BOT 102 (GENERAL BOTANY)

Section 1: Introduction

- The study of living organisms (Plant and Animals) is called as BIOLOGY.
- The study of plants is called as **BOTANY**
- The study of animal is called as **ZOOLOGY**
- Plants are green in color because of the presence of chlorophyll.
- Fungi are also belongs to plant, but fungi do not have chlorophyll.
- Thallophyta, Bryophyta, Pteridophyta, Gymonosperms and Angiosperms are the different groups of the plants.

We study plants because:

- Plants produce oxygen. We breathe oxygen. We cannot live without oxygen.
- Plants convert Carbon di oxide gas into sugars through the process of photosynthesis.
- Every things we eat comes directly or indirectly from plants.
- Plants provide fibres for paper or fabric.
- Many chemicals produced by the plants used as medicine.
- Study of plants science helps to conserve endangered plants.
- Study of plants science helps to learn more about the natural world.
- Study of plants science helps to enhance the abilities of plants to provide more food, medicines and others useful things.
- Plants can be a source of biofuels. Sugars, starches and cellulose can be fermented into ethanol. Ethanol is used as fuel.

Different braches of Botany:

Morphology	Study of external structure of plant.
Anatomy	Study of external internal structure of plant.
Histology	The study of cells and tissues with the help of microscope.
Cytology	The study of the cells.
Plant Physiology	The study of various vital activities of the plant.
Taxonomy	Study of the classification of the plants.
Ecology	Relations of organisms to one another and to their physical surroundings.
Plant Geography	Distribution of plants on the earth.
Genetics	The study of heredity and variations.
Plant breedIng	The development of improved varieties of plants.
Embryology	The study of embryos and their development.
Economic Botany	The study of the relationship between people and plants.
Plant Pathology	The study of the different types of disease of plants, their symptoms, causal agent and methods of control.
Biochemistry	Study of chemistry of plants.
Biophysics	Study of plant activities on the basis of principles of physics.
Molecular Biology	Study of biochemistry at molecular level.
Palynology	Study of pollen grains.
Agronomy	Study of the crop plants.
Horticulture	The study of flowering and fruiting plants.
Pharmacognosy	Study of the medicinal plants.
Microbiology	Study of microorganisms (viruses, bacteria, fungi, microalgae and protozoa).
Genetic Engineering	Adding, removing or repairing part of genetic material, thereby changing the phenotype of organism as desired.

Thallophyta:

- The plants which do not have Root, Stem Leaf, Flowers, Fruits and Vascular Tissue is called as Thallophyta.
- Thallophyta means thallus like body.
- A plant body which do not have Root, Stem Leaf, Flowers, Fruits, and called as thalloid body.
- The Vascular Tissue completely absent in Thallophyta.
- The Algae and Fungi belongs to the group Thallophyta.

ALGAE:

- Chlorophyll bearing thallophytic plant is called as ALGAE.
- There are about 100, 000 species of algae occurs in the world.
- Algae mainly occurs in water likes ponds, river, ocean, lakes. Many algae are edible.
- *Chlorella* is an example of edible algae.
- Many Algae is source of medicine.
- *Laminaria* is common example of medicinal algae.
- *Volvox, Chlorella, Spirogyra, Ulothrix* are the common examples of Algae.

FUNGI:

- The thallophytic plant which donot have chlorophyll is called as Fungi.
- *Penecillum, Mucor* and *Aspergillus* are the common example of fungi.
- Some fungi are edible like Mushroom.
- The Antibiotics Penecillin used in medicine obtained from *Penecillium.*
- Some fungi causing disease in plants and animals.
- May skin infection in human is due to fungi.

BRYOPHYTA:

- Bryophyta also possess thalloid body.
- True vascular tissue is absent in Bryophyta.
- Common example of Bryophyta is *Marchantia*.
- There are about 19000 species of Bryophyte occurs in world.
- Bryophytes reproduce asexually and sexually.
- Sexual reproduction takes place by fusion of male gametes and females gametes.
- The haploid or gametophyte or n is the major phase in the life cycle of a Bryophytic species.
- The Bryophytic plants mostly occurs near water or wet area.
- *Funaria* is a bryophytic plants occurs in Saudi Arabia

PTERIDOPHYTA:

- Pteridophytic plant possess Root, Stem, Leaf and Vascular Tissue.
- Common example of Pteridophyta is *Pteris*.
- There re about 11000 species of Pteridophyta occurs in different parts of the world.
- The Sexual reproduction in Pteridophyta takes place with the help of spores.
- The diploid or sporophyte or 2n is the major phase in the life cycle of a Pteridophytic species.
- *Pteris* is a Pteridophytic plants occurs in Saudi Arabia.

