis with brown spots on leaves.
- **Zinc (Zn):** Important for enzyme functions and growth hormone regulation. Due to the deficiency of this may leads to Interveinal chlorosis, smaller leaves, and delayed maturity.
- **Copper (Cu):** Essential for electron transport in photosynthesis and respiration. Wilting of young leaves and dieback of shoot tips.
- **Boron (B):** Required for cell wall synthesis and pollen tube growth. Due to the deficiency of this may leads to Brittle and deformed young leaves and roots.
- **Molybdenum (Mo):** Essential for nitrogen fixation and enzyme functions. Due to the deficiency of this may leads to General yellowing and reduced growth.
- **Chlorine (Cl):** Involved in photosynthesis, osmoregulation, and ionic balance. Due to the deficiency of this may leads to Wilting, chlorosis, and reduced growth.
- **Nickel (Ni):** Required for certain enzyme functions, particularly in nitrogen metabolism. Due to the deficiency of this may leads to reduced growth and development.

Absorption of mineral ions:

The absorption of mineral ions by plant roots involves both passive and active processes.

Passive Absorption:

- Passive absorption refers to the movement of mineral ions across the root membranes driven by concentration gradients or electrochemical potential differences. It does not require energy expenditure by the plant.
- Passive absorption occurs through two main mechanisms such as Diffusion and Mass Flow.
- **Mass Flow:** Passive absorption also occurs through the mass flow of water carrying dissolved mineral ions. As water enters the root through osmosis, it carries mineral ions along with it.

Active Absorption:

- Active absorption involves the uptake of mineral ions against their concentration gradient, requiring the expenditure of energy by the plant.
- **Active Transport:**
- Active transport involves the movement of ions across the root membrane against the concentration gradient, using energy derived from ATP (adenosine triphosphate).
- Carrier proteins embedded in the root cell membranes facilitate the selective uptake of specific mineral ions, such as nitrate (NO3-), phosphate (PO43-), and iron (Fe2+). This process allows plants to accumulate these ions even when their concentrations in the soil are low.

Ion Exchange:

- Plants can also absorb mineral ions by exchanging them with other ions present in the soil solution. This occurs through the activity of ion exchange sites on the root surfaces.
- For example, hydrogen ions (H+) released by the roots can displace and release mineral cations like potassium (K+) or calcium (Ca2+) from soil particles, making them available for root uptake.
- The combination of passive and active absorption processes allows plants to efficiently take up the necessary mineral ions for their growth and development. Passive absorption is mainly responsible for the uptake of small, uncharged ions and occurs down concentration gradients.

Enzymes:

- Enzymes are biological molecules, typically proteins that act as catalysts in living organisms. They speed up chemical reactions by lowering the activation energy required for the reaction to occur.

Characteristics of Enzymes:

- **Catalytic Activity:** Enzymes accelerate the rate of chemical reactions by lowering the activation energy required for the reaction to occur.
- **Specificity:** Enzymes exhibit high specificity towards their substrates. Each enzyme typically acts on a specific substrate or a group of closely related substrates.
- **Efficiency:** Enzymes can increase the rate of reactions by several orders of magnitude.
- **Regulation:** Enzyme activity can be regulated to control cellular processes.
- **Reusability:** Enzymes are not consumed or destroyed during a reaction.
- **pH and Temperature Sensitivity:** Enzymes exhibit optimal activity within specific ranges of pH and temperature.
- **Enzyme Kinetics:** Enzyme-catalyzed reactions follow specific kinetic patterns.
- **Enzyme-Substrate Complex:** Enzymes interact with their substrates through a highly specific binding at the enzyme's active site.

Classification of Enzymes:

Enzymes can be classified into several categories based on different criteria, including the type of reaction they catalyze, the nature of their substrates, and their overall structure.

- **Oxidoreductases:** These enzymes catalyze oxidation-reduction reactions, involving the transfer of electrons between molecules.
- **Transferases:** Transferases facilitate the transfer of functional groups (such as amino, methyl, or phosphate groups) from one molecule to another.
- **Hydrolases:** Hydrolases catalyze hydrolysis reactions, where a molecule is cleaved by the addition of water.
- **Lyases:** Lyases cleave or form bonds in a molecule without the addition or removal of water.
- **Isomerases:** Isomerases catalyze the rearrangement of atoms within a molecule, converting it into an isomeric form.
- **Ligases:** Ligases catalyze the joining of two molecules by forming new bonds, often utilizing energy from ATP.
- **Proteases:** Proteases specifically catalyze the hydrolysis of peptide bonds in proteins or peptides.
- **Kinases:** Kinases are a subclass of transferases that catalyze the transfer of a phosphate group from ATP to another molecule, typically proteins or other nucleotides.

Mechanism of enzyme action:

The mechanism of enzyme action describes the steps involved in the catalytic process of an enzyme.

It typically follows the general concept of the "lock and key" model, where the enzyme (the lock) binds to its specific substrate (the key) to form an enzyme-substrate complex.

- The enzyme then facilitates the conversion of the substrate into product(s) through specific chemical reactions.
- The enzyme remains unchanged at the end of the reaction and is available to catalyze additional reactions.

Enzyme Kinetics:

Enzyme Kinetics refers to the study of the rates of enzyme-catalyzed reactions and the factors that influence those rates.

It provides insights into the enzyme's efficiency, substrate affinity, and regulatory mechanisms.

- **Reaction Rate:** Enzyme kinetics quantifies the rate of a reaction by measuring the rate of substrate conversion into product(s) over time.
- **Michaelis-Menten Kinetics:** The Michaelis-Menten equation describes the relationship between the initial reaction rate, substrate concentration, and enzyme parameters such as the Michaelis constant (Km) and maximum reaction rate (Vmax).
- **Enzyme Inhibition:** Enzyme kinetics also explores the effects of inhibitors on enzyme activity.

- **Enzyme Activation:** Some compounds can enhance enzyme activity and increase the reaction rate.
- **Enzyme Regulation:** Enzyme kinetics investigates the regulation of enzyme activity by factors such as pH, temperature, and allosteric regulators.

Respiration:

- Respiration in plants is the process by which they convert organic compounds, such as sugars, into usable energy in the form of ATP (adenosine triphosphate).
- It occurs in plant cells throughout their entire life cycle, including germination, growth, and reproduction.
- Plant respiration can be divided into two main types: aerobic respiration and anaerobic respiration.

Aerobic Respiration:

Aerobic respiration is the most common type of respiration in plants and occurs in the presence of oxygen.

It involves the complete breakdown of glucose (or other organic compounds) to release energy. The process can be summarized in three main stages:

- **Glycolysis:** In the cytoplasm, glucose is converted into two molecules of pyruvate, producing a small amount of ATP and reducing equivalents in the form of NADH (nicotinamide adenine dinucleotide).
- **Citric Acid Cycle (Krebs cycle):** In the mitochondria, pyruvate is further broken down into carbon dioxide, generating more ATP, NADH, and FADH2 (flavin adenine dinucleotide).
- **Electron Transport Chain (ETC):** NADH and FADH2 produced in the previous steps donate their electrons to the electron transport chain embedded in the mitochondrial inner membrane. This generates a large amount of ATP through oxidative phosphorylation, using oxygen as the final electron acceptor.

Anaerobic Respiration:

- Anaerobic respiration occurs in the absence of oxygen and is less common in plants. It is typically a temporary response to conditions where oxygen availability is limited.
- The process involves the partial breakdown of glucose, producing energy and metabolic by products.
- In **alcoholic fermentation**, pyruvate is converted into ethanol, releasing carbon dioxide as a by product. This process is used by plants, such as yeast, during fermentation in the production of alcoholic beverages.
- In **lactic acid fermentation**, pyruvate is converted into lactic acid. This process can occur in plant tissues when oxygen levels are low, such as during periods of intense exercise or under certain environmental conditions.

Signature of the Lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper IV - Plant Physiology and Metabolism**
Name of the Topic	**Photosynthesis and Photorespiration**
Topic Synopsis	▪ **Photosynthesis** ▪ **Photo systems** ▪ **Photosynthetic electron transport** ▪ **Photo phosphorylation** ▪ **Photorespiration**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 3. Interpret the role of enzymes in plant metabolism. 4. Evaluate the role of minerals in plant nutrition and their deficiency symptoms.
Pre Knowledge to be reminded	• Mineral Nutrition is defined as the naturally occurring inorganic nutrient found in the soil and food that is essential for the proper functioning of animal and plant body. • Minerals are vital elements necessary for the body. Both the plants and animals require minerals essentially.

Topic Synopsis

Photosynthesis:

Photosynthesis is the process by which green plants, algae, and some bacteria convert light energy into chemical energy, specifically in the form of glucose (a sugar molecule). It is a complex biochemical reaction that occurs in the chloroplasts of plant cells.

$$6\ CO_2 + 6\ H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6\ O$$

Photosynthetic pigments:

- Photosynthetic pigments are light-absorbing molecules found in the chloroplasts of plants, algae, and some bacteria.
- The most important pigments involved in photosynthesis are chlorophyll a, chlorophyll b, carotenoids, and phycobilins.
- Each pigment has a unique absorption spectrum, which refers to the range of light wavelengths it can absorb.

Absorption spectrum:

- The absorption spectrum of a pigment shows the specific wavelengths of light that are absorbed most effectively by the pigment.
- Ex. Chlorophyll- A -around 430-450 nm- (blue) to around 660-680 nm (Red), Chlorophyll –B -around 450-470 nm (blue) to around 640-660 nm (red-orange), Carotenoids- around 450-550 nm (blue-green).

Action spectrum:

- The action spectrum, on the other hand, represents the effectiveness of different wavelengths of light in driving the process of photosynthesis.
- The action spectrum typically follows a similar pattern to the absorption spectrum of chlorophyll, indicating that chlorophyll pigments play a significant role in capturing light energy for photosynthesis.

Red drop effect:

- The Emerson enhancement effect, named after the scientist Robert Emerson, refers to the phenomenon where the efficiency of photosynthesis is significantly increased when multiple pigments with overlapping absorption spectra are simultaneously illuminated.
- This leads to an increase in the overall photosynthetic activity compared to when each pigment is illuminated separately.

Emerson enhancement effect:

- The Emerson enhancement effect demonstrates the cooperative action of different pigments in maximizing light capture and energy conversion in photosynthesis.
- It highlights the importance of having a variety of pigments in photosynthetic organisms to efficiently harvest light energy across a broad spectrum of wavelengths.

Photosystems:

- The concept of two photosystems, known as Photosystem I (PSI) and Photosystem II (PSII), is an essential component of the light-dependent reactions in photosynthesis.
- These two photosystems work together to capture and convert light energy into chemical energy.
- **Photosystem II (PSII): PSII** is responsible for the initial step in the light-dependent reactions. It absorbs light energy and uses it to split water molecules (photolysis) into oxygen (O2), protons (H+), and electrons (e^-).
- **Photosystem I (PSI): PSI** receives the electrons from Photosystem II. It absorbs additional light energy and uses the electrons to produce energy-rich molecules such as NADPH (nicotinamide adenine dinucleotide phosphate).

Photosynthetic electron transport:

- The mechanism of photosynthetic electron transport involves a series of redox reactions in which light energy is converted into chemical energy. This process occurs in the thylakoid membranes of chloroplasts in plants and in the plasma membranes of photosynthetic bacteria.

Photophosphorylation:

- Photophosphorylation is the process of generating ATP (adenosine triphosphate) using light energy during photosynthesis. It occurs in the thylakoid membranes of chloroplasts in plants and in the plasma membranes of photosynthetic bacteria.
- There are two types of photophosphorylation: non-cyclic photophosphorylation and cyclic photophosphorylation.

Non-cyclic Photophosphorylation:

- Non-cyclic photophosphorylation is the primary pathway for ATP synthesis in photosynthesis. It involves both Photosystem II (PSII) and Photosystem I (PSI) working together.

Cyclic Photophosphorylation:

- Cyclic photophosphorylation occurs in some photosynthetic bacteria and a subset of chloroplasts. It involves only PSI and generates ATP without producing NADPH or oxygen.

Evolution of oxygen:

- The evolution of oxygen on Earth is a significant event that shaped the planet's atmosphere and allowed the development of aerobic organisms.
- This process, known as the Great Oxygenation Event or Oxygen Catastrophe, occurred approximately 2.4 billion years ago and had profound impacts on the Earth's ecosystems.
- The evolution of oxygen can be explained in the following steps; Origin of Photosynthesis, Early Photosynthesis, Oxygen Production, Oxygen Accumulation, Oxygen Catastrophe, Aerobic Organisms and Ozone Formation.

Carbon assimilation pathways:

- Carbon assimilation pathways are different strategies used by plants to fix carbon dioxide (CO_2) during photosynthesis.
- The three primary pathways are C3, C4, and CAM (Crassulacean Acid Metabolism).
- These pathways differ in the way carbon dioxide is captured and fixed by plants, the location of these processes, and the efficiency of water and energy usage.

C3 Pathway:

- The C3 pathway is the most common carbon assimilation pathway and is named after the three-carbon compound formed during the initial steps of carbon fixation.
- In this pathway Carbon dioxide is initially captured by the enzyme **Rubisco** and combined with a five-carbon compound called **RuBP** (six-carbon compound).
- These six-carbon compound that quickly breaks down into two molecules of 3-phosphoglycerate (PGA), hence the name C3.
- PGA is then converted G3P, which can be further processed to produce glucose and other organic compounds.

C4 Pathway:

- The C4 pathway is an adaptation found in some plants that grow in warm and dry environments.
- It minimizes the water loss associated with C3 plants and allows for more efficient carbon fixation.
- In this pathway Carbon dioxide is first captured by Phospho enolpyruvate carboxylase in the mesophyll cells, forming a four-carbon compound called oxaloacetate or malate.
- This compound is then transported to the bundle sheath cells, where it releases carbon dioxide.

CAM Pathway:

The CAM pathway is another adaptation to arid environments and is predominantly found in succulent plants such as cacti and certain orchids.CAM plants have specialized anatomy and physiology to reduce water loss.

- In this pathway Carbon dioxide is captured at night and stored as organic acids, usually malate, in vacuoles. During the day, the stomata remain closed to prevent water loss. The stored organic acids are then decarboxylated, releasing carbon dioxide, which enters the C3 pathway for photosynthesis.
- This separation of carbon fixation in time (night) and carbon reduction (day) allows CAM plants to minimize water loss while still carrying out photosynthesis.

Photorespiration:

- Photorespiration is a metabolic pathway that occurs in plants when there is a high concentration of oxygen (O_2) and a low concentration of carbon dioxide (CO_2) in the leaf cells.
- It is considered a wasteful process because it consumes energy and reduces the efficiency of photosynthesis.
- During photorespiration, the enzyme Rubisco, which is responsible for capturing carbon dioxide during photosynthesis, can mistakenly react with oxygen instead of carbon dioxide.
- This reaction is known as oxygenation or oxygenase activity of Rubisco.
- Oxygenation of the substrate molecule, ribulose-1,5-bisphosphate (RuBP), leads to the formation of two molecules: one molecule of 3-phosphoglycerate (3-PGA) and one molecule of a two-carbon compound called phosphoglycolate.

C2 pathway:

- The C2 pathway is part of a complex network of reactions within photorespiration that aims to salvage some of the carbon lost during the oxygenation of RuBP by Rubisco.
- While photorespiration is considered a wasteful process, it is believed to have evolved as a by product of the oxygenase activity of Rubisco and has implications for plant metabolism and adaptation to various environmental conditions.

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper IV - Plant Physiology and Metabolism**
Name of the Topic	**Nitrogen and lipid metabolism**
Topic Synopsis	▪ **Nitrogen metabolism** ▪ **Biological nitrogen fixation** ▪ **Nitrogenase enzyme system** ▪ **Lipid metabolism** ▪ **saturated and unsaturated fatty acids** ▪ **Anabolism of triglycerides** ▪ **β-oxidation of fatty acids** ▪ **Glyoxylate cycle**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Analyze the biochemical reactions in relation to Nitrogen. 2. Analyze the biochemical reactions in relation to lipid metabolisms.
Pre Knowledge to be reminded	• Mineral Nutrition is defined as the naturally occurring inorganic nutrient found in the soil and food that is essential for the proper functioning of animal and plant body. • Minerals are vital elements necessary for the body. Both the plants and animals require minerals essentially.

Topic Synopsis

Nitrogen metabolism:

Nitrogen metabolism refers to the various processes by which organisms acquire, utilize, and recycle nitrogen in living systems.

Nitrogen is an essential element for the synthesis of proteins, nucleic acids, and other important molecules in cells

The atmospheric nitrogen (N2) that makes up the majority of Earth's atmosphere cannot be directly utilized by most organisms and nitrogen must be converted into a usable form through a series of biological processes.

Nitrogen metabolism includes Nitrogen Fixation, Nitrate Assimilation, Ammonium Assimilation, Amino Acid Metabolism, Nitrogen Recycling, and Nitrogen Loss.

Biological nitrogen fixation:

Biological nitrogen fixation is the process by which certain organisms convert atmospheric nitrogen (N_2) into forms that are biologically usable, such as ammonia (NH_3) or ammonium (NH_4^+).

There are two main categories of nitrogen-fixing organisms: Asymbiotic nitrogen-fixing organisms and symbiotic nitrogen-fixing organisms.

Asymbiotic Nitrogen-Fixing Organisms:

- Asymbiotic nitrogen fixation refers to the nitrogen-fixing activity of free-living organisms that do not have a symbiotic relationship with other organisms.
- The primary examples of Asymbiotic nitrogen-fixing organisms are certain bacteria and Archaea, which possess the enzyme nitrogenase that enables them to convert atmospheric nitrogen into ammonia. Ex. Azotobacter, Azospirillum and Klebsiella pneumonia.

Symbiotic Nitrogen-Fixing Organisms:

- Symbiotic nitrogen fixation occurs when nitrogen-fixing organisms form a mutualistic relationship with other organisms, typically plants.
- These organisms form specialized structures called nodules, where the nitrogen fixation takes place.
- The plant provides the nitrogen-fixing organism with carbohydrates and a suitable environment, while the nitrogen-fixing organism supplies the plant with fixed nitrogen. Ex. Rhizobium, Frankia and Cyanobacteria.

Nitrogenase enzyme system:

- The nitrogenase enzyme system is complex biological machinery responsible for catalyzing the conversion of atmospheric nitrogen (N_2) into ammonia (NH_3) or ammonium (NH_4^+), a process known as nitrogen fixation.
- The nitrogenase enzyme system consists of two main components: the nitrogenase complex and the associated electron transfer proteins
- **Nitrogenase Complex:** The nitrogenase complex is composed of two key enzymes such as **Dinitrogenase (MoFe protein)** - It binds and reduces nitrogen molecules during the nitrogen fixation process, and **Dinitrogenase reductase (Fe protein)** - It shuttles electrons from an electron donor, usually a flavodoxin or ferredoxin protein, to the dinitrogenase enzyme.
- **Electron Transfer Proteins:** The nitrogenase enzyme system requires several electron transfer proteins to provide a source of reducing power (electrons) for the nitrogen fixation reaction. These proteins include **Flavodoxin or Ferredoxin** - These small proteins accept electrons from an electron donor and **Adenosine triphosphate (ATP) -** The nitrogenase reaction requires ATP as an energy source.
- Nitrogen fixation carried out by the nitrogenase enzyme system plays a vital role in the global nitrogen cycle, as it provides a significant source of bio available nitrogen for plants and other organisms.

Lipid metabolism:

- Lipid metabolism refers to the biochemical processes that occur in living organisms to regulate the synthesis, breakdown, and utilization of lipids.

- Lipids are a diverse group of molecules that include fats, oils, phospholipids, sterols, and other related compounds.
- They serve various functions in cells, such as energy storage, structural components of membranes, signalling molecules, and insulation.
- **Lipogenesis:** It is the process of synthesizing new lipids, primarily fatty acids and glycerol, from non-lipid precursors.
- **Lipolysis:** It is the breakdown of stored triglycerides into fatty acids and glycerol.
- **β-Oxidation:** It is the process by which fatty acids are broken down in the mitochondria to generate energy.
- **Lipid Transport and Packaging:** Lipids are transported in the bloodstream as lipoprotein particles.
- **Lipid Modification and Signalling:** Lipids are also modified through various enzymatic reactions to generate biologically active molecules that act as signalling molecules or serve specific functions.