GYMNOSPERM:

- Gymnosperm possess well developed Root, Stem, Leaf and Vascular Tissue.
- The common example of Gymnosperm is *Cycas* and *Pinus*
- There are about 1100 species of Gymnosperm occurs in the different parts of the world.
- The reproductive organs in Gymnosperm are called as cones.

- The diploid or sporophyte or 2n is the major phase in the life cycle of a Gymnosperm species.
- Gymonosperms are seed bearing plants.
- Seeds are naked in Gymonosperms.
- *Welwitschia* is a member of Gymnosperm occurs in desert condition.
- *Sequoiadendron giganteum* is a largest tree belongs to the Gymnosperms.
- *Juniperous* is a Gymnospermic plants occurs in Saudi Arabia

ANGIOSPERMS:

- The flowering plants are called as Angiosperms.
- There are two types of Angiospermic plants: Monocot Plants and Dicot Plants.
- Dates, Rice and Grass is a Monoct Plants.
- Mint and Cashew is a dicot plant.
- There are about 400,000 Angiosperms plants occurs in different parts of the world.
- Flowering plants occurs in all the climatic condition such as very cold to very hot climatic condition.
- *Wolfia* is a smallest Angiosperms.
- There are several Angiospermic plants which occurs in water called as aquatic plants.
- *Nymphea* is an example of aquatic plants.
- *Agave* is a common example of monot angiosperms occurs in desert condition.

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BOT 102 (GENERAL BOTANY)

Section 2: Cyto-Genetics

- The study of the cells is called as CYTOLOGY.
- The Cell is the basic structural, functional and biological unit of all known living organisms.
- Microscope is an optical instrument used for viewing very small objects like animal or plant cells.
- There are seven characteristics of Life:
  - Living Things are Composed of Cells.
  - Living Things Have Different Levels of Organization.
  - Living Things Use Energy.
  - Living Things Respond To Their Environment.
  - Living Things Grow.
  - Living Things Reproduce.
  - Living Things Adapt To Their Environment.

Cell Theory

- The cell is the basic unit of structure and function of all living things.
- All living things are composed of one or more cells.
- All cells come from pre-existing cells.
- The cells of all living things carry on similar chemical activities.
- All cells carry on their metabolic activities in organelles.

Types of cells

- There are two types of cells Prokaryotic Cell and Eukaryotic Cells

Prokaryotic Cells

- The Prokaryotic cells do not have a well-defined nucleus and cell organelles.
- The Prokaryotic cells is the oldest cell types.
- The Prokaryotic cells are smaller and simpler than eukaryotic cells.
- Bacteria is the example of the Prokaryotic cells.

Eukaryotic cells

- The eukaryotic cell have nucleus with nuclear membrane and cell organelles.
- The eukaryotes are organisms that have a nucleus in each cell.
- The nucleus of the eukaryotic cell contains DNA.
- The eukaryotic cell have a cell membrane.
- The eukaryotic cell are generally larger and more complex than prokaryotic cells.
- The eukaryotic cell have complex membrane bound organelles like mitochondrion, chloroplast, Golgi apparatus, etc.
- Plants, animals, fungi possesses the eukaryotic cell.

Virus:

- Viruses are in between living organism and nonliving things.
- Viruses are very small infective agent consists of a nucleic acid molecule in a protein coat.
- Virus do not exhibit characteristics of life outside the host cell.
- Viruses are harmful, causing disease in plants and animals.

Cell

- The Cell is the basic structural, functional and biological unit of all known living organisms.

Cell wall

- Cell wall is present only in plant cells.
- Cell wall is absent in animal cell.
- Cell wall consists of Primary Cell Wall, Middle Lamella and Secondary Cell Wall.
- Middle Lamella is mostly chemically made up of pectin.

Plasma Membrane

- The plasma membrane or cell membrane's function is to form a barrier between the cell's inner and outer environment.
- The plasma membrane selectively permeable meaning that it allows certain materials to pass through and prevents the movement of other through it.
- The plasma membrane is composed of a phospholipid bilayer with protein molecules (integral proteins) embedded within in the bilayer.
- According to the fluid-mosaic model of plasma membrane, the membrane is literally a mosaic of protein and lipid molecules that have the ability to move from area to area on the surface of the membrane.

Cytoplasm

- A watery solution of the cell that contains the cell organelles, salts, organic molecules, enzymes.

Cytoskeleton

- The cytoskeleton is a "framework" that supports the cell membrane and other cell structures within the cytoplasm of Eukaryotic cells.
- The cytoskeleton is made up of Endoplasmic Reticulum, Microfilaments and Microtubules.
- **Endoplasmic Reticulum:** The Endoplasmic reticulum is a membranous tubules within the cytoplasm of a eukaryotic cell.
- **Microfilaments:** The Microfilaments are threadlike structures made up of the protein actin.
- **Microtubules:** The Microtubules are hollow structures made up of proteins known as tubulins. It maintain cell shape. Microtubules are important in cell division.

Plastid

- Plastids are double membranous cellular organelles found only in the cytoplasm of the plant cells.
- Plastid are meant for photosynthesis and storage.
- Plastids are of three types - Chloroplasts, Chromoplasts and Leucoplasts.

Chloroplasts

- Chloroplast occurs in the cytoplasm of the cell.
- Chloroplast are elongated disc shaped cell organelles which contains chlorophyll.
- The chloroplast are double membrane bound organelles.
- The chloroplast are the site of photosynthesis.
- The chloroplast contains flattened sacs called thylakoids.
- The thylakoids are stacked one on top of another.
- A stack of thylakoids is called a granum.
- The space in between the grana is called the stroma.
- Chlorophyll is present in green plants which helps them make food by the process of photosynthesis.
- Green plants takes carbon dioxide (CO_2) from the air, and water (H_2O) from the soil. The plants combine the CO_2 with the H_2O to make the sugar (Glucose ($C_6H_{12}O_6$).
- Photosynthesis is the conversion of light energy to chemical energy by chlorophyll in chloroplasts.

Chromoplasts

- Chromoplasts are plastids which are found in fruits and are yellow, orange and red in color.

Lecuoplasts

- Lecuoplasts are colorless plastids. They found in roots, seeds and underground stems.

Mitochondria

- The mitochondria is a double membrane structure.
- The mitochondria occurs in cytoplasm.
- The inner membrane of the mitochondria has finger like projection called cristae.
- The mitochondria produces energy in the form of ATP (Adenosine Tri Phosphate).
- The mitochondria is also called as power house of the cell.

Golgi Apparatus

- The Golgi apparatus is single membranous cell organelles occurs in cytoplasm.
- The Golgi apparatus appears as a series of flattened, stacked, membrane sacs.
- The Golgi apparatus is the center for synthesis of protein.

Ribosomes

- Ribosomes are found freely floating in the cytoplasm and nucleus or bound to Endoplasmic Reticulum.
- Ribosomes are the site for protein synthesis of the cell.
- Ribosomes are composed of two subunits, a small subunit and a large subunit.
- Prokaryotic cells have smaller ribosomes (70s).
- Eukaryotic cells have the larger ribosomes (80s).

Endoplasmic Reticulum

- The endoplasmic reticulum (ER) is a series of single membrane channels which run throughout the cytoplasm of the cell.
- There are two types of ER (Smooth ER and Rough ER).
- The smooth endoplasmic reticulum (SER) is free of ribosomes and functions in lipid synthesis and metabolism of carbohydrates.
- The rough endoplasmic reticulum (RER) has ribosomes bound to its outer membrane layer and is the active site of protein synthesis.

Vacuole

- Vacuoles are storage areas of the cell.
- Vacuoles also serve as the site of chemical digestion.
- Vacuoles in animal cells are often small.
- The plant cells have a large centrally located vacuole which contains water and dissolved solutes.

Nucleus

- The Nucleus is enclosed in an envelope which is a double membrane structure.
- The Nucleus has pore in the membranes which allow the movement of materials in and out of the nucleus.
- A watery solution of the nucleus is called as nucleoplasm.
- The Nucleus contains DNA and proteins in the form of loose threads called chromatin.
- The nucleolus is a structure composed of RNA located in the nucleoplasm. There may be more than one nucleolus present in a nucleus. The nucleolus produces ribosomes.
- The overall function of the nucleus is the regulation of cellular activities.