Classification of Plant Lipids:

Plant lipids can be classified into several categories based on their chemical structure and function.

- **Fatty Acids:** Fatty acids are the building blocks of most plant lipids. They are long hydrocarbon chains with a carboxyl group at one end. Fatty acids can be saturated (no double bonds) or unsaturated (one or more double bonds). They play a crucial role in energy storage as components of triglycerides and as structural elements in phospholipids.
- **Triacylglycerols (TAGs):** Triacylglycerols, also known as triglycerides, are the main storage form of lipids in plants. They consist of three fatty acid molecules esterified to a glycerol backbone.
- **Phospholipids:** Phospholipids are major components of cell membranes in plants. They consist of a glycerol backbone esterified with two fatty acids and a phosphate group. Phospholipids provide the structural integrity and selective permeability of cell membranes.
- **Glycolipids:** Glycolipids are lipids that have a carbohydrate moiety attached to them. They are found in the membranes of plant cells and play a role in cell recognition and signalling.
- **Sterols:** Sterols are a class of lipids that include compounds such as cholesterol and phytosterols. In plants, the predominant sterol is β-sitosterol. Sterols are important components of cell membranes and play roles in maintaining membrane fluidity and stability.
- **Cuticular Lipids:** Cuticular lipids are lipids that form a waxy layer on the outer surface of plant organs, such as leaves, stems, and fruits. They provide a protective barrier against water loss, pathogens, and environmental stresses.

Saturated Fatty Acids:

- Saturated fatty acids have hydrocarbon chains that contain only single bonds between carbon atoms, with each carbon atom saturated with hydrogen atoms. This results in a straight and rigid structure. Saturated fatty acids are typically solid at room temperature.

- Examples of common saturated fatty acids include Palmitic acid, Stearic acid and Butyric acid.

Unsaturated Fatty Acids:

- Unsaturated fatty acids have one or more double bonds between carbon atoms in their hydrocarbon chain. The presence of double bonds introduces kinks or bends in the structure, making unsaturated fatty acids more fluid and usually liquid at room temperature.
- Unsaturated fatty acids are further classified into monounsaturated and polyunsaturated fatty acids.
- **Monounsaturated fatty acids (MUFAs):** These fatty acids have one double bond in their hydrocarbon chain. Ex. Oleic acid (18 carbon atoms)
- **Polyunsaturated fatty acids (PUFAs):** These fatty acids have two or more double bonds in their hydrocarbon chain. Ex. Linoleic acid, Alpha-linolenic acid.

Anabolism of triglycerides:

Anabolism of triglycerides, also known as triglyceride synthesis or lipogenesis, involves the formation of triglyceride molecules from simpler precursor molecules.

- **Activation of Fatty Acids:** Fatty acids are activated by attaching a Coenzyme A (CoA) molecule to their carboxyl end, forming fatty acyl-CoA. This step requires ATP and is catalyzed by the enzyme fatty acyl-CoA synthetase.
- **Formation of Glycerol-3-Phosphate:** Glycerol-3-phosphate, the precursor for the glycerol backbone of triglycerides, It can be derived from glucose through glycolysis or from dihydroxyacetone phosphate (DHAP), an intermediate of Glycolysis or Glycerol-3-phosphate can be obtained from dietary glycerol or the breakdown of triglycerides.
- **Synthesis of Phosphatidic Acid:** Fatty acyl-CoA molecules and glycerol-3-phosphate combine to form phosphatidic acid; One fatty acyl-CoA molecule is transferred to the hydroxyl group of glycerol-3-phosphate, forming lysophosphatidic acid (LPA); the remaining two fatty acyl-CoA molecules are added to LPA to form phosphatidic acid (PA). This step is catalyzed by the enzyme glycerol-3-phosphate acyltransferase.
- **Triglyceride Formation:** The phosphate group of phosphatidic acid is removed by the enzyme phosphatase, resulting in the formation of diacylglycerol (DAG). Another fatty acyl-CoA molecule is added to DAG, catalyzed by diacylglycerol acyltransferase (DGAT), to form triglycerides. Triglycerides can be further modified by incorporating different fatty acids to give rise to various triglyceride molecules.

β-oxidation of fatty acids:

- β-oxidation is a metabolic pathway that occurs in the mitochondria of plant cells and involves the breakdown of fatty acids to produce acetyl-CoA, which can enter the citric acid cycle for energy production.

Activation of Fatty Acids:

- Fatty acids, obtained from stored triglycerides or dietary sources, are activated in the cytoplasm.

- Coenzyme A (CoA) is attached to the fatty acids carboxyl end, forming fatty acyl-CoA.
- This step requires ATP and is catalyzed by the enzyme fatty acyl-CoA synthetase.

<u>Transport into the Mitochondria:</u>

- Fatty acyl-CoA molecules are transported into the mitochondria from the cytoplasm.
- This process involves a carnitine shuttle system, where fatty acyl-CoA is converted to fatty acyl-carnitine by the enzyme carnitine palmitoyltransferase I (CPT1) on the outer mitochondrial membrane.
- Fatty acyl-carnitine crosses the mitochondrial membrane through a carnitine-acylcarnitine translocase.
- Once inside the mitochondrial matrix, fatty acyl-carnitine is converted back to fatty acyl-CoA by carnitine palmitoyltransferase II (CPT2).

<u>β-Oxidation Cycle:</u>

The β-oxidation cycle involves a series of enzymatic reactions that occur in the mitochondrial matrix, repeating for each cycle until the fatty acid is fully oxidized. Each cycle involves four main steps: oxidation, hydration, oxidation, and thiolysis.

- **Oxidation:** The fatty acyl-CoA undergoes oxidation by the enzyme acyl-CoA dehydrogenase, resulting in the formation of trans-Δ2-enoyl-CoA. This step generates one molecule of $FADH_2$.
- **Hydration:** The trans-Δ2-enoyl-CoA is hydrated by the enzyme enoyl-CoA hydratase, leading to the formation of L-3-hydroxyacyl-CoA.
- **Oxidation:** L-3-hydroxyacyl-CoA is oxidized by the enzyme L-3-hydroxyacyl-CoA dehydrogenase, producing 3-ketoacyl-CoA. This step generates one molecule of NADH.
- **Thiolysis:** The 3-ketoacyl-CoA is cleaved by the enzyme β-ketothiolase, resulting in the formation of acetyl-CoA and a shortened fatty acyl-CoA. This step generates one molecule of acetyl-CoA and a fatty acyl-CoA chain two carbons shorter than the original.
- The shortened fatty acyl-CoA from the thiolysis step re-enters the β-oxidation cycle, repeating the oxidation, hydration, oxidation, and thiolysis steps until the fatty acid is completely oxidized into acetyl-CoA units.

Glyoxylate cycle:

- The glyoxylate cycle allows organisms to efficiently utilize stored lipids as a carbon source for biosynthesis, especially during periods of energy demand or when carbohydrates are limited.
- By bypassing the decarboxylation steps of the TCA cycle, the cycle enables the net synthesis of carbohydrates from acetyl-CoA derived from fatty acids.
- **Isocitrate to Glyoxylate Conversion**
- **Glyoxylate to Malate Conversion**
- **Malate to Oxaloacetate Conversion**
- **Oxaloacetate Re-enters the TCA Cycle**

Signature of the lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper IV - Plant Physiology and Metabolism**
Name of the Topic	**Plant growth - development and stress physiology**
Topic Synopsis	▪ **Growth and Development** ▪ **Physiological effects of Plant Growth Regulators** ▪ **Physiology of flowering** ▪ **Photoperiodism** ▪ **Role of phytochrome** ▪ **Seed germination** ▪ **Senescence**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 3. Analyze the biochemical reactions in relation to Nitrogen. 4. Analyze the biochemical reactions in relation to lipid metabolisms.
Pre Knowledge to be reminded	• Mineral Nutrition is defined as the naturally occurring inorganic nutrient found in the soil and food that is essential for the proper functioning of animal and plant body. • Minerals are vital elements necessary for the body. Both the plants and animals require minerals essentially.

Topic Synopsis

Growth and Development:

- Growth and development are fundamental processes in living organisms that involve an increase in size, complexity, and organization.
- Growth refers to an increase in physical dimensions or mass, while development encompasses the overall changes in form, structure, and function that occur over time.

Phases of Growth:

- **Lag Phase:** In this initial phase, growth is slow as the organism adapts to the environment, synthesizes necessary molecules, and prepares for rapid growth.
- **Log Phase:** Also known as the rapid growth phase, this stage is characterized by a period of exponential growth, where cells or organisms undergo rapid division and increase in number.
- **Stationary Phase:** At this stage, growth rate levels off, and the number of dividing cells equals the number of dying cells, resulting in a stable population size.

- **Decline or Death Phase:** In this phase, the growth rate decreases, and cell or organism death exceeds new cell formation, leading to a decline in population size.

Kinetics of Growth:

- **Growth Rate:** The rate at which an organism increases in size or mass over time. It can be measured as an absolute increase (e.g., grams per day) or as a relative increase (e.g., percentage increase).
- **Growth Curve:** A graphical representation of the growth rate over time. Typically, growth follows an S-shaped curve, starting slowly, accelerating during the exponential phase, and eventually levelling off during the stationary phase.
- **Doubling Time:** The time required for a population to double in size during the exponential growth phase. It is inversely proportional to the growth rate.
- **Growth Factors:** Factors that influence the rate and extent of growth, such as availability of nutrients, environmental conditions (temperature, light, etc.), genetic factors, hormonal regulation, and interactions with other organisms.

Regulation of Growth and Development:

- Hormones: Chemical messengers that regulate growth and development in plants and animals.
- Genetic Factors: Genetic information encoded in an organism's DNA plays a crucial role in determining growth patterns, rates, and developmental processes.
- Environmental Factors: External conditions, such as temperature, light, humidity, nutrient availability, and other abiotic and biotic factors, can profoundly influence growth and development.

Plant growth regulators (PGRs):

The plant growth regulators also known as plant hormones, play vital roles in regulating various physiological processes in plants.

- **Auxins:** Cell Elongation, Apical Dominance, Root Formation and Fruit Development.
- **Gibberellins (GAs):** Stem Elongation, Seed Germination and Fruit Development.
- **Cytokinins:** Cell Division, Delay of Senescence, Apical Dominance Release and Root Growth.
- **Abscisic Acid (ABA):** Induces Seed Dormancy and Germination, Stress Response and Stomatal Closure.
- **Ethylene:** Fruit Ripening, Leaf Abscission and Apical Hook Formation in young seedlings.
- **Brassinosteroids:** Cell Expansion, Seed Germination, Stress Response and flowering induction.

Physiology of flowering:

The physiology of flowering in plants involves a series of complex and coordinated processes that result in the production of flowers.

1. **Floral Induction:** Floral induction is the process by which a plant transitions from vegetative growth to reproductive growth, leading to the initiation of flower formation. Major aspects are **Photoperiod, Temperature, Hormonal Regulation.**

2. **Flower Development:** Once floral induction occurs, the plant undergoes a series of developmental stages that lead to the formation of flowers. Major steps are **Floral Meristem Development, Organ Development, Pollination and Fertilization**.
3. **Hormonal Regulation:** Plant hormones play a crucial role in coordinating various aspects of flower development and reproductive processes. Ex. Gibberellins, Auxins, Cytokinins and Ethylene.

Photoperiodism:

Photoperiodism is the physiological response of plants to the duration of light and darkness in a 24-hour cycle. It influences the timing of flowering and other developmental processes in plants.

There are three main categories of photoperiodic responses:

- **Short-day Plants:** These plants require a longer period of darkness (night) than light to induce flowering. Flowering is typically triggered when the night duration exceeds a critical threshold.
- **Long-day Plants:** These plants require a shorter period of darkness (night) than light to induce flowering. Flowering is typically triggered when the night duration is shorter than a critical threshold.
- **Day-neutral Plants:** These plants are not significantly affected by the duration of light or darkness and can flower regardless of the photoperiod.

Phytochrome:

- Phytochrome is not a hormone but rather a light-sensitive pigment found in plants.
- It plays a crucial role in perceiving and responding to light signals, particularly in relation to Photoperiodism and various developmental processes in plants.
- Phytochrome acts as a photoreceptor, converting light signals into chemical signals that trigger specific physiological and developmental responses.

Role of Phytochrome in Flowering:

Phytochrome is a light-sensitive pigment found in plants that plays a key role in photoperiodic flowering.

It exists in two interconvertible forms: **Pr** (red-light absorbing form) and **Pfr** (far-red light absorbing form).

- **Induction of Flowering:** In long-day plants, flowering is induced when the **Pfr** form of phytochrome accumulates. **Pfr** is synthesized in response to exposure to light, particularly in the red light spectrum. It promotes flowering by activating specific genes involved in flowering initiation.
- **Inhibition of Flowering:** In short-day plants, flowering is inhibited when the **Pfr** form of phytochrome accumulates. **Pfr** is converted back to **Pr** in response to darkness or exposure to far-red light. **Pr** inhibits flowering by repressing the expression of genes involved in flowering initiation.
- The phytochrome-mediated flowering response is a complex process that involves the interaction of phytochrome with other regulatory proteins and genetic pathways.

- It helps plants adapt to their specific environmental conditions, ensuring that flowering occurs at the appropriate time.

Seed Germination:

Seed germination is the process by which a seed transitions from a dormant state to an actively growing seedling.

It involves a series of physiological and biochemical changes that allow the embryo within the seed to resume growth and develop into a new plant.

- **Imbibition:** The seed absorbs water, resulting in swelling and rehydration of the embryo. This triggers metabolic activity and enzyme activation.
- **Activation of Enzymes:** The imbibed water activates enzymes, such as amylases and proteases, which break down stored nutrients in the seed, such as starch and proteins, into simpler forms that can be utilized by the growing embryo.
- **Respiration:** Respiration rates increase as the embryo requires energy for growth. Oxygen uptake increases, and carbon dioxide is released as a byproduct of cellular respiration.
- **Hormonal Regulation:** Plant hormones, particularly gibberellins, play a crucial role in seed germination. They promote the synthesis of hydrolytic enzymes, stimulate cell division and elongation, and break seed dormancy.
- **Radicle Emergence:** The radicle (embryonic root) emerges from the seed and begins to grow downward, anchoring the seedling in the soil.

Senescence:

Senescence is the process of aging and deterioration that occurs in various parts of a plant, such as leaves, flowers, and fruits.

It involves programmed physiological and biochemical changes that lead to the eventual death and shedding of the senescent tissue.

- **Chlorophyll Breakdown:** Chlorophyll molecules degrade, resulting in a loss of green color in leaves and other green tissues. This process exposes other pigments, such as carotenoids, which give rise to the yellow, orange, and red colours often observed during senescence.
- **Nutrient Remobilization:** Nutrients, such as nitrogen and minerals, are actively transported from senescent tissues to other parts of the plant, such as developing fruits, seeds, or younger leaves.
- **Protein Degradation:** Proteins in senescing tissues are broken down into amino acids, which can be recycled and used elsewhere in the plant.
- **Cell Death and Tissue Breakdown:** The cells in senescent tissues undergo programmed cell death (apoptosis), leading to the breakdown of tissues and the eventual shedding or abscission of senescent organs, such as leaves or flowers.
- **Hormonal Regulation:** Plant hormones, including ethylene and abscisic acid, play a role in regulating senescence. Ethylene promotes senescence and fruit ripening, while abscisic acid is involved in triggering leaf senescence.

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper –V **Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**The Cell**
Topic Synopsis	▪ **Cell theory** ▪ **Ultra-structure of a plant cell** ▪ **Ultra-structure of cell wall** ▪ **Ultra-structure of plasma membrane** ▪ **Polymorphic cell organelles** ▪ **Plastid DNA**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Distinguish prokaryotic and eukaryotic cells and design the model of a cell. 2. Demonstrate techniques to observe the cell and its components under a microscope.
Pre Knowledge to be reminded	• The cell is the basic structural and functional unit of life. • All living organisms, including plants, animals, and microorganisms, are composed of one or more cells. • Cells exhibit remarkable diversity in terms of size, shape, and specialized functions, but they share common features and components.

Topic Synopsis

Cell theory:

The cell theory is a fundamental principle in biology that states:

- All living organisms are composed of one or more cells.
- The cell is the basic unit of structure and function in all organisms.
- Cells arise from pre-existing cells through cell division.

Prokaryotic vs. Eukaryotic Cells:

Prokaryotic cells and eukaryotic cells are the two main types of cells.

Prokaryotic	Eukaryotic Cell
Simpler in structure and smaller in size.	More complex and larger in size.
Lack a true nucleus and membrane-bound organelles.	Have a true nucleus that houses the DNA.
DNA is present in a single circular molecule and floats freely in the cytoplasm.	Contain membrane-bound organelles that perform specific functions.
Found in bacteria and archaea.	Found in plants, animals, fungi, and protists.

Animal vs. Plant Cells:

Animal cells and plant cells are both eukaryotic cells but have some distinct differences.

Animal cell	Plant cell
Lack a cell wall.	Have a rigid cell wall made of cellulose outside the cell membrane.
May have small vacuoles or no vacuoles.	Have a large central vacuole for storage of water, nutrients, and waste.
Have centrioles involved in cell division.	Lack centrioles.
Store carbohydrates in the form of glycogen.	Contain chloroplasts for photosynthesis.
May have cilia or flagella for movement.	Store carbohydrates in the form of starch.

Ultra structure of a Plant Cell:

The ultra structure of a plant cell refers to its detailed internal organization, including the organelles and other structures. Here are some key components:

- **Cell Wall:** Plant cells have a rigid cell wall composed of cellulose, hemi cellulose, and other polysaccharides. It provides structural support and protection for the cell.
- **Cell Membrane:** The cell membrane (plasma membrane) surrounds the cell and regulates the passage of molecules in and out of the cell.
- **Nucleus:** The nucleus contains the DNA and is surrounded by a nuclear envelope. It controls cellular activities and houses the genetic material.
- **Chloroplasts:** Chloroplasts are the site of photosynthesis in plant cells. They contain chlorophyll pigments and other molecules necessary for capturing light energy and converting it into chemical energy.
- **Mitochondria:** Mitochondria are the powerhouses of the cell, producing energy in the form of ATP through cellular respiration.
- **Endoplasmic Reticulum (ER):** The endoplasmic reticulum is involved in the synthesis and transport of proteins and lipids within the cell.
- **Golgi apparatus:** The Golgi apparatus modifies, sorts, and packages proteins for transport within the cell or for secretion outside the cell.
- **Vacuoles:** Plant cells typically have one or more large central vacuoles that store water, nutrients, and other substances. The vacuole helps maintain cell turgidity and plays a role in plant growth and development.

- **Plasmodesmata:** Plasmodesmata are cytoplasmic connections between adjacent plant cells. They allow for communication and transport of molecules between cells.

Ultra-structure of cell wall:

The cell wall is a rigid structure that surrounds the cell membrane in plant cells, fungi, bacteria, and some protists.

The cell wall is a rigid structure that surrounds the cell membrane in plant cells, fungi, bacteria, and some protists.

- **Primary Cell Wall:** The primary cell wall is the outermost layer of the cell wall in growing plant cells. It is composed mainly of cellulose, a complex carbohydrate, along with other polysaccharides such as hemi cellulose and pectin.
- **Middle Lamella:** The middle lamella is a thin layer of pectin that lies between adjacent plant cells. It acts as a cementing material, holding the neighbouring cells together.
- **Secondary Cell Wall:** Some plant cells, particularly those that have stopped growing, develop a secondary cell wall inside the primary cell wall. The secondary cell wall provides additional strength and rigidity to the cell.
- **Plasmodesmata:** Plasmodesmata are small channels that traverse the cell wall, connecting the cytoplasm of adjacent plant cells.

Plasma membrane:

- In eukaryotic cells, the plasma membrane surrounds a cytoplasm filled with ribosomes and organelles.
- Organelles are structures that are themselves encased in membranes. Some organelles (nuclei, mitochondria, chloroplasts) are even surrounded by double membranes.
- All cellular membranes are composed of two layers of phospholipids embedded with proteins.

Lipid and Lipid Bilayer Model:

- Gorter and Grendel (1925)' were the first to suggest a possible structure of the cell membrane.
- The membrane consisted of double layers of lipid molecules, the polar hydrophilic groups of the molecules being situated on the outside and hydrophobic ends standing at right angles to the surface are oriented inwardly.