Gene

- Genes passes genetic information from one generation to another generation.
- Genes are made up of DNA.
- Genes lies on Chromosomes.
- There are large number of genes occurs in each cell on each chromosomes.

Chromosomes

- The chromosomes are the thread-like structure of nucleic acids and protein found in the nucleus of the living cells, carrying genetic information in the form of gene.
- The number of chromosome can be counted in the metaphase stage of cell division.
- Haploid Number (n): The number of chromosomes comprising one set.
- Diploid Number (2n): The number of chromosomes in a cell containing two sets.

Human	Haploid (n)= 23 Diploid (2n)=46
Dates	Haploid (n)= 14 Diploid (2n)=28

- Chromosomes exist in homologous pairs in diploid cells.

DNA (Deoxyribo Nucleic Acid)

- DNA is the genetic materials of living organism.
- The model of DNA was given by James Watson and Francis Crick in 1962.

DNA Replication

- The process of producing two identical DNA from one original DNA is called as DNA replication.
- DNA replication occurs during the cell division.

Self-Replicating Cell Organelles

- Mitochondria and Plastid contains their own DNA and capable of self-replication in the cells.

Cell Division

- Production of two or more cells from one cell is called as cell division.
- Cell division is required for the growth of the living organism.
- The process of cell division completes in two steps:
- Karyokinesis:– the karyokinesis is process of division of the nucleus.
- Cytokinesis:– the cytokinesis is the process of the division of the cytoplasm.
- There are two types of cell division (Mitosis cell division and Meiosis cell division).

Mitosis Cell Division

- The Eukaryotic cell divides by a process called as Mitosis cell division.

The cell cycle:

- The cells divide along with own time frame called Cell Cycle.
- The cell cycle consists of the following three steps:
- G1 (Gap 1) Phase:- In this phase, the cell performs its normal function, cells do not divide in this phase, this phase is called as resting phase.
- S (Synthesis) Phase:- In this phase, the cell actively duplicates its DNA in preparation for division.
- G2 (Gap 2) Phase:- In this phase, the amount of cytoplasm and cell organelles increases in preparation for division.

- M Phase or Mitotic phase:- The actual division of cell occurs in the Mitotic or M phase. The M phase consists four different phase which are Prophase, Metaphase, Anaphase, Telophase.
- The Mitosis cell division occurs in somatic or body cells.
- The words somatic comes from Soma. The meaning of Soma is body.
- The division of replicated chromosomes in one nucleus to form two genetically identical 'daughter nuclei'.
- One cell after Mitosis cell division gives two cells (the new cells are called as daughter cells).
- Each "daughter" nucleus has the same number or set of chromosomes that the "parent" nucleus had.
- Daughter cells are genetically identical.
- Chromosome number does not change after mitosis division.

Meiosis Cell Division

- The Meiosis cell division occurs in reproductive cells.
- One cell after Meiosis cell division gives four daughter cells.
- Chromosome number changed after Meiosis cell division.
- Meiosis cell division is similar in many ways to mitosis cell division. But there are several differences in between Mitosis and Meiosis cell division.
- There are two process that is Meiosis I and Meiosis II involves in Meiosis cell division.
- As a results of Meiosis cell division, one parent cell gives four daughter cells.
- As a result of Meiosis cell division, the chromosomes number reduced to half in the daughter cells.
- Meiosis cell division completes in two steps (Meiosis I and Meiosis II).
- The Meiosis I completes in five steps (Meiosis I Prophase I, Meiosis I Metaphase I, Meiosis I Anaphase I, Meiosis I Telophase I).
- The Meiosis I competes in five different stages (Leptotene, Zygotene, Pachytene, Diplotene, Dikinesis).
- In Leptotene the chromosome starts condense.
- In Zygotene, Synapsis begins. Synapsis is the pairing of two homologous chromosomes.
- In Pachytene, a bivalent formed, and crossing over occurred. Bivalent is the structure formed after completion of pairing of two homologous chromosomes.
- In Diplotene, synaptonemal complex dissociates. The synaptonemal complex is a protein that forms between homologous chromosomes (two pairs of sister chromatids) during meiosis and is thought to mediate chromosome pairing, synapsis, and recombination.
- In Diplotene stage, the chiasmata formed. The Chaismata is the point where two homologous non-sister chromatids exchange genetic material during chromosomal crossover in meiosis.
- In this Dikinesis, crossing over completed.
- After completion of Prophase I of Meiosis I, the chromosomes reach to equatorial plane of the cells. The chromosome attached with spindle fiber.
- After completion of Prophase 1 of Meiosis I, the dividing cells enters into Anaphase I of Meiosis I. In Anaphase I of Meiosis I, shrinkage of spindle fiber starts. As a results each half set of the chromosomes starts to move towards two different poles.
- After Anaphase I of Meiosis I, the dividing cell enters into Telophase I of Meiosis I. In this phase shrinkage of spindle fiber completes. As a results two nuclei formed in one cell.
- After completion of Telophase I of Meiosis I, the diving cells enters into Meiosis II. The process of the Meiosis II is just similar to Mitosis cell division.
- Reduction of Chromosome number occurs in Meiosis I division.

GENETICS

- The study of hereditary and variations is called as Genetics.
- Gregor Mendel (Year 1860) an Austrian Monk, was interested in figuring out how heredity was determined in plants and animals.
- Gregor Mendel selected pea plants for his experiment.
- Seven pairs of contrasting traits selected by Mendel. And made two types of crosses in between the different traits of pea plants.
- Gregor Mendel selected quantitative (Mathematical) approach to collect data.

Monohybrid Crosses

- **Trait:** A trait is a specific characteristic, such as seed color or plant height, that varies from one individual to another.
- Monohybrid cross is a cross between two individual having single contrasting traits.
- Dihybrid cross is a cross between two individual having two different traits.
- The pea plants were cross pollinated.
- **Cross pollination:** The transfer of pollen from an ANTHER of a flower of one plant to a STIGMA of a flower of another plant). The offspring were called as F1 or "first filial" generation.

Monohybrid Crosses: The Principles of Dominance and Segregation

- Results of Mendel's F1 Crosses: When Mendel crossed the plants with contrasting characters for the same trait (for example all round), the resulting offspring had only one of the characters in F1 generation.
- But when the population of F1 generation were self-pollinated, the resulting offspring had characters of two different traits in the ratio of 3: 1.
- From these, Mendel concluded that:
    - Each Phenotype (traits or morphological characters to which we can see) of an organism is governed by a specific Factor.
    - Each organism has 2 factors for each of traits (Factors = Allelles = Genes), one trait is dominant and other trait is recessive. Or it may be said that one factor is dominant and other factor is recessive.
    - The two factors segregates at the time of gamete formation.

Dihybrid Crosses: (The Law of Segregation or Independent Assortment)

- For dihybrid crosses, Mendel selected two different characters (for example seed shape Round and seed color Yellow, and seed shape Wrinkled and seed color Green). The F1 generation produced all round yellow seeds.
- But F2 generation produced four different types of offspring in the ratio of 9:3:3:1.
    - 9 seed shape Round and seed color Yellow
    - 3 seed shape Round and seed shape Green
    - 3 seed shape Wrinkled and seed shape Yellow
    - 1 seed shape Wrinkled and seed color Green

- From the results of dihybrid cross, Mendel concluded that the two dominant and recessive factors remains in a pair but segregates at the time of gamete formation.

FACTOR WAS LATER PROVED AS GENE.

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Section 3: Plant Structure (Morphology)

- Study of external structure of a plant is called as Plant morphology.
- There are two types of systems in plants. They are root system and Shoot system.
- Root system anchors the plant, absorbs water and minerals from soil, storage the food, and sometimes helps in propagation or asexual reproduction.
- The Shoot system consists of stem, leaf and reproductive parts. The Stem supports and places leaves, transports H_2O and nutrients. The main function of Leaves is photosynthesis. The Reproductive structures of Angiospermic plant is Flowers.
- A seed is a sporophyte embryo with its own food supply in a protective coat.
- Cotyledon: An embryonic leaf in seed-bearing plants, one or more of which are the first leaves to appear from a germinating seed.
- Plants can be categorized in tow broad groups on the basis of cotyledon,.
  - Monocotyledons (Monocots):- have a single cotyledon or seed leaf
  - Dicotyledons (Dicots):- have two cotyledon or seed leaves

- The leaf is the main photosynthetic organ of most vascular plants.
- Leaves generally consist of a flattened blade and a petiole, which joins the leaf to a node of the stem. Midrib is the large central vein.
- Some plant species have evolved modified leaves that serve various functions. For example: climbing, pollinator attraction, storage, digestion, prevention of water loss, etc.