Dannelli Model (Sandwich Models):

- James Danielli and Hugh Davson in 1935 have suggested bimolecular leaflet model of cell membrane.
- Plasma membrane consists of two layers of phospholipids molecules (a bimolecular leaflet) in which phospholipids molecules are arranged in such a way that hydrophilic

heads of the phospholipids molecules face outside and hydrophobic non-polar lipid chains are associated in the inner region of leaflet.

Unit Membrane Model:

- Robertson proposed in 1953.
- The unit membrane concept implies a trilaminar appearance with a bimolecular lipid layer between two protein layers.
- Each dense osmiophilic band is made up of protein and the polar groups of phospholipids and is thus 25 Å thick.

Fluid Mosaic Model:

- The fluid mosaic model was first proposed by S.J. Singer and Garth L. Nicolson in 1972 to explain the structure of the plasma membrane.
- The fluid mosaic model describes the structure of the plasma membrane as a mosaic of components —including phospholipids, cholesterol, proteins, and carbohydrates— that gives the membrane a fluid character.

Polymorphic cell organelles;

Polymorphic cell organelles refer to organelles that can exist in different forms or exhibit diverse functions within a cell.

Plastids:

- Plastids are a class of organelles found in plant cells. They include various types, such as chloroplasts, chromoplasts, and amyloplasts.
- The most well-known and studied plastid is the chloroplast, which is responsible for photosynthesis.

Structure of Chloroplast:

Chloroplasts are double-membrane-bound organelles that contain a complex internal structure. The key components of chloroplast ultra structure include

- Outer Membrane: The chloroplast is surrounded by an outer membrane that acts as a selective barrier, controlling the movement of molecules into and out of the organelle.
- Inner Membrane: Inside the outer membrane is an inner membrane, which is also selectively permeable and regulates the transport of molecules.
- Thylakoid Membrane System: The inner membrane encloses a system of membranous sacs called thylakoids, which are arranged in stacks called **grana** (singular: **granum**). Thylakoids contain pigments such as chlorophyll and carotenoids, as well as protein complexes involved in the light-dependent reactions of photosynthesis.
- Stroma: The space inside the inner membrane but outside the thylakoid membranes is called the stroma. The stroma contains enzymes and molecules required for the light-independent reactions of photosynthesis, including the Calvin cycle.

- Starch Granules: Chloroplasts often contain starch granules, which are storage forms of glucose. Starch granules are synthesized and stored in the stroma and can be broken down to provide energy for the cell when needed.

Plastid DNA (ptDNA):

- Plastid DNA, also known as ptDNA or plastome, is the genetic material present in plastids. It is distinct from the nuclear DNA found in the cell nucleus.
- Plastid DNA is usually circular, similar to bacterial DNA, and contains genes that encode proteins involved in plastid function and development.
- Plastid DNA plays a crucial role in the synthesis of proteins and other components required for plastid function and maintenance.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper –V **Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Chromosomes**
Topic Synopsis	▪ **Prokaryotic & Eukaryotic chromosome** ▪ **Euchromatin and Heterochromatin** ▪ **Chromosomal aberrations** ▪ **Organization of DNA in a chromosome**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Explain the organization of a eukaryotic chromosome and the structure of genetic material. 2. Demonstrate techniques to observe the cell and its components under a microscope.
Pre Knowledge to be reminded	• Chromosomes are thread-like structures located inside the nucleus of animal and plant cells. • Each chromosome is made of protein and a single molecule of deoxyribonucleic acid (DNA). • Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique.

Topic Synopsis

Prokaryotic and Eukaryotic chromosomes:

Chromosomes are structures found in the nucleus of cells that contain the genetic material, specifically the DNA (deoxyribonucleic acid).

They play a crucial role in the transmission of genetic information from one generation to the next and are essential for the proper functioning and development of organisms.

Characteristic	**Prokaryotic Chromosomes**	**Eukaryotic Chromosomes**
Structure	Single, circular DNA molecules	Linear DNA molecules
Organization	Less structured and compact	Highly organized and tightly packaged
Histone Proteins	Not associated with histones	Associated with histones for packaging
Nuclear Membrane	Absent	Present, chromosomes located in the nucleus

Replication	Bidirectional from a single origin	Bidirectional at multiple origins of replication
Genetic Content	Contains essential genes	Contains numerous genes
Additional Elements	Plasmids may be present	No plasmids, but mitochondrial DNA in some cases.
Examples	Bacteria (e.g., E. coli)	Animals, plants, fungi, protists

Eukaryotic Chromosome:

- Eukaryotic chromosomes are linear DNA molecules that are tightly associated with histone proteins.
- Eukaryotic DNA is organized into highly structured units called **nucleosomes**. **Nucleosomes** consist of DNA wrapped around histone proteins, forming a bead-like structure.
- These nucleosomes further coil and fold to form more condensed structures known as **chromatin**.
- Chromatin undergoes further condensation during cell division to form visible **chromosomes**.
- Eukaryotic chromosomes are larger and more complex than prokaryotic chromosomes.
- Eukaryotic DNA replication bidirectionally at multiple origins of replication along each chromosome.
- Eukaryotic chromosomes have specialized regions called **Telomeres** and **Centromeres**.

Euchromatin:

- Euchromatin is a loosely packed and less condensed form of chromatin that is transcriptionally active. It appears as lightly stained regions during cell staining procedures.
- It is characterized by a more open structure, allowing for easier access of transcription factors, RNA polymerase, and other molecules involved in gene transcription.

Heterochromatin:

- Heterochromatin is a tightly packed and highly condensed form of chromatin that is transcriptionally inactive or has low levels of gene expression.
- It appears as densely stained regions during cell staining procedures.
- Heterochromatin contains genes that are not actively transcribed and may be involved in processes such as chromosome structure maintenance or gene silencing

Karyotype:

- A karyotype refers to the visual representation and arrangement of chromosomes in an organism's cell.

- Karyotype that provides information about the number, size, and structure of chromosomes within a cell.

Ideogram:

- An ideogram is a simplified and standardized representation of a chromosome or a specific region of a chromosome.
- It is a graphical representation that depicts the relative positions of genes, bands, and other features on a chromosome.
- Ideograms are typically depicted as schematic drawings or diagrams where chromosomes are represented as linear structures, and the various bands and regions are indicated by different colours or patterns.

Chromosomal aberrations:

- Chromosomal aberrations, also known as chromosomal abnormalities or chromosomal mutations, refer to structural or numerical changes in the chromosomes.
- These abnormalities can occur spontaneously or be caused by various factors such as mutations, exposure to radiation or chemicals, errors in DNA replication or repair, or errors during meiosis.
- Chromosomal aberrations can be broadly categorized into two types: structural changes and numerical changes.

Structural Chromosomal Aberrations:

- Structural chromosomal aberrations involve changes in the structure of chromosomes.
- These changes can result from breakages, rearrangements, or loss/gain of chromosomal segments. Some common structural chromosomal aberrations include
- **Deletion:** A portion of a chromosome is missing or deleted.
- **Duplication:** A segment of a chromosome is duplicated, resulting in extra genetic material.
- **Inversion:** A segment of a chromosome is flipped or reversed in orientation.
- **Translocation:** A segment of a chromosome breaks off and attaches to a non-homologous chromosome or another location on the same chromosome.

Numerical Chromosomal Aberrations:

- Numerical chromosomal aberrations involve changes in the number of chromosomes in a cell.
- These changes can occur due to errors during chromosome segregation in cell division (meiosis or mitosis).
- Two common types of numerical chromosomal aberrations are:
- **Aneuploidy:** Aneuploidy refers to the presence of an abnormal number of chromosomes in a cell. It can occur as Monosomy (loss of one chromosome) or Trisomy (gain of an extra chromosome).

- **Monosomy:** The loss of one copy of a chromosome, resulting in the presence of only one copy instead of the usual two.
- **Trisomy:** The presence of an additional copy of a chromosome, resulting in the presence of three copies instead of the usual two.
- **Polyploidy:** The presence of more than two complete sets of chromosomes in a cell.

Organization of DNA in a chromosome:

The organization of DNA in a chromosome can be explained by two models: the solenoid model and the nucleosome model. These models describe different levels of compaction and packaging of DNA within the chromosome.

- **Nucleosome Model:** The nucleosome model describes the basic unit of DNA packaging. It involves the wrapping of DNA around histone proteins to form nucleosomes. A nucleosome consists of a core histone octamer, which is composed of two copies each of histones H2A, H2B, H3, and H4. Approximately 147 base pairs of DNA are wrapped around this core histone octamer. The nucleosomes are connected by linker DNA, which is less tightly associated with histones.
- **Solenoid Model:** In the solenoid model, the chromatin fiber is organized into a solenoid-like structure. The DNA helix forms a series of tight loops or coils that are stacked on top of each other, resembling a solenoid or spring. The nucleosomes are connected by linker DNA, which is less tightly associated with histones. This results in a "beads-on-a-string" structure, where the nucleosomes are like beads and the linker DNA acts as the string.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper –V **Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Mendelian and Non-Mendelian genetics**
Topic Synopsis	▪ **Mendel's laws of inheritance** ▪ **Incomplete dominance and co-dominance** ▪ **Multipleallelism** ▪ **Gene interactions** ▪ **Linkage and Crossing over** ▪ **Chromosomal mapping** ▪ **Maternal inheritance** ▪ **Mitochondrial DNA**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Discuss the basics of Mendelian genetics, its variations and interpret inheritance of traits in living beings. 2. Elucidate the role of extra-chromosomal genetic material for inheritance of characters.
Pre Knowledge to be reminded	• Genetics is the scientific study of genes and heredity—of how certain qualities or traits are passed from parents to offspring as a result of changes in DNA sequence. • A gene is a segment of DNA that contains instructions for building one or more molecules that help the body work. • Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique.

Topic Synopsis

Mendel's laws of inheritance:

- Mendel's laws of inheritance are fundamental principles in genetics that describe how traits are passed from parents to offspring.
- Mendel's laws laid the foundation for our understanding of inheritance and formed the basis of modern genetics.
- The three main laws of inheritance proposed by Mendel are following

- **Law of Segregation:** The law of segregation states that during the formation of gametes (sex cells), the two alleles (alternative forms of a gene) for each trait segregate or separate from each other.
- **Law of Independent Assortment:** The law of independent assortment states that the inheritance of different traits is independent of each other.
- **Law of Dominance:** The law of dominance states that in a heterozygous individual (having two different alleles for a trait), one allele, known as the dominant allele, will determine the phenotype (observable trait) while the other allele, known as the recessive allele, will have no noticeable effect on the phenotype.

Incomplete Dominance:

- In incomplete dominance, neither allele is completely dominant over the other, resulting in an intermediate phenotype in heterozygous individuals. This means that when two different alleles for a trait are inherited, neither allele fully masks the other, and the resulting phenotype is a blend of the two alleles.

Co-dominance:

- Co-dominance occurs when both alleles in a heterozygous individual are expressed simultaneously and distinctly. In this case, neither allele is dominant or recessive, nor both contribute to the phenotype.

Multiple Allelism:

- Multiple allelism refers to the existence of more than two different alleles for a particular gene within a population. While each individual can possess only two alleles (one from each parent), there may be more than two alleles in the population as a whole. This is observed in genes where there are multiple alternative forms or variants.

Complementary Gene Interaction:

- In complementary gene interaction, two or more different genes work together to produce a specific trait. Both genes are required for the expression of the trait, and if either of the genes is absent or non-functional, the trait will not be observed.

Supplementary Gene Interaction:

- In supplementary gene interaction, multiple genes independently contribute to the expression of a trait, but each gene contributes to a different aspect of the trait. The presence of any one of the genes is sufficient to produce a certain level of the trait, and the presence of multiple genes increases the expression of the trait.

Duplicate Gene Interaction:

- In duplicate gene interaction, multiple genes have similar functions, and the loss or non-functionality of one gene can be compensated by the presence of a duplicate gene. Duplicate genes are copies of the same gene that have evolved due to gene duplication events.

Linkage:

- Linkage refers to the phenomenon where two or more genes are located on the same chromosome and tend to be inherited together as a unit, rather than undergoing independent assortment during meiosis.

Crossing Over:

- Crossing over is a genetic process that occurs during meiosis, specifically in the prophase I stage, and involves the exchange of genetic material between homologous chromosomes.
- It leads to the creation of new combinations of alleles and plays a significant role in genetic variation and inheritance.

Chromosomal mapping:

- Chromosomal mapping, also known as genetic mapping, is the process of determining the relative positions of genes on a chromosome. It allows scientists to create a map or diagram of the genetic loci (positions) of genes and other genetic markers along the length of a chromosome.

2 Point Test Cross:

- One common method of chromosomal mapping is the 2-point test cross, which involves crossing individuals that are heterozygous for two different genes of interest with individuals that are homozygous recessive for both genes.
- By analyzing the phenotypic ratios of the offspring resulting from the test cross, scientists can determine the recombination frequency between the two genes.

3 Point Test Cross:

- The 3-point test cross is an extension of the 2-point test cross and involves analyzing the inheritance patterns of three different genes.
- By performing a test cross between an individual heterozygous for three genes and an individual homozygous recessive for all three genes, the recombination frequencies between the three genes can be determined.
- The analysis of the recombination frequencies allows for the determination of the gene order and the distances between the three genes on the chromosome.

Maternal inheritance:

- Maternal inheritance, also known as maternal effect or maternal effect inheritance refers to the transmission of certain traits or characteristics from the mother to her offspring through factors present in the cytoplasm of the egg cell.

- These factors can influence the early development and phenotype of the offspring, independent of the genetic information encoded in the nuclear DNA.
- Correns' experiment on Mirabilis jalapa, also known as four o'clock flower, provided evidence for the concept of maternal inheritance.
- Carl Correns, a German botanist, conducted this experiment in the early 20th century to study the inheritance of flower color in Mirabilis jalapa.

Mitochondrial DNA (mtDNA):

- Mitochondrial DNA (mtDNA) is a type of genetic material found in the mitochondria, which are organelles responsible for energy production in cells.
- Unlike nuclear DNA, which is located in the cell nucleus, mtDNA is located in the mitochondria themselves.
- Mitochondrial DNA is a circular double-stranded molecule, similar to bacterial DNA. In most organisms, including humans, mitochondrial DNA is inherited exclusively from the mother.
- Mitochondrial DNA exhibits a higher mutation rate compared to nuclear DNA. Mitochondrial DNA contains genes that code for proteins involved in energy production through oxidative phosphorylation.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper –V **Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Structure and functions of DNA**
Topic Synopsis	▪ **Watson and Crick model of DNA** ▪ **DNA Replication** ▪ **Transcription** ▪ **Types and functions of RNA** ▪ **Gene concept and genetic code** ▪ **Translation** ▪ **Regulation of gene expression - Lac Operon**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Evaluate the structure, function of genetic material. 2. Evaluate the regulation of genetic material.
Pre Knowledge to be reminded	• DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. • RNA serves as a messenger for the transmission of information. RNA carries genetic information as well, thus functioning as genetic material.

Topic Synopsis

Watson and Crick model of DNA

- The Watson-Crick model of DNA, proposed by James Watson and Francis Crick in 1953, is the widely accepted double-helix structure of DNA.
- Their model was based on existing scientific data and their own insights, and it provided a groundbreaking understanding of the molecular structure of DNA and its mechanism of replication.
- Key features of the Watson - Crick Model of DNA:
- Double Helix Structure, Base Pairing, Sugar-Phosphate Backbone, Base Stacking, Directionality.

DNA replication:

DNA replication is the process by which a DNA molecule makes an exact copy of itself. The semi-conservative method of DNA replication, proposed by Watson and Crick, describes how the two strands of the DNA double helix separate and each serves as a template for the synthesis of a new complementary strand.

- **Initiation:** DNA replication begins at specific sites on the DNA molecule called origins of replication.
- **Primer Binding:** Primase, an RNA polymerase, synthesizes a short RNA primer on each of the DNA strands. These primers provide a starting point for DNA synthesis.
- **Elongation:** DNA polymerases, specifically DNA polymerase III in prokaryotes and a combination of DNA polymerase alpha, delta, and epsilon in eukaryotes, catalyze the addition of nucleotides to the growing DNA strands.
- **Proofreading and Repair:** DNA polymerases have a proofreading function that helps detect and correct errors during DNA replication.
- **Termination:** DNA replication continues until the replication forks meet at specific termination sites on the DNA molecule. The newly synthesized DNA strands are released, and the replication process is complete.

Ribonucleic acid (RNA):

RNA, or ribonucleic acid, is a versatile molecule that plays various roles in gene expression and cellular processes. There are several types of RNA molecules, each with distinct functions.

- **Messenger RNA (mRNA):** mRNA carries the genetic information from DNA to the ribosome's, where it serves as a template for protein synthesis.
- **Ribosomal RNA (rRNA):** rRNA is a major component of ribosome's, the cellular structures where protein synthesis occurs.
- **Transfer RNA (tRNA):** tRNA molecules transport specific amino acids to the ribosome's during protein synthesis.
- **Small Nuclear RNA (snRNA):** snRNAs are involved in the processing of pre-mRNA (precursor mRNA) molecules.
- **Micro RNA (miRNA):** miRNAs are small RNA molecules that regulate gene expression by binding to specific mRNA molecules. They can inhibit translation or promote degradation of the target mRNA, thereby controlling the levels of certain proteins in the cell.
- **Small Interfering RNA (siRNA):** siRNAs are similar to miRNAs and are involved in gene silencing. They can trigger the degradation of target mRNA or inhibit its translation.
- **Long Non-Coding RNA (lncRNA):** lncRNAs are a diverse group of RNA molecules that do not encode proteins but have important regulatory functions in gene expression, chromatin remodeling, and other cellular processes.

Gene Concept:

- The gene is the fundamental unit of heredity and carries the genetic information that determines the traits and characteristics of an organism.

- Genes are segments of DNA (deoxyribonucleic acid) that contain instructions for building and functioning proteins.
- Genes are located on chromosomes and are inherited from one generation to the next.

Genetic Code:

- The genetic code is the set of rules that governs the translation of genetic information stored in DNA or RNA into proteins.
- It determines the relationship between the sequence of nucleotides in the DNA or RNA molecule and the sequence of amino acids in a protein.
- The genetic code is universal, meaning that it is shared by all living organisms and is highly conserved throughout evolution.
- There are 64 possible codons, but only 20 different amino acids, so multiple codons can code for the same amino acid (referred to as degeneracy or redundancy of the genetic code).

Translation:

- Translation is the process by which the genetic information carried by mRNA (messenger RNA) is used to synthesize proteins.
- It occurs in the ribosomes, cellular structures composed of rRNA (ribosomal RNA) and proteins.
- It converts the genetic information encoded in the DNA into functional proteins, which play essential roles in cellular processes, structure, and function.

Steps:

- **Initiation:** The small ribosomal subunit binds to the mRNA molecule at a specific start codon (usually AUG) with the help of initiation factors.
- **Elongation:** The ribosome moves along the mRNA molecule in a 5' to 3' direction, reading the codons and bringing in tRNA molecules that carry the corresponding amino acids.
- **Termination:** When a stop codon (UAA, UAG, or UGA) is encountered, it signals the end of protein synthesis. Release factors bind to the stop codon, causing the release of the completed protein from the ribosome.

Regulation of gene expression in prokaryotes

Regulation of gene expression in prokaryotes, such as bacteria, involves various mechanisms to control when and how genes are expressed. One well-known example of gene regulation in prokaryotes is the lac operon, which controls the expression of genes involved in lactose metabolism.

Lac Operon:

- The Lac Operon consists of three main components:
- **Promoter:** The region of DNA where RNA polymerase binds to initiate transcription.

- **Operator:** A DNA sequence located between the promoter and the structural genes. It acts as a switch that can either allow or block the binding of RNA polymerase.
- **Structural Genes:** Genes responsible for the production of enzymes involved in lactose metabolism, including the lacZ gene encoding β-galactosidase and the lacY gene encoding lactose permease.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	Paper –V **Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Plant Breeding**
Topic Synopsis	▪ **Plant Breeding and its scope** ▪ **Plant Introduction and acclimatization** ▪ **Mass selection** ▪ **Pure line selection** ▪ **Clonal selection** ▪ **Hybridization** ▪ **Molecular breeding** ▪ **RAPD & RFLP**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Understand the application of principles and modern techniques in plant breeding. 2. Explain the procedures of selection and hybridization for improvement of crops.
Pre Knowledge to be reminded	• Plant breeding is the science and practice of manipulating the genetic traits of plants to develop new and improved plant varieties with desirable characteristics. • It is a vital discipline in agriculture and horticulture, aiming to enhance crop productivity, quality, disease resistance, and other desirable traits.

Topic Synopsis

Plant Breeding and its scope

- Plant breeding is the science and practice of altering the genetic characteristics of plants to create new and improved varieties that possess desirable traits.
- It involves the selection, crossing, and propagation of plants to develop cultivars with improved yield, quality, disease resistance, adaptability, and other desirable traits.
- The scope of plant breeding is vast and encompasses various aspects, including Crop Improvement, Genetic Diversity Conservation Genetic, Diversity Conservation, Specialty Crop Development and Disease and Pest Resistance.

Genetic basis for plant breeding:

- The genetic basis for plant breeding lies in the principles of inheritance and genetic variation. Breeders utilize genetic variation present in plants to create new combinations of desirable traits.
- They employ various breeding methods, including selection, hybridization, mutation breeding, and genetic engineering, to introduce and enhance desirable traits in cultivated crops.

Plant Introduction and acclimatization:

- Plant Introduction and acclimatization is the process of introducing plant species or varieties from their native regions to new geographic locations and adapting them to local environmental conditions.
- This process involves collecting plant materials, such as seeds, cuttings, or tissue cultures, from their natural habitats and establishing them in new locations.
- Once introduced, plants undergo acclimatization, which involves adjusting to the new environmental conditions, including climate, soil, photoperiod, and biotic factors.

Mass Selection:

Mass selection is a plant breeding method in which a large population of plants is selected and propagated based on the overall performance of the population.

- In mass selection, a diverse population of plants is grown and evaluated for various traits.
- Plants showing desirable characteristics, such as high yield, disease resistance, or quality traits, are selected as parents for the next generation.
- The selected plants are allowed to cross-pollinate naturally, and their seeds are collected and mixed to create a new population.
- Mass selection is commonly used in the improvement of self-pollinated crops, such as wheat, rice, and soybeans. It is effective in improving traits that are controlled by multiple genes and are not easily measurable or visually distinguishable.
- Mass selection is a simple and cost-effective breeding method
- It does not provide precise control over the inheritance of specific traits, and it may result in the loss of genetic diversity if only a few selected individuals are used as parents.

Pure Line Selection:

Pure line selection is a plant breeding method that involves the identification and isolation of individual plants with superior traits and the subsequent development of pure lines through self-fertilization or asexual propagation.

- In pure line selection, individual plants showing desirable traits are identified within a population.
- These selected plants are self-pollinated or vegetatively propagated to create a pure line population.
- Pure line selection is widely used in the improvement of self-pollinated crops, such as wheat, barley, and oats. It is particularly useful for improving traits with simple inheritance patterns, such as height, maturity, and disease resistance.
- Pure line selection is time-consuming, as it involves several generations of self-pollination or vegetative propagation to achieve genetic stability.

Clonal Selection:

Clonal selection is a plant breeding method that involves the identification and propagation of individual plants or clones with superior traits through vegetative propagation.

- In clonal selection, individual plants showing desirable traits are identified within a population.
- These selected plants are propagated vegetatively through methods like stem cuttings, tissue culture, or grafting, preserving the genetic identity and traits of the selected individuals.
- Clonal selection is commonly used in the improvement of plants that reproduce asexually or have specific cultivars with desirable traits, such as fruit trees, ornamental plants, and potatoes.
- Clonal selection ensures that the genetic traits of selected individuals are preserved without any recombination or genetic variation.
- Clonal selection limits genetic diversity as it relies on the propagation of genetically identical plants. Clonal propagation can be labour-intensive and may require specialized techniques such as tissue culture.

Hybridization:

Hybridization is a plant breeding technique that involves the crossing of two genetically diverse parents to produce offspring with desired traits.

The process of hybridization typically includes the following

- Parental Selection: Two parents with desirable traits are chosen for crossbreeding.
- Cross-Pollination: The flowers of the female parent (seed parent) are emasculated or protected to prevent self-pollination.
- Hybrid Seed Production: After successful pollination, the fertilized flowers develop into hybrid seeds.
- Evaluation and Selection: The hybrid seeds are grown, and the resulting plants are evaluated for various traits.

Heterosis:

- Heterosis, also known as hybrid vigour, refers to the phenomenon where hybrid offspring exhibit superior traits compared to their parents.
- Heterosis is a result of the combination of favourable alleles from different parents, leading to increased genetic diversity and hybrid vigour in the offspring.

Advantages of heterosis:

- Increased Yield, Improved Adaptability, Disease Resistance, Better Quality

Limitations:

- Hybrid Seed Production, Seed Cost, Genetic Uniformity.

Molecular breeding:

Molecular breeding, also known as marker-assisted breeding or molecular-assisted selection, is a plant breeding technique that incorporates DNA markers to assist in the selection and breeding of plants with desired traits.

DNA markers are specific regions of the DNA sequence that can be easily identified and are associated with particular traits of interest.

DNA Markers:

- **Simple Sequence Repeats (SSRs):** Also known as microsatellites, SSRs are short repeating DNA sequences that vary in length among individuals.
- **Single Nucleotide Polymorphisms (SNPs):** SNPs are single base pair differences in the DNA sequence.
- **Insertion-Deletion Polymorphisms (InDels):** InDels are variations in the number of nucleotides present at a specific location in the genome.
- **Restriction Fragment Length Polymorphisms (RFLPs):** RFLPs involve changes in the DNA sequence that result in different patterns of DNA fragments after digestion with specific enzymes.

Applications of DNA Markers in Plant Breeding:

- **Marker-Assisted Selection (MAS):** DNA markers are used to identify plants with desirable traits at an early stage.
- **Quantitative Trait Locus (QTL) Mapping:** DNA markers are used to identify regions in the genome that are associated with specific traits of interest.
- **Genetic Diversity Analysis:** DNA markers are used to assess the genetic diversity within plant populations.
- **Marker-Assisted Backcrossing (MABC):** DNA markers are used to track the inheritance of specific genomic regions during the backcrossing process.

RAPD (Random Amplified Polymorphic DNA):

RAPD is a PCR-based technique that uses short, random primers to amplify random regions of DNA in the genome.

- These primers bind to multiple sites in the genome, resulting in the amplification of random DNA fragments.
- RAPD is used for genetic diversity analysis, population studies, DNA fingerprinting, and marker-assisted selection in plant breeding.
- RAPD is a simple and cost-effective technique that does not require prior knowledge of the DNA sequence.
- RAPD markers are dominant, meaning they do not distinguish between homozygous and heterozygous genotypes.

RFLP (Restriction Fragment Length Polymorphism):

- RFLP is based on the detection of variations in DNA fragment sizes resulting from the presence of specific restriction enzyme recognition sites in the genome.
- RFLP is used for genetic mapping, linkage analysis, gene mapping, and genetic diversity analysis.
- RFLP is a time-consuming and labour-intensive technique that requires a substantial amount of DNA.

Signature of the lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –IV Plant Physiology and Metabolism**
Name of the Topic	**Plant – Water relations**
Topic Synopsis	▪ **Physical properties of water** ▪ **Diffusion** ▪ **Imbibition** ▪ **Osmosis** ▪ **Water potential** ▪ **Absorption and transport of water** ▪ **Ascent of sap** ▪ **Transpiration** ▪ **Stomata**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Comprehend the importance of water in plant life and mechanisms for transport of water and solutes in plants. 2. Evaluate the role of minerals in plant nutrition and their deficiency symptoms.
Pre Knowledge to be reminded	• 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.

Topic Synopsis

Physical properties of water:

- The physical properties of water, such as its high specific heat capacity, cohesion, and ability to exist in three states (solid, liquid, and gas), make it unique and essential in various natural processes.
- These properties enable water to regulate temperature, support life through its cohesive and adhesive properties, and play a crucial role in Earth's water cycle.
- Water's ability to dissolve many substances also allows it to act as a universal solvent, facilitating chemical reactions and serving as a medium for transport in biological systems

Diffusion:

- Diffusion is the passive movement of particles or molecules from an area of higher concentration to an area of lower concentration.

- In the context of water, it refers to the movement of water molecules across a semi-permeable membrane or through a permeable material, such as soil or plant tissues, until equilibrium is reached.

Imbibition:

- Imbibition is the process by which substances, such as water, is absorbed and swells into the pores or spaces within a solid material, typically a hydrophilic substance like cellulose or gel-like substances.
- This process is commonly observed in seeds, where water absorption causes them to swell and initiate germination.

Osmosis:

- Osmosis is the movement of water molecules across a semi-permeable membrane from an area of lower solute concentration to an area of higher solute concentration.
- It is driven by the need to equalize the concentration of solutes on both sides of the membrane, resulting in the movement of water towards the more concentrated solution.

Water Potential:

- Water potential is a measure of the potential energy of water in a system, specifically in relation to its tendency to move from one area to another.
- It is influenced by various factors, including solute concentration, pressure, and gravity.
- Water always moves from an area of higher water potential to an area of lower water potential.

Osmotic Potential:

- Osmotic potential, also known as solute potential, is a component of water potential that relates to the effect of solute concentration on water movement.
- It represents the amount of pressure required to prevent the net movement of water through osmosis.
- The more negative the osmotic potential, the higher the concentration of solutes and the lower the water potential.

Pressure Potential:

- Pressure potential is another component of water potential that accounts for the physical pressure exerted on water in a system.
- It can be positive or negative, depending on whether the pressure is exerted on or by the system.
- Positive pressure potential, such as turgor pressure in plant cells, can increase water potential, while negative pressure potential, like tension in xylem vessels, can decrease water potential.

Absorption and transport of water:

- The absorption and transport of water in plants are essential processes for their survival and growth.
- These processes involve several mechanisms that work together to move water from the soil, through the roots, and up to the leaves.
- The absorption of water is driven by several factors, including: Osmosis and Root Pressure

Ascent of Sap:

The upward movement of water in plants is known as the ascent of sap.

The transport of water in plants occurs through the xylem, which is a complex tissue composed of specialized cells that form tubes for water movement.

- **Cohesion-Tension Theory:** This theory explains the primary mechanism behind the upward movement of water in the xylem. It relies on the cohesion (attraction between water molecules) and adhesion (attraction between water and cell walls) properties of water.
- **Transpiration Pull:** Transpiration, the process of water loss from the aerial parts of the plant (mainly leaves), generates tension or negative pressure within the xylem. This transpiration pull facilitates the movement of water upwards through the xylem vessels.
- **Capillarity:** Capillary action, the phenomenon of water rising in narrow tubes, can also contribute to the ascent of sap in some plants with very narrow xylem vessels.

Factors Influencing Ascent of Sap:

- Transpiration Rate
- Environmental Conditions
- Xylem Structure

Transpiration:

Transpiration is the process by which water is lost from the aerial parts of a plant, mainly through the stomata (small pores) on the surface of leaves, stems, and flowers.

Types of Transpiration:

- Stomatal Transpiration
- Cuticular Transpiration
- Lenticular Transpiration
- Hydathode Transpiration

Structure of stomata:

- The structure of stomata consists of specialized cells found on the epidermis of leaves, stems, and other plant organs.
- Stomata serve as the primary sites for gas exchange, allowing the plant to take in carbon dioxide (CO_2) for photosynthesis and release oxygen (O_2) and water vapour.
- **Guard Cells:** Guard cells are two specialized kidney-shaped cells that surround the stomatal pore. They are the key regulators of stomatal opening and closing.

- **Stomatal Pore:** The stomatal pore is the opening between the two guard cells. It allows gases, such as CO2, O2, and water vapour, to move in and out of the leaf.
- **Subsidiary Cells:** Subsidiary cells are specialized cells surrounding the guard cells and helping to support their function.
- **Epidermal Cells:** The epidermal cells are the outermost layer of the leaf. They cover and protect the inner tissues of the leaf.
- **Cuticle:** The cuticle is a waxy, waterproof layer covering the outer surface of the epidermis.
- **Stomatal Aperture:** The stomatal aperture refers to the opening between the two guard cells.

Opening and closing mechanisms of stomata:

Opening Mechanism of Stomata:

- Light triggers photosynthesis in guard cells.
- Photosynthesis leads to the production of glucose, generating osmotic gradients
- An influx of potassium ions (K+) occurs due to the osmotic gradients
- This leads to an increase in turgor pressure within the guard cells
- The guard cells swell and bend outward, creating an opening between them
- The stomatal pore is open, allowing gas exchange (CO2 uptake, O2 release) and transpiration

Closing Mechanism of Stomata:

- In the absence of light, photosynthesis stops, reducing glucose production and osmotic gradients.
- Water exits the guard cells due to decreased osmotic pressure.
- The guard cells become flaccid, closing the stomatal pore.
- Stomatal closure helps to conserve water and prevent excessive transpiration.
- Abscisic acid (ABA) hormone, produced in response to water stress, can also induce stomatal closure by reducing the uptake of potassium ions and leading to a decrease in turgor pressure within the guard cells.

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Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –IV Plant Physiology and Metabolism**
Name of the Topic	**Mineral nutrition & Enzymes**
Topic Synopsis	▪ **Essential elements** ▪ **Mineral ion uptake** ▪ **Nitrogen metabolism** ▪ **Protein synthesis** ▪ **Enzymes**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Interpret the role of enzymes in plant metabolism. 2. Evaluate the role of minerals in plant nutrition and their deficiency symptoms.
Pre Knowledge to be reminded	• Mineral Nutrition is defined as the naturally occurring inorganic nutrient found in the soil and food that is essential for the proper functioning of animal and plant body. • Minerals are vital elements necessary for the body. Both the plants and animals require minerals essentially.

Topic Synopsis

Essential elements:

- Essential elements, also known as essential nutrients, are chemical elements that are necessary for the proper growth, development, and functioning of plants.
- These elements are required in specific quantities and play crucial roles in various physiological processes within the plant.
- Essential elements can be broadly classified into two categories such as Macronutrients and Micronutrients.

Macronutrients:

- Macronutrients are elements that plants require in relatively large quantities, as they are essential components of plant biomass.
- **Nitrogen (N):** Essential for protein synthesis, chlorophyll production, and overall plant growth. Due to the deficiency of this may leads to stunted growth, yellowing of older leaves (chlorosis), and reduced protein content.

- **Phosphorus (P):** Involved in energy transfer processes (ATP), nucleic acid synthesis, and root development. Due to the deficiency of this may leads to poor root development, purple or reddish leaves, and delayed flowering.
- **Potassium (K):** Essential for enzyme activation, water uptake, and osmoregulation in plant cells. Due to the deficiency of this may leads to Weak stems, scorched leaf edges, and poor fruit development.
- **Calcium (Ca):** Important for cell wall structure, cell division, and membrane integrity. Due to the deficiency of this may leads to Poor root growth, leaf deformation, and blossom end rot in fruits.
- **Magnesium (Mg):** An essential component of chlorophyll and involved in enzyme activation. Due to the deficiency of this may leads to Interveinal chlorosis in older leaves and reduced chlorophyll content.
- **Sulphur (S):** Essential for the synthesis of amino acids, proteins, and some vitamins. Due to the deficiency of this may leads to Yellowing of new leaves, similar to nitrogen deficiency, but occurs in young tissues.

Micronutrients:

- Micronutrients, also known as trace elements, are elements that plants need in smaller quantities but are equally important for their growth and development.
- **Iron (Fe):** Essential for chlorophyll synthesis, enzyme functions, and electron transport in photosynthesis. Due to the deficiency of this may leads to Interveinal chlorosis in young leaves.
- **Manganese (Mn):** Involved in photosynthesis, enzyme activation, and nitrogen metabolism. Due to the deficiency of this may leads to Interveinal chlorosis with brown spots on leaves.
- **Zinc (Zn):** Important for enzyme functions and growth hormone regulation. Due to the deficiency of this may leads to Interveinal chlorosis, smaller leaves, and delayed maturity.
- **Copper (Cu):** Essential for electron transport in photosynthesis and respiration. Wilting of young leaves and dieback of shoot tips.
- **Boron (B):** Required for cell wall synthesis and pollen tube growth. Due to the deficiency of this may leads to Brittle and deformed young leaves and roots.
- **Molybdenum (Mo):** Essential for nitrogen fixation and enzyme functions. Due to the deficiency of this may leads to General yellowing and reduced growth.
- **Chlorine (Cl):** Involved in photosynthesis, osmoregulation, and ionic balance. Due to the deficiency of this may leads to Wilting, chlorosis, and reduced growth.
- **Nickel (Ni):** Required for certain enzyme functions, particularly in nitrogen metabolism. Due to the deficiency of this may leads to reduced growth and development.

Mineral Ion Uptake in Plants:

- Mineral ion uptake occurs primarily in the root hair zone, where root hairs extend into the soil.

- **Active Transport:** Energy-dependent process. Specialized transport proteins (e.g., ATPases) in the plasma membrane of root cells actively move mineral ions against their concentration gradient. ATP (Adenosine Triphosphate) is required to power the transport process.
- **Passive Transport:** Energy-independent process. Mineral ions move down their concentration gradient. Passive transport includes diffusion and facilitated diffusion. Occurs through specific ion channels or pores in the plasma membrane.
- **Mycorrhizal Symbiosis:** Mycorrhizal fungi form a mutualistic association with plant roots. Extensive hyphal network of fungi increases the effective root surface area for mineral ion uptake. Fungi enhance the uptake of certain mineral ions, especially phosphorus, and receive organic compounds from the plant.

Nitrogen metabolism:

- Nitrogen metabolism in plants involves the various processes by which nitrogen is assimilated, utilized, and recycled within the plant.
- Nitrogen Uptake
- Nitrate Reduction
- Ammonium Assimilation
- Amino Acid Synthesis
- Protein Synthesis
- Nitrogen Remobilization
- Nitrogen Recycling

Biological Nitrogen Fixation in Rhizobium:

- Rhizobium is a type of nitrogen-fixing bacteria that forms a symbiotic relationship with leguminous plants (e.g., beans, peas, clover). This symbiosis takes place in the root nodules of the plant.
- Recognition and Infection
- Nodule Formation
- Infection Thread
- Bacteroids Formation
- Nitrogen Fixation
- Ammonium Assimilation
- Ammonium Transport

Protein synthesis:

- Protein synthesis is the biological process by which cells generate proteins.
- Proteins are large molecules composed of amino acids that play critical roles in various cellular functions.

Transcription:

Transcription is the first step of protein synthesis, where the genetic information in DNA is converted into RNA.

- **Initiation:** RNA polymerase, an enzyme, binds to the promoter region on the DNA and the DNA double helix unwinds to expose the template strand.
- **Elongation:** RNA polymerase moves along the template strand and synthesizes a complementary RNA strand. RNA is synthesized in the 5' to 3' direction. The RNA strand is called the pre-mRNA

- **Termination:** Transcription stops when RNA polymerase reaches the termination sequence on the DNA. The pre-mRNA is released from the DNA template.

Translation:

- Translation is the second step of protein synthesis, and it occurs in the cytoplasm of the cell, specifically on ribosomes.
- During translation, the mRNA produced during transcription is used as a template to synthesize a protein.
- **Initiation:** The small ribosomal subunit binds to the mRNA at the start codon (AUG), and the initiator tRNA carrying Methionine attaches to the ribosome.
- **Elongation:** The ribosome moves along the mRNA in a 5' to 3' direction, and tRNA molecules bring specific amino acids to the ribosome based on the codons in the mRNA.
- **Termination:** Translation continues until a stop codon is reached (UAA, UAG, or UGA). At this point, release factors bind to the ribosome, and the newly synthesized protein (polypeptide chain) is released.

Enzymes:

- Enzymes are biological molecules that play a crucial role in catalyzing and regulating chemical reactions within living organisms.