- There are two types of leaf. They are Simple leaf and Compound leaf.
  - Simple leaf:- A simple leaf is a single, undivided blade
  - Compound leaf: -In a compound leaf, the blade consists of multiple leaflets. The leaflet has no axillary bud at its base.

- The arrangement of veins in a leaf is called as Leaf Venation. The leaf venation is of two types. The leaf venation in monocot plant is of Parallel Type. Dates is common example of Parallel Type of Leaf Venation. In the Dicot plant the leaf venation is of Reticulate Type.

- There are various type of roots stem and leaf, and their modification. The different organ of the plants sometimes Modified into special structure for special function.

  - Rhizome, Corm, bulb, and Tuber is modified stem.
  - Zinger is Rhizome type of modified underground stem.
  - Onion is Bulb type of modified underground stem.
  - Potato is Tuber type of modified underground stem.

  - Tendril is pea plant is a modified leaf.

  - Spines in cactus is modified leaf.

  - Carrot is modified root for storage

- **Apical Dominance:** the Apical Dominance is the phenomenon whereby the main, central stem of the plant grows more than other side stems.

Section 3: Plant Structure (Anatomy)

- The study of internal structure of plant is called as **PLANT ANATOMY**.
- Group of cells having similar structure and function is called as **TISSUE**

❖ Tissue Systems:

There are four types of plant tissue systems. They are: Ground Tissue System, Vascular Tissue System, Dermal Tissue System, and Meristematic Tissue System.

- **Ground Tissue System:** The ground tissue of plants includes all tissues that are neither dermal nor vascular. Ground tissue functions primarily in storage, support, photosynthesis, and the production of defensive and attractant substances (oils and toxins). There are three types of ground tissue: Parenchyma cells, Collenchyma cells, Sclerenchyma cells.
  - Parenchyma cells have thin primary walls. Parenchyma forms the "filler" tissue in the soft parts of plants.
  - Collenchyma cells have thin primary walls with secondary thickening. Collenchyma provides extra structural support.
  - Sclerenchyma cells have thick lignified secondary walls. Sclerenchyma provides the main structural support to a plant.

- **Vascular Tissue System:**
  - The vascular tissue system includes the xylem and phloem.
  - The vascular tissue system is the conductive or "plumbing" system of the plant.
  - The phloem transports carbohydrates from leaves to other parts of the plant.
  - The xylem distributes water and mineral ions taken up by the roots to the stem and leaves.

- **Dermal Tissue System:**
  - Dermal tissue covers the plant body.
  - Dermal tissue consists of epidermis.
  - Epidermis is made of parenchyma cells in a single layer.
  - Epidermis on stem and leaves prevents water loss by transpiration.
  - Epidermis produces a waxy material called cuticle.

- **Meristematic Tissue System:**
  - The Meristems or Meristamatic cells are dividing cell.
  - The Meristems are found in zones of the plant where growth take place.
  - There are three main types of meristematic tissue in angiosperms, they are Apical Meristem, Intercalary Meristem, and Lateral Meristems

Plant Tissue	Cell Type	Site of occurrence in the plant body
Epidermis	Ground cells, Guard cells, cells forming Trichomes, Sclerenchyma cells	Outer layer of plant body
Periderm	Cork cells, Cork Cambium Cells, Sclerenchyma cells	Outer layer, mainly stems
Xylem	Tracheids, Vessel Members, Sclerenchyma Cells, Parenchyma cells	All organs
Phloem	Sieve cells, albuminous cells or companion cells, Sclerenchyma cells	All organs
Parenchyma	Parenchyma cells	Cortex, Pith
Collenchyma	Collenchyma cells	Mainly stems
Sclerenchyma	Sclerenchyma cells	All Organs

- **STOMATA:** Openings in the epidermis on the underside of a leaf where gases are exchanged are called.

❖ Major Anatomical Difference Between DICOT and MONOCOT

- **Major anatomical difference between Dicot and Monocot Root**

Anatomical characters	Dicot Root	Monocot Root
Vascular bundles	2-6 alternate bundles or xylem and phloem	8 or more alternate bundles of xylem and phloem

- **Major anatomical difference between Dicot and Monocot Stem**

Anatomical characters	Dicot Stem	Monocot Stem
Vascular bundles	Wedge shaped, arranged in ring	Oval in shape, numerous and scatted

- **Major anatomical difference between Dicot and Monocot Leaf**

	Dicot Leaf	Monocot Leaf
1	Cuticle thick at upper epidermis and thin at lower epidermis	Uniform cuticle on both the surface
2	Stomata are more on lower surface	Equal number of stomata on both the surface
3	Mesophyll is differentiated into Palisade Parenchyma and Spongy Parenchyma	Mesophyll is not differential into palisade and spongy Parenchyma

❖ Secondary growth

The vascular cambium is a plant tissue located between the xylem and the phloem in the stems and roots of vascular plants.