Characteristics:

- Biological Catalysts
- Specificity
- Active Site
- Reaction Rate
- pH and Temperature Sensitivity
- Biological Regulation

Mechanism of Enzyme Action:

- Substrate Binding
- Enzyme-Substrate Complex Formation
- Catalysis
- Product Release

Regulation of Enzyme Activity:

- Allosteric Regulation: Molecules (allosteric effectors) bind to regulatory sites on the enzyme, leading to a change in enzyme shape and activity.
- Covalent Modification: Enzyme activity can be altered by adding or removing chemical groups, such as phosphorylation or glycosylation.
- Competitive Inhibition
- Non-Competitive Inhibition
- Feedback Inhibition
- Enzyme Induction and Repression

Applications of Enzymes:

- Biotechnology
- Medicine
- Research Tools

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –IV Plant Physiology and Metabolism**
Name of the Topic	**PHOTOSYNTHESIS**
Topic Synopsis	▪ **Photosynthetic pigments** ▪ **Photo- phosphorylation** ▪ **Carbon assimilation pathways** ▪ **Photorespiration** ▪ **Translocation of organic solutes**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Interpret the role of enzymes in plant metabolism. 2. Evaluate the role of minerals in plant nutrition and their deficiency symptoms
Pre Knowledge to be reminded	• Photosynthesis is the process by which autotrophic organisms convert light energy into chemical energy, stored in the form of glucose and other organic molecules. • It sustains life by producing oxygen, providing food, and driving various ecosystems.

Topic Synopsis

Photosynthesis:

- Photosynthesis is the process by which green plants, algae, and some bacteria convert light energy into chemical energy, specifically in the form of glucose (a sugar molecule).
- It is a complex biochemical reaction that occurs in the chloroplasts of plant cells.

$$6\ CO_2 + 6\ H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6\ O$$

Photosynthetic pigments:

- Photosynthetic pigments are light-absorbing molecules found in the chloroplasts of plants, algae, and some bacteria.
- The most important pigments involved in photosynthesis are chlorophyll a, chlorophyll b, carotenoids, and phycobilins.
- Each pigment has a unique absorption spectrum, which refers to the range of light wavelengths it can absorb.

Photosynthetic Light Reactions:

- Photosynthetic light reactions are the initial stages of photosynthesis, occurring in the thylakoid membranes of chloroplasts.
- These reactions capture light energy and convert it into chemical energy in the form of ATP and NADPH, which are used to produce glucose and other organic molecules.

Light Absorption and Pigments:

- Light-absorbing pigments, primarily chlorophyll a and chlorophyll b, and other accessory pigments are embedded in the thylakoid membranes.
- These pigments absorb light energy from the sun, exciting electrons to higher energy levels.

Photolysis and Oxygen Production:

- Water molecules are split by light energy in a process called photolysis or water splitting.
- This releases oxygen gas (O2) as a by product and provides electrons to replace those lost from the excited chlorophyll molecules.

Photosystem I (PSI):

- Electrons from the ETC are accepted by PSI's chlorophyll molecules after being re-energized by light.
- These energized electrons are passed to a protein carrier molecule, Ferredoxin.

NADPH Formation:

- Electrons from Ferredoxin are used to reduce NADP+ (nicotinamide adenine dinucleotide phosphate), forming NADPH.
- NADPH is an energy-rich molecule that carries electrons for the subsequent dark reactions.

ATP Synthesis:

- The proton gradient generated by the electron transport chain drives the enzyme ATP synthase to synthesize ATP from ADP and inorganic phosphate (Pi).
- This process is known as chemiosmotic ATP synthesis.

Photophosphorylation:

- Photophosphorylation is the process of using light energy to generate ATP from ADP and inorganic phosphate (Pi).
- It occurs during the light reactions of photosynthesis and involves the thylakoid membrane's electron transport chain.
- Light energy absorbed by pigments drives the movement of electrons through the chain, creating a proton gradient across the thylakoid membrane.
- ATP synthase utilizes the proton gradient to phosphorylate ADP, producing ATP.

Carbon Assimilation Pathways:

- Carbon assimilation pathways involve the incorporation of atmospheric carbon dioxide (CO_2) into organic compounds through photosynthesis.
- Different pathways have evolved to optimize carbon fixation in various environmental conditions:

C_3 Pathway (Calvin Cycle):

- Occurs in most plants under normal conditions.
- Carbon dioxide is initially fixed into a three-carbon compound (3-phosphoglycerate, 3-PGA) in the Calvin cycle.
- The enzyme RuBisCO catalyzes the first step of carbon fixation.
- 3-PGA is then converted into glucose and other sugars through a series of enzymatic reactions.

C_4 Pathway:

- Found in plants adapted to hot and arid environments.
- Carbon dioxide is initially fixed into a four-carbon compound (oxaloacetate, OAA) in mesophyll cells.
- OAA is transported to bundle sheath cells, where it releases CO_2 for the Calvin cycle.
- This separation reduces photorespiration and enhances CO_2 concentration around RuBisCO.

CAM Pathway (Crassulacean Acid Metabolism):

- Adaptation to arid conditions, mainly seen in succulent plants.
- Stomata remain closed during the day to minimize water loss.
- At night, CO_2 is fixed into a four-carbon compound and stored in vacuoles as malic acid.
- During the day, malic acid is decarboxylated to release CO_2 for the Calvin cycle.

Significance:

- C3 plants are the most common and efficient in temperate regions but may suffer from photorespiration.
- C4 plants have an advantage in hot and dry environments due to reduced photorespiration.
- CAM plants minimize water loss and are well-suited for arid conditions but may have lower growth rates.

Photorespiration:

- Photorespiration is a metabolic process that occurs in plants during photosynthesis, particularly in C3 plants.
- It involves the uptake of oxygen and release of carbon dioxide in the presence of light and can lead to the breakdown of organic compounds.

Process:

- **Oxygen Uptake:** Under certain conditions, the enzyme RuBisCO, responsible for fixing carbon dioxide in the Calvin cycle, may also react with oxygen.
- **Breakdown:** The breakdown of this compound consumes energy and releases carbon dioxide.

Significance:

- **Energy Drain:** Photorespiration consumes energy produced by photosynthesis without contributing to the synthesis of carbohydrates.
- **Reduced Yield:** In some conditions, photorespiration can lead to a significant reduction in the yield of crops, impacting agriculture.
- **Adaptation to Environmental Conditions:** Photorespiration is more prominent in conditions of high temperature, high light intensity, and low carbon dioxide levels.

C3 vs. C4 Plants:

- C3 plants, which include many common crops like wheat and rice, are more prone to photorespiration due to the initial carbon fixation product being a three-carbon compound (3-PGA).
- C4 plants, such as maize and sugarcane, have evolved a biochemical mechanism to concentrate carbon dioxide around RuBisCO, reducing the occurrence of photorespiration and improving water-use efficiency.

Translocation:

- Translocation in plants refers to the movement of water, nutrients, and organic compounds from one part of the plant to another.
- This process is essential for distributing resources needed for growth, energy production, and various physiological functions.
- **Xylem Translocation:** Xylem is responsible for the upward movement of water and minerals from the roots to the rest of the plant.
- **Phloem Translocation:** Phloem is responsible for the transport of organic compounds, primarily sugars (such as glucose and sucrose), amino acids, and hormones.

Mechanism of Phloem Transport:

- The mechanism of phloem transport involves the movement of organic compounds, primarily sugars, from source tissues to sink tissues through the phloem sieve tube elements.

Pressure Flow Hypothesis (Mass Flow Hypothesis):

- Proposed by Ernst Munch in the mid-20th century.
- It suggests that the movement of phloem sap is driven by differences in hydrostatic pressure between source and sink tissues.

- The process involves the active loading of sugars into the phloem at source tissues, creating a higher solute concentration and thus a higher hydrostatic pressure.

Chemiosmotic Hypothesis:

- This theory proposes that phloem transport is driven by proton pumps that create an electrochemical gradient, causing solutes to move through co transport proteins.

Mobilization of Protons:

- Another theory suggests that protons are released during photosynthesis and actively move into the phloem, generating a proton motive force that drives sugar transport.

Mechanism:

- Loading at Source Tissues
- Pressure Gradient
- Unloading at Sink Tissues
- Pressure Difference Drives Flow

Source-Sink Relationship:

- Source-sink relationships in plants refer to the dynamic distribution of nutrients, particularly sugars and other organic compounds, between source tissues and sink tissues.
- Source tissues are regions where organic compounds, mainly sugars produced through photosynthesis, are synthesized and released.
- Source tissues generate excess organic compounds and provide the energy and building blocks for the plant's various metabolic processes.
- Sink tissues are regions where organic compounds are used or stored for growth, energy production, or other physiological activities.
- Sink tissues receive and utilize the nutrients transported from source tissues to support their specific functions, such as growth, storage, or reproduction.

High Flow Scenario (Strong Source):

- When source tissues have high photosynthetic activity (e.g., sunny days), they produce an abundance of organic compounds (sugars).
- Excess sugars are transported through the phloem from source to sink tissues.

Low Flow Scenario (Weak Source):

- During periods of reduced photosynthesis (e.g., cloudy days, winter), source tissues produce fewer organic compounds.
- Despite lower sugar production, sink tissues continue to consume nutrients

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Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –IV Plant Physiology and Metabolism**
Name of the Topic	**PLANT METABOLISM**
Topic Synopsis	▪ **Respiration** ▪ **Glycolysis** ▪ **TCA cycle** ▪ **Electron transport system** ▪ **Oxidative phosphorylation** ▪ **Lipids** ▪ **Lipid Metabolism** ▪ **Beta-oxidation**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Interpret the role of enzymes in plant metabolism. 2. Evaluate the role of minerals in plant nutrition and their deficiency symptoms.
Pre Knowledge to be reminded	• Plant metabolism refers to the complex set of biochemical reactions that occur within plants to maintain their growth, development, and survival. • Metabolism in plants involves various processes that help convert nutrients and energy sources into essential compounds needed for life.

Topic Synopsis

Respiration:

- Respiration in plants is a fundamental metabolic process that involves the conversion of organic compounds, typically glucose, into energy and carbon dioxide.
- Plant respiration can be broadly categorized into two types: aerobic respiration and anaerobic respiration.
- **Aerobic Respiration:** This is the primary form of respiration in plants and occurs in the presence of oxygen.
- **Anaerobic Respiration:** In situations where oxygen availability is limited (e.g., waterlogged soils), plants can undergo anaerobic respiration.

Glycolysis:

- The breakdown of glucose (a six-carbon sugar) into two molecules of pyruvate (a three-carbon compound) occurs in the cytoplasm.

- A small amount of ATP is produced, and electrons are transferred to carrier molecules like NADH.
- The key steps and reactions of the glycolysis pathway are as follows
- Glucose Activation
- Cleavage of Six-Carbon Sugar
- Energy Production
- Electron Carrier Generation
- Substrate-Level Phosphorylation
- Pyruvate Formation

TCA cycle:

- Tricarboxylic Acid (TCA) cycle, also known as the Krebs cycle or citric acid cycle, is a fundamental metabolic pathway that takes place in the mitochondria of cells.
- Pyruvate is transported into the mitochondria, where it undergoes further reactions to generate carbon dioxide, more ATP, and reduced electron carriers (NADH and FADH2).
- The key steps and reactions of the TCA cycle as follows
- Acetyl-CoA Formation
- Isomerization
- Decarboxylation
- Release of Carbon Dioxide
- Redox Reactions
- Regeneration of Oxaloacetate

Electron Transport Chain (ETC):

- The electron carriers produced in previous steps donate their electrons to the ETC, a series of protein complexes located in the inner mitochondrial membrane.
- As electrons move through the chain, their energy is used to pump protons (H+ ions) across the membrane, creating a proton gradient.

Oxidative phosphorylation:

- Oxidative phosphorylation is a crucial process that occurs in the mitochondria of eukaryotic cells, enabling the production of adenosine triphosphate (ATP), the primary energy currency of cells.
- This process involves the coupling of electron transport through the mitochondrial electron transport chain (ETC) with the synthesis of ATP using a proton gradient across the inner mitochondrial membrane.

1. **Electron Transport Chain (ETC):**
   - The ETC consists of a series of protein complexes embedded in the inner mitochondrial membrane.
   - These complexes are organized into four main complexes:
   - **Complex I** (NADH dehydrogenase),
   - **Complex II** (succinate dehydrogenase),
   - **Complex III** (cytochrome bc1 complex), and Complex IV (cytochrome c oxidase).
   - Electrons are transferred sequentially through these complexes, moving from higher to lower energy states.
   - **Electron Donors:** Electrons enter the ETC from reduced electron carriers, primarily NADH and FADH2, which are generated during earlier stages of cellular respiration

- **Proton Pumping:** As electrons move through the complexes, protons (H+ ions) are pumped across the inner mitochondrial membrane, from the mitochondrial matrix to the intermembrane space.

2. **Chemiosmosis:**
   - The proton gradient created by the ETC is a form of potential energy.
   - This energy is harnessed through a process called Chemiosmosis, which involves the movement of protons back into the mitochondrial matrix through ATP synthase.
   - ATP synthase is an enzyme complex embedded in the inner mitochondrial membrane that couples the flow of protons with the synthesis of ATP.
   - **ATP Synthesis:** As protons flow back into the mitochondrial matrix through ATP synthase, their energy is used to convert adenosine diphosphate (ADP) and inorganic phosphate (Pi) into ATP.
3. **Oxygen as the Final Electron Acceptor:**
   - At the end of the ETC, oxygen (O2) serves as the final electron acceptor. It combines with electrons and protons to form water (H2O).

Lipids:

- Lipids are a diverse group of bio molecules that are hydrophobic (insoluble in water) due to their nonpolar nature.
- They play essential roles in various biological processes, including energy storage, cell membrane structure, insulation, protection, and signaling.

Types of lipids:

There are several types of lipids, each with distinct structures and functions

- **Fatty Acids:** Fatty acids are the simplest form of lipids and serve as the building blocks for other lipid molecules. They consist of a hydrocarbon chain with a carboxyl group (-COOH) at one end.
- **Triglycerides (Triacylglycerols):** Triglycerides are the main storage form of energy in the body. They consist of three fatty acids attached to a glycerol molecule.
- **Phospholipids:** Phospholipids are major components of cell membranes. They have a hydrophilic "head" region (containing a phosphate group) and two hydrophobic "tail" regions (fatty acid chains).
- **Lipoproteins:** Lipoproteins are complexes of lipids and proteins that transport lipids in the bloodstream.
- **Waxes:** Waxes are long-chain fatty acids combined with long-chain alcohols.
- **Eicosanoids:** Eicosanoids are lipid molecules derived from arachidonic acid.

Beta-oxidation:

- Beta-oxidation is a catabolic metabolic pathway that occurs in the mitochondria of cells and is responsible for breaking down fatty acids into acetyl-CoA units.

- These acetyl-CoA units can then enter the citric acid cycle (TCA cycle) to generate energy in the form of adenosine triphosphate (ATP).

Activation of Fatty Acids:

- Before beta-oxidation can occur, fatty acids must be activated by attaching a molecule of coenzyme A (CoA) to the fatty acid molecule.
- This step requires the input of ATP and is catalyzed by an enzyme called fatty acyl-CoA synthetase.

Transport into the Mitochondria:

- Long-chain fatty acyl-CoA molecules cannot directly cross the mitochondrial inner membrane. Instead, they are transported into the mitochondria through a series of reactions involving a carrier molecule called carnitine.
- Carnitine acyltransferase I (CPT-I) catalyzes the transfer of the fatty acyl group from CoA to carnitine on the outer mitochondrial membrane.
- Carnitine acylcarnitine translocase transports the acylcarnitine molecule into the mitochondrial matrix.

Beta-Oxidation Steps:

Once inside the mitochondrial matrix, beta-oxidation involves a series of four main reactions that repeat for each two-carbon segment of the fatty acid chain:

- **Oxidation:** An enzyme called acyl-CoA dehydrogenase removes a pair of hydrogen atoms (dehydrogenation) from the beta carbon, forming a trans-double bond between the alpha and beta carbons.
- **Hydration:** Enzymes add a molecule of water across the trans-double bond, resulting in a hydroxyl group attached to the beta carbon.
- **Oxidation:** A second dehydrogenation reaction removes hydrogen atoms from the beta carbon's hydroxyl group, generating a beta-ketoacyl-CoA molecule.
- **Thiolysis:** The beta-ketoacyl-CoA molecule is cleaved into two molecules: a molecule of acetyl-CoA and a shorter acyl-CoA chain, which can re-enter the beta-oxidation cycle.

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –IV Plant Physiology and Metabolism**
Name of the Topic	**GROWTH AND DEVELOPMENT**
Topic Synopsis	▪ **Growth and development** ▪ **Kinetics of growth** ▪ **Phytohormones** ▪ **Physiology of flowering** ▪ **Vernalization** ▪ **Scenescence and Ageing**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Acquire a critical knowledge on sterilization techniques related to plant tissue culture. 2. Understand the biotransformation technique for production of secondary metabolites.
Pre Knowledge to be reminded	• Tissue culture allows for the rapid and large-scale production of identical plant clones from a single parent plant. • Tissue culture provides a means to preserve the genetic diversity of plants through in vitro conservation.

Topic Synopsis

Growth and Development:

- Growth and development are fundamental processes in living organisms that involve an increase in size, complexity, and organization.
- Growth refers to an increase in physical dimensions or mass, while development encompasses the overall changes in form, structure, and function that occur over time.

Phases of Growth:

- **Lag Phase:** In this initial phase, growth is slow as the organism adapts to the environment, synthesizes necessary molecules, and prepares for rapid growth.
- **Log Phase:** Also known as the rapid growth phase, this stage is characterized by a period of exponential growth, where cells or organisms undergo rapid division and increase in number.
- **Stationary Phase:** At this stage, growth rate levels off, and the number of dividing cells equals the number of dying cells, resulting in a stable population size.

- **Decline or Death Phase:** In this phase, the growth rate decreases, and cell or organism death exceeds new cell formation, leading to a decline in population size.

Kinetics of Growth:

- **Growth Rate:** The rate at which an organism increases in size or mass over time. It can be measured as an absolute increase (e.g., grams per day) or as a relative increase (e.g., percentage increase).
- **Growth Curve:** A graphical representation of the growth rate over time. Typically, growth follows an S-shaped curve, starting slowly, accelerating during the exponential phase, and eventually levelling off during the stationary phase.
- **Doubling Time:** The time required for a population to double in size during the exponential growth phase. It is inversely proportional to the growth rate.
- **Growth Factors:** Factors that influence the rate and extent of growth, such as availability of nutrients, environmental conditions (temperature, light, etc.), genetic factors, hormonal regulation, and interactions with other organisms.

Regulation of Growth and Development:

- Hormones: Chemical messengers that regulate growth and development in plants and animals.
- Genetic Factors: Genetic information encoded in an organism's DNA plays a crucial role in determining growth patterns, rates, and developmental processes.
- Environmental Factors: External conditions, such as temperature, light, humidity, nutrient availability, and other abiotic and biotic factors, can profoundly influence growth and development.

Plant growth regulators (PGRs):

The plant growth regulators also known as plant hormones, play vital roles in regulating various physiological processes in plants.

- **Auxins:** Cell Elongation, Apical Dominance, Root Formation and Fruit Development.
- **Gibberellins (GAs):** Stem Elongation, Seed Germination and Fruit Development.
- **Cytokinins:** Cell Division, Delay of Senescence, Apical Dominance Release and Root Growth.
- **Abscisic Acid (ABA):** Induces Seed Dormancy and Germination, Stress Response and Stomatal Closure.
- **Ethylene:** Fruit Ripening, Leaf Abscission and Apical Hook Formation in young seedlings.
- **Brassinosteroids:** Cell Expansion, Seed Germination, Stress Response and flowering induction.

Physiology of flowering:

The physiology of flowering in plants involves a series of complex and coordinated processes that result in the production of flowers.

1. **Floral Induction:** Floral induction is the process by which a plant transitions from vegetative growth to reproductive growth, leading to the initiation of flower formation. Major aspects are **Photoperiod, Temperature, Hormonal Regulation.**
2. **Flower Development:** Once floral induction occurs, the plant undergoes a series of developmental stages that lead to the formation of flowers. Major steps are **Floral Meristem Development, Organ Development, Pollination and Fertilization**.
3. **Hormonal Regulation:** Plant hormones play a crucial role in coordinating various aspects of flower development and reproductive processes. Ex. Gibberellins, Auxins, Cytokinins and Ethylene.

Photoperiodism:

Photoperiodism is the physiological response of plants to the duration of light and darkness in a 24-hour cycle. It influences the timing of flowering and other developmental processes in plants.

There are three main categories of photoperiodic responses:

- **Short-day Plants:** These plants require a longer period of darkness (night) than light to induce flowering. Flowering is typically triggered when the night duration exceeds a critical threshold.
- **Long-day Plants:** These plants require a shorter period of darkness (night) than light to induce flowering. Flowering is typically triggered when the night duration is shorter than a critical threshold.
- **Day-neutral Plants:** These plants are not significantly affected by the duration of light or darkness and can flower regardless of the photoperiod.

Phytochrome:

- Phytochrome is not a hormone but rather a light-sensitive pigment found in plants.
- It plays a crucial role in perceiving and responding to light signals, particularly in relation to Photoperiodism and various developmental processes in plants.
- Phytochrome acts as a photoreceptor, converting light signals into chemical signals that trigger specific physiological and developmental responses.

Role of Phytochrome in Flowering:

- Phytochrome is a light-sensitive pigment found in plants that plays a key role in photoperiodic flowering.
- It exists in two interconvertible forms: **Pr** (red-light absorbing form) and **Pfr** (far-red light absorbing form).
- **Induction of Flowering:** In long-day plants, flowering is induced when the **Pfr** form of phytochrome accumulates. **Pfr** is synthesized in response to exposure to light, particularly in the red light spectrum. It promotes flowering by activating specific genes involved in flowering initiation.
- **Inhibition of Flowering:** In short-day plants, flowering is inhibited when the **Pfr** form of phytochrome accumulates. **Pfr** is converted back to **Pr** in response to

darkness or exposure to far-red light. **Pr** inhibits flowering by repressing the expression of genes involved in flowering initiation.

- The phytochrome-mediated flowering response is a complex process that involves the interaction of phytochrome with other regulatory proteins and genetic pathways. It helps plants adapt to their specific environmental conditions, ensuring that flowering occurs at the appropriate time.

Vernalization:

- Vernalization is a fascinating biological process that influences the flowering and reproductive timing of certain plant species in response to exposure to cold temperatures.

Process:

- **Perception of Cold:** Certain plants have evolved the ability to sense and respond to extended periods of cold temperatures.
- **Molecular Changes:** Cold exposure triggers changes in gene expression and molecular pathways within the plant.
- **Gene Regulation:** VRN1 promotes the suppression of a gene called "FT" (Flowering Locus T), which usually inhibits flowering.
- **Flowering Induction:** The relief of FT repression leads to the activation of other genes responsible for flowering.

Advantages of Vernalization:

- Synchronization with Seasonal Changes
- Avoidance of Unfavourable Conditions
- Enhanced Reproductive Success
- Genetic Diversity
- Ecosystem Services
- Crop Production
- Climate Adaptation
- Research Insights

Limitations of Vernalization:

- Species Specificity
- Climate Dependence
- Environmental Variability
- Sensitive Timing
- Chilling Injury
- Ecological Competition
- Pest and Disease Vulnerability
- Agricultural Constraints
- Climate Change Impact

Senescence:

- Senescence is the process of aging and deterioration that occurs in various parts of a plant, such as leaves, flowers, and fruits.
- It involves programmed physiological and biochemical changes that lead to the eventual death and shedding of the senescent tissue.

Process:

- **Chlorophyll Breakdown**
- **Nutrient Remobilization**
- **Protein Degradation**
- **Cell Death and Tissue Breakdown**
- **Hormonal Regulation**.

Aging:

- Aging, on the other hand, encompasses the entire process of gradual decline and changes that occur at the Organismal level as a result of the passage of time.
- It involves the cumulative effects of cellular senescence and other factors.

Process:

- Physiological Changes
- Genetic and Environmental Factors
- Systemic Effects
- Heterogeneity

Relationship between Senescence and Aging:

- Cellular senescence contributes to aging by impairing tissue function and increasing the risk of age-related diseases.
- However, senescence is just one of many factors contributing to the aging process, which is a more comprehensive phenomenon affecting the entire organism.

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –V Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Cell Biology**
Topic Synopsis	▪ **Cell- unit of life** ▪ **Eukaryotic cell** ▪ **Ultra structure of cell wall** ▪ **Ultra structure of cell membrane** ▪ **Chromosomes** ▪ **Organization of DNA in a chromosome** ▪ **Euchromatin and heterochromatin**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Distinguish prokaryotic and eukaryotic cells and design the model of a cell. 2. Explain the organization of a eukaryotic chromosome and the structure of genetic material.
Pre Knowledge to be reminded	• The cell is the basic structural and functional unit of life. • All living organisms, including plants, animals, and microorganisms, are composed of one or more cells. • Each chromosome is made of protein and a single molecule of deoxyribonucleic acid (DNA).

Topic Synopsis

Cell theory:

The cell theory is a fundamental principle in biology that states:

- All living organisms are composed of one or more cells.
- The cell is the basic unit of structure and function in all organisms.
- Cells arise from pre-existing cells through cell division.

Prokaryotic vs. Eukaryotic Cells:

Prokaryotic cells and eukaryotic cells are the two main types of cells.

Prokaryotic	Eukaryotic Cell
Simpler in structure and smaller in size.	More complex and larger in size.
Lack a true nucleus and membrane-bound organelles.	Have a true nucleus that houses the DNA.
DNA is present in a single circular molecule and floats freely in the cytoplasm.	Contain membrane-bound organelles that perform specific functions.

Found in bacteria and archaea.	Found in plants, animals, fungi, and protists.

Ultra structure of a Plant Cell:

The ultra structure of a plant cell refers to its detailed internal organization, including the organelles and other structures. Here are some key components:

- **Cell Wall:** Plant cells have a rigid cell wall composed of cellulose, hemi cellulose, and other polysaccharides. It provides structural support and protection for the cell.
- **Cell Membrane:** The cell membrane (plasma membrane) surrounds the cell and regulates the passage of molecules in and out of the cell.
- **Nucleus:** The nucleus contains the DNA and is surrounded by a nuclear envelope. It controls cellular activities and houses the genetic material.
- **Chloroplasts:** Chloroplasts are the site of photosynthesis in plant cells. They contain chlorophyll pigments and other molecules necessary for capturing light energy and converting it into chemical energy.
- **Mitochondria:** Mitochondria are the powerhouses of the cell, producing energy in the form of ATP through cellular respiration.
- **Endoplasmic Reticulum (ER):** The endoplasmic reticulum is involved in the synthesis and transport of proteins and lipids within the cell.
- **Golgi apparatus:** The Golgi apparatus modifies, sorts, and packages proteins for transport within the cell or for secretion outside the cell.
- **Vacuoles:** Plant cells typically have one or more large central vacuoles that store water, nutrients, and other substances. The vacuole helps maintain cell turgidity and plays a role in plant growth and development.
- **Plasmodesmata:** Plasmodesmata are cytoplasmic connections between adjacent plant cells. They allow for communication and transport of molecules between cells.

Ultra-structure of cell wall:

- The cell wall is a rigid structure that surrounds the cell membrane in plant cells, fungi, bacteria, and some protists.
- The cell wall is a rigid structure that surrounds the cell membrane in plant cells, fungi, bacteria, and some protists.
- **Primary Cell Wall:** The primary cell wall is the outermost layer of the cell wall in growing plant cells. It is composed mainly of cellulose, a complex carbohydrate, along with other polysaccharides such as hemi cellulose and pectin.
- **Middle Lamella:** The middle lamella is a thin layer of pectin that lies between adjacent plant cells. It acts as a cementing material, holding the neighbouring cells together.
- **Secondary Cell Wall:** Some plant cells, particularly those that have stopped growing, develop a secondary cell wall inside the primary cell wall. The secondary cell wall provides additional strength and rigidity to the cell.
- **Plasmodesmata:** Plasmodesmata are small channels that traverse the cell wall, connecting the cytoplasm of adjacent plant cells.

Plasma membrane:

- In eukaryotic cells, the plasma membrane surrounds a cytoplasm filled with ribosomes and organelles. Organelles are structures that are themselves encased in membranes.
- Some organelles (nuclei, mitochondria, chloroplasts) are even surrounded by double membranes.
- All cellular membranes are composed of two layers of phospholipids embedded with proteins.

Lipid and Lipid Bilayer Model:

- Suggested by Gorter and Grendel (1925).
- The membrane consisted of double layers of lipid molecules.
- The hydrophilic molecules being situated on the outside and hydrophobic ends standing at inwardly.

Dannelli Model (Sandwich Models):

- Suggested by James Danielli and Hugh Davson in 1935.
- A Phospholipid bilayer that forms the main structural framework.
- Plasma membrane contains a Phospholipid layer and in between two layers of protein like a sandwich in P-L-L-P structure with nonpolar tails of the lipid bilayer in the center

Unit Membrane Model:

- Proposed by J. David Robertson in 1959
- The plasma membrane consists of a trilaminar (three-layered) structure.
- The outermost layer of the plasma membrane is formed by a thin layer of proteins and phospholipids.
- The middle layer of the plasma membrane is composed of phospholipids.
- The innermost layer is similar in composition to the outer layer, containing integral proteins and phospholipids.

Fluid Mosaic Model:

- Proposed by S.J. Singer and Garth L. Nicolson in 1972.
- The plasma membrane is composed of a lipid bilayer with embedded proteins.
- The lipid bilayer consists of phospholipids, which have a hydrophilic (water-loving) head and two hydrophobic (water-repelling) tails.

Chromosomes:

- Chromosomes are thread-like structures found in the nucleus of eukaryotic cells.
- They carry genetic information in the form of DNA (deoxyribonucleic acid)

Structure of chromosome:

The typical structure of a condensed chromosome can be described as follows

- **Chromatids:** A chromosome consists of two identical arms , called chromatids,

- **Centromere:** together by a specialized region called the centromere, It serves as a site for the attachment of spindle fibers
- **Telomeres:** Telomeres are specialized structures located at the ends of each chromosome arm.

Organization of DNA in a chromosome:

The organization of DNA in a chromosome can be explained by two models: the solenoid model and the nucleosome model. These models describe different levels of compaction and packaging of DNA within the chromosome.

- **Nucleosome Model:** The nucleosome model describes the basic unit of DNA packaging. It involves the wrapping of DNA around histone proteins to form nucleosomes. A nucleosome consists of a core histone octamer, which is composed of two copies each of histones H2A, H2B, H3, and H4. Approximately 147 base pairs of DNA are wrapped around this core histone octamer. The nucleosomes are connected by linker DNA, which is less tightly associated with histones.
- **Solenoid Model:** In the solenoid model, the chromatin fiber is organized into a solenoid-like structure. The DNA helix forms a series of tight loops or coils that are stacked on top of each other, resembling a solenoid or spring. The nucleosomes are connected by linker DNA, which is less tightly associated with histones. This results in a "beads-on-a-string" structure, where the nucleosomes are like beads and the linker DNA acts as the string.

Euchromatin:

- Euchromatin is a loosely packed and less condensed form of chromatin that is transcriptionally active. It appears as lightly stained regions during cell staining procedures.
- It is characterized by a more open structure, allowing for easier access of transcription factors, RNA polymerase, and other molecules involved in gene transcription.

Heterochromatin:

- Heterochromatin is a tightly packed and highly condensed form of chromatin that is transcriptionally inactive or has low levels of gene expression.
- It appears as densely stained regions during cell staining procedures.
- Heterochromatin contains genes that are not actively transcribed and may be involved in processes such as chromosome structure maintenance or gene silencing

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Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –V Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Genetic Material**
Topic Synopsis	▪ **DNA as the genetic material** ▪ **Hershey – Chase bacteriophage experiment** ▪ **DNA structure** ▪ **Replication of DNA** ▪ **Types of RNA**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Evaluate the structure, function of genetic material. 2. Evaluate the regulation of genetic material.
Pre Knowledge to be reminded	• DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. • RNA serves as a messenger for the transmission of information. RNA carries genetic information as well, thus functioning as genetic material.

Topic Synopsis

DNA as the genetic material:

- The discovery of DNA (deoxyribonucleic acid) as the genetic material is one of the most significant breakthroughs in the history of science.
- It revolutionized our understanding of inheritance and paved the way for modern genetics and molecular biology.
- Friedrich Miescher discovered a substance called "nuclein" in the cell nucleus, which was later identified as DNA. However, at that time, the significance of DNA as the genetic material was not fully understood.

Griffith's Transformation Experiment (1928):

- Frederick Griffith's experiments with Streptococcus pneumoniae bacteria showed that something from the dead virulent bacteria could transform the non-virulent bacteria into a virulent form.
- This phenomenon was termed "transformation.

Avery, MacLeod, and McCarty's Transformation Experiment (1944):

- Building on Griffith's work, Oswald Avery, Colin MacLeod, and Maclyn McCarty demonstrated that DNA was the transforming substance in Griffith's experiments.

- By selectively degrading proteins, lipids, carbohydrates, and DNA from the heat-killed virulent bacteria, they found that only DNA could transform the non-virulent bacteria into a virulent form.
- This provided strong evidence that DNA was the genetic material.

Hershey-Chase Bacteriophage Experiment (1952):

- Martha Chase and Alfred Hershey used bacteriophages to confirm that DNA was the genetic material in viruses as well.
- Their experiment, using radioactive isotopes to label DNA and protein components of the bacteriophage, showed that only the DNA entered the bacterial cells during infection.
- This further supported the idea that DNA carried genetic information.

DNA structure (Watson & Crick model):

- The DNA structure, describes the molecular arrangement of deoxyribonucleic acid (DNA), which is the genetic material present in almost all living organisms.
- The model was proposed by James Watson and Francis Crick in 1953 and is considered one of the most significant discoveries in the history of biology.
- **Double Helix:** The most prominent feature of the DNA structure is its double helix shape. The DNA molecule consists of two long strands that wind around each other in a twisted ladder-like configuration.
- **Sugar-Phosphate Backbone:** Each strand of the DNA double helix is composed of alternating units of deoxyribose sugar and phosphate groups which provides stability and structural support.
- **Nucleotide Base Pairs:** The interior of the DNA double helix is made up of nucleotide base pairs. Each nucleotide consists of three components: a deoxyribose sugar, a phosphate group, and a nitrogenous base.
- These base pairs are complementary to each other, meaning that A always pairs with T, and G always pairs with C.
- **Antiparallel Strands:** The two strands of the DNA double helix run in opposite directions and are said to be "antiparallel." One strand runs in the 5' to 3' direction (with the 5' end having a free phosphate group and the 3' end having a free hydroxyl group), while the other strand runs in the 3' to 5' direction.
- **Major and Minor Grooves:** DNA strands wind around each other; they create grooves along the helix. These grooves are called the major and minor grooves.

DNA replication:

DNA replication is the process by which a DNA molecule makes an exact copy of itself. The semi-conservative method of DNA replication, proposed by Watson and Crick, describes how the two strands of the DNA double helix separate and each serves as a template for the synthesis of a new complementary strand.

- **Initiation:** DNA replication begins at specific sites on the DNA molecule called origins of replication.
- **Primer Binding:** Primase, an RNA polymerase, synthesizes a short RNA primer on each of the DNA strands. These primers provide a starting point for DNA synthesis.

- **Elongation:** DNA polymerases, specifically DNA polymerase III in prokaryotes and a combination of DNA polymerase alpha, delta, and epsilon in eukaryotes, catalyze the addition of nucleotides to the growing DNA strands.
- **Proofreading and Repair:** DNA polymerases have a proofreading function that helps detect and correct errors during DNA replication.
- **Termination:** DNA replication continues until the replication forks meet at specific termination sites on the DNA molecule. The newly synthesized DNA strands are released, and the replication process is complete.

Ribonucleic acid (RNA):

RNA, or ribonucleic acid, is a versatile molecule that plays various roles in gene expression and cellular processes. There are several types of RNA molecules, each with distinct functions.

- **Messenger RNA (mRNA):** mRNA carries the genetic information from DNA to the ribosomes, where it serves as a template for protein synthesis. mRNA is a single-stranded RNA molecule that carries the genetic information from the DNA in the cell nucleus to the ribosomes in the cytoplasm, where protein synthesis occurs.
- **Ribosomal RNA (rRNA):** rRNA is a major component of ribosomes, the cellular structures where protein synthesis occurs. rRNA is a major component of ribosomes, the cellular organelles where protein synthesis takes place. It exists in the form of multiple RNA strands, folded and associated with ribosomal proteins to form the large and small subunits of the ribosome.
- **Transfer RNA (tRNA):** tRNA molecules transport specific amino acids to the ribosomes during protein synthesis. tRNA is a relatively small RNA molecule, typically around 70-90 nucleotides long, that folds into a characteristic cloverleaf structure.

Signature of the Lecturer

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –V Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Mendelian Inheritance**
Topic Synopsis	▪ **Mendel's laws of Inheritance** ▪ **Mono- and Di- hybrid crosses** ▪ **Backcross and test cross** ▪ **Chromosome theory of Inheritance** ▪ **Linkage** ▪ **Crossing Over**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Discuss the basics of Mendelian genetics, its variations and interpret inheritance of traits in living beings. 2. Elucidate the role of extra-chromosomal genetic material for inheritance of characters.
Pre Knowledge to be reminded	• Genetics is the scientific study of genes and heredity—of how certain qualities or traits are passed from parents to offspring as a result of changes in DNA sequence. • A gene is a segment of DNA that contains instructions for building one or more molecules that help the body work.

Topic Synopsis

Mendel's laws of Inheritance:

Mendel's laws of inheritance:

- Mendel's laws of inheritance are fundamental principles in genetics that describe how traits are passed from parents to offspring.
- Mendel's laws laid the foundation for our understanding of inheritance and formed the basis of modern genetics.
- The three main laws of inheritance proposed by Mendel are following
- **Law of Segregation:** The law of segregation states that during the formation of gametes (sex cells), the two alleles (alternative forms of a gene) for each trait segregate or separate from each other.
- **Law of Independent Assortment:** The law of independent assortment states that the inheritance of different traits is independent of each other.

- **Law of Dominance:** The law of dominance states that in a heterozygous individual (having two different alleles for a trait), one allele, known as the dominant allele, will determine the phenotype (observable trait) while the other allele, known as the recessive allele, will have no noticeable effect on the phenotype.

Monohybrid Cross:

- A monohybrid cross involves mating two individuals that differ in only one characteristic, usually a single gene with two alleles.
- The parents are referred to as the P generation (parental generation), and their offspring are called the F1 generation (first filial generation).
- The phenotypic ratio of the F1 generation will be 1:1.

Dihybrid Cross:

- A dihybrid cross involves mating two individuals that differ in two characteristics, each controlled by different genes located on different chromosomes.
- These genes have two alleles each. The parents are referred to as the P generation, and their offspring are called the F1 generation.
- The Genotypic ratio is **1:2:1** and Phenotypic ratio is **9:3:3:1.**

Backcross and Test Cross:

Both backcross and test cross are types of breeding experiments used in genetics to determine the genotype of an individual for a specific trait.

Backcross:

- Backcross is a breeding experiment where an individual from the F1 generation of a monohybrid cross is crossed back to one of the parental genotypes (usually a homozygous recessive individual from the P generation).
- The backcross helps identify the genotype of the F1 individual and provides insights into the inheritance pattern of the trait under study.

Test Cross:

- A test cross is a breeding experiment that involves crossing an individual with an unknown genotype for a trait with a known homozygous recessive individual.
- The test cross is used to determine the genotype of an individual for a specific trait.

Chromosome theory of Inheritance:

a. Proposed independently by Walter Sutton and Theodor Boveri in the early 20th century,
b. This theory established a strong link between the behaviour of chromosomes during cell division and the inheritance of specific traits.

- Chromosomes are the carriers of genes
- Chromosomes occur in pairs
- Homologous chromosomes segregate during meiosis
- Independent assortment
- Sex determination

Linkage:

- Linkage refers to the phenomenon where two or more genes are located on the same chromosome and tend to be inherited together as a unit, rather than undergoing independent assortment during meiosis.

Complete Linkage:

- Complete linkage occurs when two genes are located very close together on the same chromosome, and as a result, they are always inherited together as a single unit.

Incomplete linkage:

- Incomplete linkage occurs when two genes are located on the same chromosome but are not very close together.
- During meiosis, crossing over can occur between these genes, leading to the exchange of genetic material between the homologous chromosomes.

Coupling:

- Also known as the "same" configuration, coupling occurs when the two dominant alleles or the two recessive alleles of linked genes are present on the same chromosome.

Repulsion:

- Also known as the "opposite" configuration, repulsion occurs when each chromosome carries one dominant and one recessive allele for the linked genes.