- Secondary growth increases the diameter of stems and roots.
- Annual rings can be seen by the cross sections of most tree trunks.
- Annual rings form due to differential rates of growth of the plant in spring and in summer.
- Wood that is no longer conducting water is known as heartwood.

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Section 4: Plant Physiology

- Plant physiology is a discipline of botany which concerned with the functioning of plants.

❖ Transport in Plants

- There is no circulatory system in plants, but water and minerals moves from root to leaves, and nutrients moves from leaves to roots.
- Each levels of structural organization participate in the physiology / functions of the plant. The different levels of structural organization are:
  - **Cell:-** unit of structure of all living organisms.
  - **Tissue:-** composed of groups of similar cells.
  - **Organs:-** composed of groups of tissues functioning together.
  - **Organ Systems:-** composed of groups of organs functioning together.
  - **Organism:-** an individual animal, plant, or single-celled life form.

❖ Types of Transport in Cells

Concentration:- The amount of a particular substance in a contained area compared with the amount of the same substance in another area.

There are two types of transport in cells.

- **Passive Transport:** The movement of substances through a membrane from a region of high to a region of low concentration. No energy needed (ATP) in the passive transport. Diffusion and Osmosis is the example of passive transport.
- **Active Transport:** The movement of substances through a membrane from a region of low concentration to a region of high concentration. The active transport Requires cellular energy (ATP).

❖ Plant-Water Relations

Solution: A liquid mixture in which the minor component (the solute) is uniformly distributed within the major component (the solvent).
Hypotonic Solution: A solution that causes a cell to swell because of osmosis meaning water rushes into the cell
Isotonic Solution: A solution that causes no change in cell size. Meaning there is no movement of water.
Hypertonic Solution: A solution that causes a cell to shrink because of osmosis. Meaning water leaves the cell.

- **Processes of transport in the living system**
  - There are two types of process of transport in the living system. These are Diffusion and Osmosis.
  - **Diffusion:** The tendency of molecules to move from an area of higher concentration to an area of lower concentration.
  - **Osmosis:** The movement of water through a membrane from a region of higher to lower concentration

  - The goal of both diffusion and osmosis is to reach Equilibrium within the cell. Equilibrium is a condition in which the movement in one direction is equal to the movement in another direction.

Solute: substance being dissolved in a liquid (e.g. salt).
Solvent: substance doing the dissolving (e.g. water).
Permeability: the extent to which a membrane will allow particular sized molecules to pass.
Semi-permeable membrane (selectively permeable): allows some molecules to pass but not others.

❖ Transpiration

- It is mainly the evaporation of water from plant leaves.
- Transpiration is the process by which water is carried through plants from roots to small pores on the underside of leaves, where the water changes to vapor, and is released to the atmosphere.

❖ Photosynthesis

- ❖ The green plants takes carbon dioxide (CO_2) from the air, and water (H_2O) from the soil. The plants combine the CO_2 with the H_2O to make the sugar (Glucose ($C_6H_{12}O_6$).
- ❖ Photosynthesis is the conversion of light energy to chemical energy by chlorophyll in chloroplasts.
- ❖ Overall net equation for photosynthesis is: 6 Water + 6 Carbon dioxide gives glucose + 6 oxygen (when catalyzed by chlorophyll in the presence of sunlight) → 1 Sugar + 6 Oxygen

$$6CO_2 + 6H_2O = C_6H_{12}O_6 + 6O_2$$

- ❖ Photosynthesis is the major path through which carbon re-enters the biosphere (from CO_2).
- ❖ Photosynthesis is also the major source of oxygen (O_2) in the earth's atmosphere.
- ❖ Photosynthesis completes in two phase: 1. Photochemical phase (Light Reaction), and 2. Biosynthetic Phase (Calvin cycle).
- ❖ In the Photochemical phase (Light Reaction), the water molecular breakdown into Hydrogen and Oxygen.
- ❖ The released Hydrogen molecules helps in the conversion of Adenosine Diphosphate (ADP) into Adenosine Triphosphate (ATP).
- ❖ The released Hydrogen molecules also help in the conversion of Nicotinamide Adenine Dinucleotide Phosphate (NADPH) into reduced Nicotinamide Adenine Dinucleotide Phosphate ($NADP^+$)
- ❖ ATP and Nicotinamide Adenine Dinucleotide Phosphate ($NADP^+$) used in Biosynthetic Phase called as Calvin Cycle in which CO_2 molecules convert into Glucose.