Linkage maps:

- Linkage maps, also known as genetic maps, are important tools in genetics that help us understand the relative positions of genes on a chromosome and the frequency of recombination between them.

Linkage Maps Based on Two-Factor Crosses:

- The goal is to determine the linkage between these genes and the distance separating them on the chromosome.
- The frequency of recombination (crossing over) between the two genes allows us to construct a linkage map.
- **Coupling and Repulsion Configuration:** Two genes can be in either the coupling (cis) or repulsion (trans) configuration based on the alleles present on the homologous chromosomes.
- **Recombination Frequency:** The recombination frequency is the percentage of recombinant offspring resulting from crossing over during meiosis.
- **Map Units (Centimorgans):** The distance between two genes on a chromosome is measured in map units (Morgans or centimorgans). One map unit represents a 1% recombination frequency between two genes.

Linkage Maps Based on Three-Factor Crosses:

In three-factor crosses, we study the inheritance of three genes located on the same chromosome. The goal is to determine the relative order of the genes and the distance between them

- **Three-Point Cross:** A three-point cross involves analyzing the inheritance of three genes (A, B, and C) in a single cross.
- **Double Crossovers:** Occasionally, two crossing-over events can occur between the three genes during meiosis, leading to the exchange of genetic material. These are called double crossovers and provide valuable information to determine gene order.
- **Map Distances:** By analyzing the types and frequencies of offspring resulting from the three-point cross, we can calculate the map distances between the three genes in centimorgans.

Crossing Over:

It involves the exchange of genetic material between homologous chromosomes, resulting in the recombination of alleles and the creation of new genetic combinations in the offspring.

Process of crossing:

- Synapsis
- Formation of Chiasmata
- Exchange of Genetic Material
- Separation of Homologous Chromosomes

Significance of Crossing Over:

- Genetic Diversity
- Gene Mapping
- Maintaining Linkage
- Evolutionary Advantage

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S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –V Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Plant Breeding**
Topic Synopsis	▪ **Objectives of plant breeding** ▪ **Methods of crop improvement** ▪ **Introduction** ▪ **Selection** ▪ **Hybridization**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Understand the application of principles and modern techniques in plant breeding. 2. Explain the procedures of selection and hybridization for improvement of crops.
Pre Knowledge to be reminded	• Plant breeding is the science and practice of manipulating the genetic traits of plants to develop new and improved plant varieties with desirable characteristics. • It is a vital discipline in agriculture and horticulture, aiming to enhance crop productivity, quality, disease resistance, and other desirable traits.

Topic Synopsis

Plant Breeding:

Plant breeding is a science-driven agricultural practice aimed at improving the genetic makeup of plants to develop new and improved varieties with desirable traits.

Objectives of Plant Breeding:

The primary objectives of plant breeding are to address the challenges faced in agriculture and horticulture and to meet the increasing demands of a growing global population.

- Improved Yield
- Disease and Pest Resistance
- Abiotic Stress Tolerance
- Improved Nutritional Content
- Environmental Sustainability
- Adaptation to Different Agroecological Zones
- Agronomic Performance
- Market and Consumer Preferences

Methods of crop improvement:

- Crop improvement involves various methods and techniques aimed at developing new and improved plant varieties with desirable traits.
- These methods can be broadly classified into conventional breeding methods and modern biotechnological approaches.

Conventional Breeding:

- Selection
- Hybridization
- Backcrossing:
- Mutation Breeding
- Polyploidization

Genetic Engineering (Biotechnology):

- Recombinant DNA Technology
- Gene Editing (CRISPR-Cas9)
- RNA Interference (RNAi)
- Marker-Assisted Selection (MAS)
- Genomic Selection
- Embryo Rescue
- Somaclonal Variation
- Translocation Breeding
- Participatory Plant Breeding

Introduction:

It is a plant breeding technique that involves transferring specific genes or traits from one plant species to another closely related plant species.

Procedure of Introduction:

- Selection of Donor and Recipient Species
- Hybridization
- Backcrossing
- Selection
- Repeated Backcrossing and Selection
- Fixation

Advantages of Introduction:

- Genetic Diversity
- Trait Improvement
- Faster Trait Incorporation
- Conservation of Genetic Resources

Limitations of Introduction:

- Time and Effort
- Undesirable Traits
- Genetic Incompatibility
- Regulatory and Market Acceptance

Selection:

- Selection is one of the fundamental and oldest methods in plant breeding.
- It involves the process of choosing and propagating plants with desirable traits for the next generation, leading to the accumulation of the desired characteristics in a population.

Procedure of Selection:

- Phenotypic Evaluation
- Trait Identification
- Selection Criteria
- Selection Method
- Repetition and Successive election
- Genetic Gain

Advantages of Selection:

- Efficiency
- Genetic Diversity
- Adaptation
- Tailored to Breeding Goals
- Low Cost

Limitations of Selection:

- Slow Process
- Limited Genetic Pool
- Genetic Load
- Influence of Environment
- Undiscovered Traits

Hybridization:

- Hybridization is a plant breeding technique that involves controlled cross-pollination between two genetically distinct parent plants to produce hybrid offspring.
- The goal of hybridization is to combine desirable traits from the parent plants to create new and improved varieties.

Procedure of Hybridization:

- Selection of Parental Lines
- Emasculation
- Controlled Pollination
- Hybrid Seed Development
- Seed Harvesting and Germination
- Phenotypic Evaluation
- Selection and Advancement
- Repeated Cycles

Advantages of Hybridization:

- Hybrid Vigour (Heterosis)
- Combining Desirable Traits
- Uniformity
- Increased Yield Potential
- Reduced Inbreeding Depression

Limitations of Hybridization:

- Dependency on Parental Traits
- High Cost
- Seed Production Challenges
- Loss of Adaptation
- Hybrid Breakdown

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Teaching Synopsis 2021-22

Name Of The Lecturer	T.D. RAJASHEKAR
Program	B. Sc - BZC
Course (Paper)	**Paper –V Cell Biology, Genetics and Plant Breeding**
Name of the Topic	**Breeding, Crop Improvement and Biotechnology**
Topic Synopsis	▪ **Role of mutations** ▪ **Role of somaclonal variations** ▪ **Molecular breeding**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Understand the application of principles and modern techniques in plant breeding. 2. Explain the procedures of selection and hybridization for improvement of crops.
Pre Knowledge to be reminded	• Plant breeding is the science and practice of manipulating the genetic traits of plants to develop new and improved plant varieties with desirable characteristics. • It is a vital discipline in agriculture and horticulture, aiming to enhance crop productivity, quality, disease resistance, and other desirable traits.

Topic Synopsis

Role of Mutations in Crop Improvement:

Mutations play a crucial role in crop improvement as they introduce genetic variations that can lead to desirable traits in plants. This process, known as mutation breeding, has been used for decades to develop new crop varieties with improved characteristics.

- **Natural Mutations:** Some of these mutations result in beneficial traits, such as increased resistance to pests and diseases, improved yield, or enhanced nutritional content.
- **Induced Mutations:** These induced mutations create genetic diversity and can lead to the discovery of valuable traits that might not have occurred naturally.
- **Genetic Diversity:** This genetic diversity is crucial in breeding programs, as it provides a broader range of traits to select from and crossbreed with existing varieties.
- **Selective Breeding:** These selected plants become the parents of the next generation, and their progeny inherit the beneficial mutations.
- **Accelerated Crop Improvement:** Mutation breeding allows for rapid crop improvement compared to traditional breeding methods.

- Disease Resistance: Mutations can confer resistance to diseases and pests
- Abiotic Stress Tolerance: Certain mutations can make crops more resilient to abiotic stresses like drought, heat, or salinity.
- Improved Nutritional Content: Mutations can also enhance the nutritional content of crops.

Role of somaclonal variations in crop improvement:

Somaclonal variation refers to genetic changes or mutations that occur in plants derived from in vitro tissue culture, where plant cells or tissues are cultured in a controlled environment.

- Genetic Diversity
- Rapid Genetic Changes
- New Traits and Characteristics
- Source of Rare Traits
- Identifying and Exploiting Mutations
- Crop Rescue and Regeneration
- Stress Response and Adaptation
- Biotechnological Applications

Molecular breeding:

- Molecular breeding is a powerful approach in plant breeding and crop improvement that involves the use of DNA markers to assist in the selection and breeding of desirable traits.
- Two common types of DNA markers used in molecular breeding are RAPD (Random Amplified Polymorphic DNA) and RFLP (Restriction Fragment Length Polymorphism).

RAPD (Random Amplified Polymorphic DNA):

RAPD is a PCR (Polymerase Chain Reaction)-based technique that utilizes short, random primers to amplify specific regions of the genome.

- Random primers: RAPD uses short, single-stranded DNA primers of arbitrary sequences.
- PCR amplification: The genomic DNA is subjected to multiple cycles of heating and cooling, which allows the primers to anneal to complementary DNA sequences and facilitate DNA amplification.
- Polymorphic bands: RAPD markers produce bands on the gel, and the presence or absence of bands indicates genetic variation among individuals or populations.

Advantages of RAPD markers:

- Quick and cost-effective
- No prior sequence information needed

Limitations of RAPD markers:

- Lack of reproducibility
- Dominant markers

RFLP (Restriction Fragment Length Polymorphism):

RFLP is a DNA marker technique based on variations in the lengths of DNA fragments resulting from the use of restriction enzymes.

- Restriction enzymes: Genomic DNA is digested with specific restriction enzymes that cut the DNA at specific recognition sites.
- Gel electrophoresis: The digested DNA fragments are separated on an agarose gel based on their size using electrophoresis.
- Polymorphic bands: The presence of different fragment sizes indicates genetic variation between individuals or populations, and these variations are used as markers.

Advantages of RFLP markers:

- High resolution
- Co dominant markers

Limitations of RFLP markers:

- Time-consuming and costly
- Requires prior sequence information

Applications of markers:

- Both RAPD and RFLP markers have been valuable tools in molecular breeding and crop improvement.
- They help in identifying genetic variations associated with desirable traits, thereby assisting breeders in making more informed decisions during the selection process.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper –VI-C Plant Tissue Culture**
Name of the Topic	**Basic concepts of plant tissue culture**
Topic Synopsis	▪ **Plant tissue culture** ▪ **Totipotency** ▪ **Differentiation** ▪ **Infrastructure and Equipment**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Comprehend the basic knowledge and applications of plant tissue culture. 2. Identify various facilities required to set up a plant tissue culture laboratory.
Pre Knowledge to be reminded	• Plant Tissue Culture is the process of creating more plants from one plant. • Since the conventional breeding techniques could not fulfil the required demand of crops, tissue culture came around as a grand leap in breeding practices. • The technique exploits the property of totipotency of plant cell which means that any cell from any part of the plant can be used to generate a whole new plant.

Topic Synopsis

Plant tissue culture

Plant tissue culture is a technique used to propagate and grow plants in a controlled environment under sterile conditions. It involves the aseptic culture of plant cells, tissues, or organs on a nutrient medium supplemented with growth regulators, such as plant hormones.

History:

- The concept of plant tissue culture can be traced back to the late 19th century, when scientists first discovered that individual plant cells have the ability to regenerate into whole plants.
- However, it wasn't until the mid-20th century that tissue culture techniques were developed and refined.

Scope:

- Plant tissue culture has a broad scope and is used in various fields. Some key areas of its application include Micro propagation, Germplasm conservation, Genetic transformation, Disease elimination.

Significance:

- Plant tissue culture offers several advantages and holds great significance in various fields for Rapid propagation, Clonal propagation, Crop improvement, Conservation of plant biodiversity, Research and experimentation.
- Plant tissue culture has revolutionized the field of plant biology and has extensive applications in agriculture, horticulture, forestry, and biotechnology.

Totipotency:

- Totipotency refers to the ability of a single plant cell to give rise to an entire plant.
- Totipotent cells have the capacity to differentiate into all types of cells and tissues found in a mature plant.
- This characteristic is crucial in plant tissue culture, as it allows for the regeneration of whole plants from small plant parts, such as explants or individual cells.

Differentiation:

- Differentiation is the process by which cells become specialized and acquire distinct structures and functions.
- The differentiation process is influenced by various factors, including the composition of the culture medium, hormonal signals, and environmental cues.

Dedifferentiation:

- Dedifferentiation refers to the process in which specialized cells, such as root or leaf cells, revert back to an undifferentiated state.
- When cells dedifferentiate, they regain their totipotent properties and can subsequently give rise to different cell types and ultimately form a whole plant.

Redifferentiation:

- Redifferentiation occurs when dedifferentiated cells regain their specialized characteristics and form specific cell types.
- After dedifferentiation, the cells can undergo redifferentiation to give rise to various cell types, such as root, shoot, or vascular cells.
- The process of redifferentiation is controlled by specific signals and factors present in the culture environment.

Types of Cultures:

There are various types of cultures used in plant tissue culture, each serving specific purposes. Some common types of cultures include Callus Culture (Callus as explant), Suspension Culture (production of secondary metabolites), Organ Culture (plant organs as Explants), Meristem Culture and Protoplast Culture.

Infrastructure and equipment:

Setting up a tissue culture laboratory requires specific infrastructure and equipment to maintain a sterile and controlled environment.

Here are some essential components and equipment needed to establish a tissue culture laboratory

- Laboratory Space: A dedicated space is needed to house the tissue culture laboratory. The space should be designed to minimize contamination and should have controlled environmental conditions, including temperature, humidity, and lighting.
- Laminar Flow Hood: A laminar flow hood or laminar airflow cabinet is crucial for creating a sterile working area.
- Sterilization Equipment: Autoclaves or pressure cookers are required for sterilizing culture media, glassware, and other equipment.
- Culture Vessels and Containers: Various types of culture vessels are needed, including Petri dishes, test tubes, flasks, and containers for storage.
- Culture Media and Chemicals: Murashige and Skoog (MS) medium or Woody Plant Medium (WPM), a range of chemicals and reagents, such as plant growth regulators, vitamins, agar, and sugars, are needed for media preparation.
- Growth Chambers/Incubators: Growth chambers or incubators provide controlled environmental conditions, including temperature, light intensity, photoperiod, and humidity, to promote plant growth.
- Microscopes: High-quality microscopes with magnification capabilities are necessary for observing and analyzing plant cultures at various stages.
- pH Meter and Balances: A pH meter is required to measure and adjust the pH of culture media accurately.
- Tissue Culture Tools: Various tools are needed for plant manipulation and tissue culture procedures, including scalpels, forceps, pipettes, syringes, and sterile disposable materials.
- Storage and Cold Rooms: Proper storage facilities are essential for preserving culture media, chemicals, and plant materials.
- Safety Equipment: Personal protective equipment (PPE), such as lab coats, gloves, safety glasses, and face shields, should be available to ensure the safety of laboratory personnel.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper –VI-C Plant Tissue Culture**
Name of the Topic	**Sterilization techniques and culture media**
Topic Synopsis	▪ **Aseptic conditions** ▪ **Sterilization**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Comprehend the basic knowledge and applications of plant tissue culture. 2. Acquire a critical knowledge on sterilization techniques related to plant tissue culture.
Pre Knowledge to be reminded	• Sterilization is the removal of all forms of microorganisms from the surface of an object. It includes both spore and vegetative forms. • Sterilization is achieved by different physical and chemical methods in microbiology. Sterilization is classified into 2 types – physical sterilization and chemical sterilization. • Culture media is a gel or liquid that contains nutrients and is used to grow bacteria or microorganisms. They are also termed growth media.

Topic Synopsis

Aseptic conditions

Aseptic conditions are essential in a tissue culture laboratory to prevent contamination and maintain a sterile environment.

In a tissue culture laboratory, aseptic conditions are essential to ensure the successful growth and development of plant cells, tissues, and organs without the interference of unwanted organisms.

Sterilization:

- Sterilization is the process of eliminating or destroying all forms of microorganisms, including bacteria, viruses, fungi, and spores.
- Sterilization is divided into two types based on methods using for sterilization, Such as Physical and Chemical sterilizations.

Physical Sterilization:

Physical sterilization methods rely on physical processes, such as heat, filtration, and radiation, to achieve sterilization. These are following

- **Heat Sterilization:** Heat is one of the most common and effective methods of sterilization. Ex. Autoclaving and dry heat sterilization.
- **Filtration:** Filtration involves passing liquids or gases through filters with specific pore sizes to remove microorganisms and particles.
- **Radiation Sterilization:** Radiation-based methods utilize ionizing radiation to achieve sterilization. Ex. Gamma Irradiation, Electron Beam (E-beam) Radiation.

Chemical Sterilization:

Chemical sterilization involves the use of chemicals to kill or inactivate microorganisms. These chemicals can be gases, liquids, or vaporized substances.

- **Ethylene Oxide (ETO):** ETO gas is a commonly used chemical sterilant for heat- and moisture-sensitive materials.
- **Hydrogen Peroxide:** Hydrogen peroxide vapour or gas is another chemical sterilization method.
- **Glutaraldehyde:** Glutaraldehyde is a liquid sterilant commonly used for cold sterilization of heat-sensitive medical instruments and endoscopes.

Fumigation:

Fumigation involves the use of gaseous chemicals, such as formaldehyde or ethylene oxide, to eliminate microorganisms in the laboratory environment.

- The fumigant is released and allowed to disperse throughout the space, penetrating into hard-to-reach areas.
- Fumigation is typically carried out when the laboratory is empty and sealed off.

Wet sterilization (Autoclaving):

- Wet sterilization involves the use of autoclaves, which subject items to high pressure and temperature steam for a specific duration to kill microorganisms effectively.

Dry sterilization (Hot Air Oven):

- Dry sterilization techniques include the use of hot air ovens, which heat items to a high temperature for a specified time period, eliminating microorganisms.

UV Sterilization:

- Ultraviolet (UV) sterilization employs UV light to disinfect surfaces and equipment.
- UV light damages the genetic material of microorganisms, preventing their growth and reproduction.
- UV sterilization is commonly used for the sterilization of laminar flow hoods, culture vessels, and other equipment surfaces.

Ultra filtration:

- Ultra filtration is a technique used to sterilize liquid culture media and other solutions.
- It involves the use of filters with a specific pore size that can retain bacteria, fungi, and other microorganisms while allowing the passage of sterilized liquid.

Nutrient media:

Nutrient media used in tissue culture provide the essential nutrients and growth factors required for the growth and development of plant cells, tissues, and organs. The composition of nutrient media can vary depending on the specific requirements of the plant species or cell type being cultured.

Inorganic Chemicals:

- **Macronutrients:** Nutrient media typically contain macronutrients such as nitrates, phosphates, sulphates, and potassium salts.
- **Micronutrients:** Micronutrients include trace elements such as iron, zinc, manganese, copper, molybdenum, and boron.
- **Inorganic Salts:** Nutrient media often contain salts like calcium chloride, magnesium sulphate, and potassium dehydrogenase phosphate to provide essential ions for cell growth.

Organic Constituents:

Carbon Source: Nutrient media usually include a carbon source, such as sucrose or glucose, to provide energy for cell growth and metabolism.

- **Agar:** Agar is a gelatinous substance derived from seaweed and is commonly used to solidify the nutrient media for culturing plants in a solid form.
- **Other Organic Compounds:** Some nutrient media may contain specific organic compounds, such as organic acids, growth regulators or plant hormones, to support specific culture requirements.

Vitamins: Nutrient media may contain vitamins like thiamine (B1), pyridoxine (B6), niacin (B3), and myo-inositol, which are essential for plant growth and development.

Amino Acids: Some nutrient media may contain specific amino acids, such as L-glutamine, L-proline, or L-asparagine, which are important for protein synthesis and cell growth.

Murashige and Skoog culture medium:
Murashige and Skoog (MS) medium is a widely used culture medium for plant tissue culture, particularly for the growth and regeneration of plant cells, tissues, and organs.
It was developed by Murashige and Skoog in 1962.
Composition of MS Medium:
Macronutrients: MS medium typically includes macronutrients like nitrates, phosphates, and sulphates in the form of salts.
Micronutrients: MS medium includes micronutrients like iron, zinc, copper, manganese, molybdenum, and boron in the form of salts or complexes.

Vitamins: MS medium contains various vitamins that are essential for plant growth and development; Such as Thiamine (B1), Riboflavin (B2), Pyridoxine (B6), Nicotinic acid (B3), Pantothenic acid (B5), Folic acid (B9), Inositol and Biotin (B7).

Growth Regulators: MS medium is often supplemented with plant growth regulators, such as auxins and Cytokinins to promote cell division, differentiation, and organogenesis.

Carbon Source: MS medium usually contains a carbon source, typically sucrose, at a concentration of around 30 g/L.

Preparation

- Gather the necessary ingredients and equipment.
- Prepare a stock solution of macro- and micronutrients
- Prepare a stock solution of vitamins
- Adjust the final volume and pH,
- Add plant growth regulators
- Add the carbon source
- Mix the medium thoroughly to ensure uniform distribution of all components and autoclave the medium
- Allow the medium to cool to room temperature before use

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Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper –VI-C Plant Tissue Culture**
Name of the Topic	**Callus culture technique**
Topic Synopsis	▪ **Explant** ▪ **Explant inoculation methods** ▪ **Callus culture** ▪ **Initiation and maintenance of callus** ▪ **Callus subculture** ▪ **Soma clonal variations**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Demonstrate skills of callus culture through hands on experience. 2. Acquire a critical knowledge on sterilization techniques related to plant tissue culture.
Pre Knowledge to be reminded	• The culture of the Callus is the technique of growing tissues or cells in an artificial medium outside of the original organism. • This method is also known as micro propagation. • Culture media is a gel or liquid that contains nutrients and is used to grow bacteria or microorganisms. They are also termed growth media.

Topic Synopsis

Explant:

An explant refers to a small piece of plant tissue that is excised or removed from a plant and used as the starting material for initiating a culture.

The explant serves as the source of cells or tissues that can be grown and regenerated in vitro under controlled conditions.

There are several different types of explants commonly used in plant tissue culture, such as

- **Shoot Tip:** The shoot tip is the actively growing apical portion of a plant's shoot. It usually contains the apical meristem, leaf primordia, and young developing leaves.
- **Axillary Buds:** Axillary buds are small buds found in the leaf axils of plants. They are formed in the axile of a leaf where the leaf attaches to the stem.

- **Leaf Discs:** Leaf discs are circular sections of leaves that are excised and used as explants. They can be obtained from mature leaves and are often used for genetic transformation studies.
- **Cotyledons:** Cotyledons are the embryonic leaves of a seedling. They are usually fleshy or leaf-like structures that provide nutrients to the developing plant embryo.
- **Inflorescence and Floral Organs:** Inflorescence refers to the flowering portion of a plant, which includes flowers, buds, and associated structures. Floral organs such as petals, sepals, stamens, and pistils can be used as explants for tissue culture studies focused on flower development, genetic transformation.

Isolation and sterilization of explants:

- **Selection and Excision:** Select healthy and disease-free plant material for explant isolation. Excise the desired explants using sterile scalpels or razor blades.
- **Washing:** Place the excised explants in a container with sterile distilled water and gently swirl or rinse the explants to remove any surface debris or loosely attached contaminants.
- **Surface Sterilization:** Prepare a sterilization solution i.e. Sodium hypochlorite (bleach) or ethanol. Immerse the explants in the sterilization solution for a brief period, usually 30 seconds to a few minutes and rinse the explant with sterile distilled water to remove the sterilization solution.
- **Transfer to Culture Medium:** Using sterile forceps or tools transfer the sterilized explants onto the appropriate culture medium or agar plates.

Inoculation methods:

- **Direct Placement:** This method involves placing the explant directly onto the surface of the solid or liquid culture medium.
- **Embedding:** This method is commonly used for explants that benefit from partial or full embedding in the culture medium.
- **Agar Plug or Support:** In this method, the explant is placed on a small piece of solidified medium (agar plug) and transferred to the culture vessel.
- **Suspension Culture:** Suspension culture involves placing small explant pieces or cells in a liquid culture medium.
- **Bioreactor Systems:** Explants are placed in specialized bioreactors that provide controlled agitation, aeration, and nutrient supply.

Callus culture:

- Callus culture refers to the in vitro cultivation of undifferentiated mass of cells, called callus, derived from plant explants.
- Callus is a heterogeneous population of cells that can be stimulated to undergo organogenesis or somatic embryogenesis, leading to the formation of new shoots, roots, or whole plants.

Steps involved in callus culture:

- Explant Selection and Surface Sterilization
- Inoculation and Callus Initiation
- Callus Proliferation and Subculture
- Medium Optimization
- Differentiation and Organogenesis

Initiation and maintenance of callus:

- Select an appropriate explant and perform surface sterilization to remove contaminants.
- Transfer the sterilized explant onto a suitable culture medium, typically containing plant growth regulators such as auxins which promote callus formation.
- Incubate the explant in a controlled environment, providing appropriate temperature, light conditions, and nutrient supply.

Callus Growth Measurements:

- Monitor the growth of the callus over time by measuring its fresh weight or dry weight.
- Harvest a sample of the callus, gently blot excess moisture, and weigh it to determine its fresh weight.

Subculture:

- As callus grows and reaches an optimal size or density, it needs to be subcultured onto fresh culture medium to prevent overgrowth and maintain its viability.
- Subculture involves transferring a small portion of the actively growing callus to a new culture vessel with fresh medium.
- The frequency of subculture depends on the growth rate of the callus and can range from a few weeks to several months.

Somaclonal Variations:

- Somaclonal variations refer to genetic and phenotypic variations that arise spontaneously in callus cultures due to somatic mutations or epigenetic changes.
- These variations can result in changes in growth characteristics, morphology, physiology, or even the production of secondary metabolites.
- Somaclonal variations can be both desirable and undesirable.
- To minimize somaclonal variations, maintaining strict aseptic conditions, controlling culture parameters, and using appropriate subculture techniques are important.

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Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper –VI-C Plant Tissue Culture**
Name of the Topic	**Micro propagation**
Topic Synopsis	▪ **Morphogenesis** ▪ **Organogenesis** ▪ **Role of PGRs** ▪ **Somatic embryogenesis** ▪ **Synthetic seeds** ▪ **Acclimatization and hardening of plantlets** ▪ **Pathogen indexing**
Hours Required	**10**
Learning Objectives	On completion of this topic students will be able to 1. Demonstrate skills of callus culture through hands on experience. 2. Acquire a critical knowledge on sterilization techniques related to plant tissue culture.
Pre Knowledge to be reminded	• Micro propagation is the artificial process of producing plants vegetatively through tissue culture or cell culture techniques. • Micropropagation is the clonal propagation of plants in closed vessels under aseptic conditions. Inside the vessels, the plants are grown on culture media

Topic Synopsis

Morphogenesis:

- Morphogenesis refers to the biological process by which organisms develop their shape, form, and structures.
- It involves the coordinated growth, differentiation, and organization of cells, tissues, and organs to generate complex body structures and patterns.
- There are two different pathways by which new organs or tissues are formed in plant tissue culture.

1. **Direct Morphogenesis:** Direct morphogenesis refers to the direct differentiation and development of new organs or tissues from the explant without the intermediate formation of a callus. In this pathway, specific plant organs, such as shoots or roots, directly emerge from the explant.

2. **Indirect Morphogenesis:** Indirect morphogenesis involves the formation of a callus as an intermediate phase before the development of new organs. In this pathway, the explant first forms a mass of undifferentiated cells called callus, which can then give rise to shoots, roots, or other organs.

Organogenesis:

Plant organogenesis refers to the process by which distinct organs, such as leaves, stems, roots, flowers, and fruits, develop from undifferentiated cells or tissues in plants.

Stages of Organogenesis:

- Meristem Establishment
- Primordium Initiation
- Organ Differentiation
- Patterning and Growth
- Senescence and Abscission

Plant Growth Regulators (PGRs):

Plant Growth Regulators (PGRs), also known as plant hormones or phytohormones, play essential roles in regulating various aspects of plant growth, development, and physiological processes.

Role of PGRs:

- Cell Division and Growth
- Cell Differentiation and Morphogenesis
- Tropic Responses
- Reproductive Development
- Stress Responses
- Senescence and Aging

Somatic Embryogenesis:

Somatic embryogenesis is a process in plant tissue culture where somatic cells are induced to form embryos.

- Explant Selection
- Callus Induction
- Callus Formation
- Selection and Subculture
- Proliferation
- Maturation Medium
- Embryo Formation
- Germination Medium
- Rooting and Acclimatization

Synthetic seeds:

- Synthetic seeds, also known as artificial seeds, are encapsulated structures that resemble true seeds but are produced through tissue culture techniques.
- They are composed of somatic embryos or other plant propagules encapsulated within a protective coating, allowing them to be handled and stored like conventional seeds.

Preparation of synthetic seeds:

- Production of Somatic Embryos
- Encapsulation
- Development and Maturation
- Dormancy Induction
- Storage and Germination

Applications of Synthetic Seeds:

- Clonal Propagation
- Germplasm Preservation
- Distribution and Transportation
- Crop Improvement

Greenhouse hardening unit operation and management:

- Greenhouse hardening refers to the process of gradually acclimatizing plants grown in a controlled environment, such as a greenhouse, to the external conditions before they are transplanted into the field or garden.
- This process helps plants transition from the protected environment of the greenhouse to the harsher conditions outside, reducing the risk of transplant shock and improving their chances of survival.

Operation and management:

- Timing and Planning
- Gradual Exposure
- Temperature and Humidity Control
- Watering and Fertilization
- Pest and Disease Management
- Shelter and Shade
- Monitoring and Evaluation

Acclimatization and hardening:

- This is a processes transitioning from a controlled laboratory or greenhouse environment to the field or commercial production.
- These processes help the plantlets adapt to the external conditions, develop stronger root systems, and improve their chances of survival and successful growth.

Need for Acclimatization and Hardening of Plantlets:

- Environmental Adaptation
- Root Development
- Stress Tolerance

Process of Acclimatization and Hardening

- Gradual Transition
- Reduced Environmental Control
- Ventilation and Air Circulation
- Watering and Fertilization
- Pest and Disease Managemen

Packaging and Exports of Plantlets:

When it comes to packaging and exporting plantlets, it is crucial to follow relevant regulations and ensure the plants are properly packaged to maintain their health and vitality during transportation.

Pathogen indexing:

- Pathogen indexing, specifically for viruses, is a crucial process in the field of infectious disease research and epidemiology.
- It involves the identification, classification, and characterization of different viral strains or species present in a particular population or environment.

Significance:

- Disease prevention
- Quality assurance
- Genetic purity
- Mass production

Methods:

- **Biological indexing:** This method involves inoculating indicator plants, which are known to be susceptible to specific viruses, with plant extracts or sap from tissue-cultured plants.
- **Molecular techniques:** Polymerase Chain Reaction (PCR) and other molecular methods can detect the presence of viral DNA or RNA in plant tissues.

Advantages:

- Early detection
- High sensitivity and specificity
- Rapid results
- Cost-effective

Applications in plant tissue culture:

- Stock plant selection
- In vitro conservation
- Production of disease-free plants
- Germplasm exchange
- Certification programs

Signature of the Lecturer

S.G.K Government Degree College – Vinukonda

Department of Botany

Teaching Synopsis 2021-22

Name Of The Lecturer	G. MANI KUMAR
Program	B. Sc - BZC
Course (Paper)	**Paper –VI-C Plant Tissue Culture**
Name of the Topic	**Applications of plant tissue culture**
Topic Synopsis	▪ **Germplasm conservation** ▪ **Cryopreservation methods** ▪ **Crayoprotectants** ▪ **Production of secondary metabolites** ▪ **Transgenic plants** ▪ **Gene transfer methods** ▪ **Plant transformation techniques and bioreactors**
Hours Required	**12**
Learning Objectives	On completion of this topic students will be able to 1. Acquire a critical knowledge on sterilization techniques related to plant tissue culture. 2. Understand the biotransformation technique for production of secondary metabolites.
Pre Knowledge to be reminded	• Tissue culture allows for the rapid and large-scale production of identical plant clones from a single parent plant. • Tissue culture provides a means to preserve the genetic diversity of plants through in vitro conservation.

Topic Synopsis

Germplasm conservation:

- Germplasm conservation, also known as plant genetic resource conservation, is the process of preserving and maintaining the genetic diversity of plant species for future use.
- It involves the collection, characterization, and storage of plant genetic material, including seeds, embryos, pollen, tissues, and cells.

Importance of germplasm conservation:

- Preservation of genetic diversity
- Adaptation to changing environments
- Sustainable agriculture

Types of conservation methods:

- **In situ conservation:** This type of conservation focuses on the preservation of plants in their natural habitats. Ex. National parks and reserves.
- **Ex situ conservation:** Ex situ conservation involves the preservation of plant genetic resources outside their natural habitats. It includes botanical gardens, arboreta, seed banks, field gene banks, and living plant collections.
  - **A. Seed banks:** Seed banks store seeds of different plant species under controlled conditions, usually at low temperatures and low humidity, to maintain their viability and longevity.
  - **B. Field gene banks:** Field gene banks conserve plants in the form of living collections, such as in vitro cultures, field plots, or orchards.

Cryopreservation:

- Cryopreservation is a method of germplasm conservation that involves the storage of plant tissues, cells, or embryos at ultra-low temperatures (-196°C) in liquid nitrogen.

Cryopreservation methods:

1. **Slow growth storage:** In this method, plant materials, such as seeds or shoot cultures, are stored under low-temperature conditions (typically 4-10°C) that slow down their growth rate.
2. **Crayoprotectants-based techniques:** Crayoprotectants are chemical substances that protect cells and tissues from damage during freezing and thawing processes.
3. **Encapsulation-Dehydration:** This method involves encapsulating small plant tissue samples in a desiccated matrix, such as calcium alginate beads, and then dehydrating them.

Applications of Cryopreservation:

- Conservation of plant genetic resource
- Facilitating germplasm exchange
- Micropropagation optimization
- Disease eradication

Limitations of Cryopreservation:

- Species and tissue-dependent
- Genetic stability
- Regeneration challenges
- Cost and infrastructure requirements

Crayoprotectants:

Crayoprotectants are essential components of cryopreservation protocols. They help protect plant cells and tissues from freezing-induced damage during the cryopreservation process.

- Dimethyl Sulfoxide (DMSO)
- Glycerol
- Ethylene Glycol
- Sucrose
- Polyethylene Glycol (PEG)
- Plant Protective Agents

Plant transformation techniques:

- Plant transformation techniques are methods used to introduce foreign DNA into plant cells, leading to the generation of transgenic plants.
- These techniques are crucial for various applications, including crop improvement, genetic engineering, and production of recombinant proteins.

Transform methods:

- **Agrobacterium-mediated Transformation:** Agrobacterium-mediated transformation involves the use of modified Agrobacterium strains carrying the desired DNA construct (transgene) to deliver it into plant cells. This technique is widely used for a broad range of plant species and offers high transformation efficiency.
- **Biolistic (Particle Bombardment) Transformation:** Biolistic transformation involves the delivery of DNA-coated micro projectiles into plant cells using a particle gun or gene gun. High-pressure gas is used to accelerate the particles, which penetrate the plant cell wall and plasma membrane, allowing the foreign DNA to enter the cells.
- **Electroporation:** Electroporation involves applying an electric field to plant cells, which temporarily disrupts the cell membrane, creating small pores. Foreign DNA is introduced into the cells and can enter through these pores.
- **Floral Dip:** The floral dip method is a simple and rapid transformation technique commonly used for Arabidopsis thaliana, a model plant species. It involves immersing the entire flowering plant into a suspension of Agrobacterium cells carrying the desired DNA construct.

Bioreactors:

- Bioreactors in plant tissue culture refer to controlled environments where plant cells, tissues, or whole plants are cultured for mass propagation, production of secondary metabolites, or recombinant protein expression.
- Bioreactors provide optimal conditions for plant growth and can be designed to accommodate specific requirements.

Types of Bioreactors:

- **Stirred Tank Bioreactors:** Stirred tank bioreactors are commonly used for large-scale plant cell suspension cultures. They consist of a vessel equipped with agitation systems, temperature control, pH control, and aeration.
- **Temporary Immersion Bioreactors (TIBs):** TIBs are a type of bioreactor that involves periodic immersion of plant tissues or explants in liquid medium. The immersion and subsequent draining of the medium provide efficient nutrient supply and gas exchange to the tissues.
- **Air-Lift Bioreactors:** Air-lift bioreactors are designed to provide a continuous circulation of culture medium using air bubbles. They consist of a central draft tube

and an outer annular section. The rising air bubbles create a flow of medium, ensuring efficient nutrient delivery and gas exchange.

- **Photoautotrophic Bioreactors:** Photoautotrophic bioreactors utilize light as the energy source for plant growth. They are equipped with artificial lighting systems to provide the necessary light intensity and spectrum.
- **Perfusion Bioreactors:** Perfusion bioreactors involve the continuous or semi-continuous supply of fresh culture medium while removing spent medium. They provide a steady supply of nutrients and removal of waste products, allowing for prolonged cultivation of plant cells or tissues.

Production of secondary metabolites:

- It is the process of cultivating plants or plant cells under controlled conditions to maximize the yield of desirable compounds with pharmaceutical, agricultural, or industrial significance.

Optimization of Yield:

- **Selection of plant species:** Choosing plant species known for high secondary metabolite production is a key factor in optimizing yield.
- **Tissue culture techniques:** Plant tissue culture methods, such as cell suspension cultures or organ cultures, can be used to produce secondary metabolites in a controlled environment.
- **Genetic engineering:** Genetic modification techniques can be employed to enhance the production of secondary metabolites by introducing or over expressing genes responsible for their biosynthesis.
- **Elicitation and stress factors:** Applying specific elicitors or stress factors, such as hormones, chemicals, or physical stresses, can stimulate secondary metabolite production.

Commercial Aspects:

- **Market demand:** The commercial viability of secondary metabolite production depends on the demand for the specific compound.
- **Scale-up considerations:** Moving from lab-scale to commercial-scale production requires optimizing the bioprocess, including choosing suitable bioreactor systems, developing efficient purification methods, and implementing cost-effective downstream processing.
- **Cost analysis:** Assessing the cost of production, including raw materials, labor, infrastructure, and regulatory compliance, is essential to determine the economic feasibility of commercial production.

Applications:

- **Pharmaceuticals:** Secondary metabolites often possess medicinal properties and can be used as drugs or as leads for drug discovery. Examples include the production of alkaloids, flavonoids, and terpenoids.
- **Nutraceuticals and functional foods:** Secondary metabolites with nutritional or health-promoting benefits, such as antioxidants or phytochemicals, can be utilized in the production of nutraceuticals and functional foods.
- **Agricultural applications:** Secondary metabolites can have agricultural applications, including natural pesticides, insect repellents, or plant growth regulators.

Limitations:

- Low yield
- Genetic variability
- Regulatory challenges
- Complexity of extraction and purification

Transgenic plants:

- Transgenic plants, also known as genetically modified (GM) plants, are organisms that have been genetically engineered to introduce specific genes from other organisms.
- The process of creating transgenic plants involves isolating and manipulating specific genes from one organism, which can be a plant, animal, or even a microorganism, and introducing them into the genome of the target plant.

Applications:

- Pest and disease resistance
- Herbicide tolerance
- Improved nutritional content
- Extended shelf life
- Environmental adaptation

Gene transfer methods:

- **Agrobacterium-mediated transformation:** Agrobacterium tumefaciens, a soil bacterium, naturally transfers a segment of its DNA, known as T-DNA, into plant cells, causing a plant disease called crown gall.
- **Biolistic or particle bombardment:** Tiny particles, such as gold or tungsten, are coated with the desired DNA and then propelled into target cells using high-pressure gas or an electric discharge.
- **Electroporation:** Electroporation involves applying a brief electric pulse to cells, creating temporary pores in their membranes.
- **Microinjection:** In this method, a fine glass needle is used to physically inject DNA directly into the nucleus or cytoplasm of target cells.
- **Viral vectors:** Viruses can be modified to act as vectors for gene transfer.

- **Liposome-mediated transfection:** Liposomes are tiny lipid vesicles that can encapsulate DNA or RNA.

BT cotton:

- BT cotton refers to cotton plants that have been genetically modified to express a protein derived from the soil bacterium Bacillus thuringiensis (BT).
- This protein, called BT toxin, is toxic to certain pests that commonly attack cotton crops, particularly the larvae of certain moth and butterfly species, such as the cotton bollworm.

Advantages:-

- Reduced pesticide use
- Pest control effectiveness
- Increased yields

Signature of the Lecturer