❖ Respiration / Cellular Respiration / Cellular Oxidation

- The respiration is the process of the breakdown of food materials within the cell to release energy in the form of ATP (Adenosine Tri Phosphate) is
- Overall Net equation for Respiration is: $C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$ + ATP (Energy).
- The process of Respiration involves Cytoplasm and Mitochondria.
- The process of Respiration completes in two phase. These are (1) Glycolysis and (2) Krebs cycle.

Glycolysis:

- The process of Glycolysis occurs in cytoplasm.
- The Glucose available in the cytoplasm passed thru a series of enzymatic reaction in which glucose converted in to pyruvic acid.
- The process of the conversion of the Glucose into Pyruvic acid occurs in the presence of oxygen.
- Pyruvic acid converted to Acetyl Co enzyme A.
-

Krebs Cycle:

- Krebs cycle is also known as Citric Acid Cycle or Tricarboxylic Acid (TCA) cycle.
- Pyruvic acid comes from the process of glycolysis enters into Mitochondria in the form of Acetyl Co enzyme A, and then passed thru a series of cyclic enzymatic reaction, and finally gives ATP.

❖ Plant Growth Hormones

- Plant hormones (also known as phytohormones) are chemicals that regulate plant growth.
- Auxin, gibberellin and Cytokinin are the three important plant growth hormones.

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Section 5: Classification of Organisms

- **Taxonomy / Systematics:** The branch of biology that deals with classification and nomenclature.
- **Nomenclature:** The nomenclature deals with the application of a correct name to a plant or a taxonomic group.

Taxonomic Hierarchy

- **Species:** Organisms sharing a set of biological traits and reproducing only their exact kind. Species is the fundamental unit in taxonomy
- **Genus:** The genus are the closely related species.
- **Family:** The family are the closely related genera.
- **Order:** The order are the closely related families.
- **Class:** The class are the closely related order.
- **Division:** The division are the related classes.
- **Kingdom:** The most basic category of organisms is called a kingdom.

Classification of living organism

- Most scientists divide organisms into five major kingdoms. These are Monera (includes Eubacteria and Archeobacteria), Protista, Fungi, Plantae and Animalia.
- Viruses, Bacteria, Algae, Fungi and Protozoa are the Microorganisms

❖ Kingdom: Archaebacteria

- Archaebacteria are unicellular prokaryotes with distinctive Cell Membranes.
- Most of the Archaebacteria are heterotrophic. But there are some Archaebacteria are autotrophic, producing food by chemosynthesis.
- A heterotroph is an organism that cannot fix carbon from inorganic sources (such as carbon dioxide) but uses organic carbon for growth.
- Many Archaebacteria live in harsh environments such as Sulfurous Hot Springs, very salty lakes, and in anaerobic environments, such as the intestines of mammals.

❖ Kingdom Eubacteria

- Eubacteria are unicellular prokaryotes.
- Most of the bacteria causing disease in human.
- Eubacteria are both autotrophic and heterotrophic.
- Eubacteria is normally reproduce by binary fission.

- **Morphology of Bacteria:**
    - Bacterial are prokaryotes.
    - Three are different shapes of bacteria:
        - Cocci (spherical, ovoid, or generally round shape)
        - Bacilli (a rod-shaped bacterium)
        - Spiral (Bacteria of spiral / helical shape)

❖ Kingdom Protista

- Kingdom Protista contains all eukaryotes that are not Plants, Animal, or Fungi,
- There are more than 50,000 species in Protista.
- Kingdom Protista includes unicellular and a few simple multicellular Eukaryotes.
- The cells of multicellular Protista are not specialized to perform specific functions in the organisms.

❖ Kingdom Fungi

- Fungi are eukaryotes, and most are multicellular.
- The cell wall of fungi are made up of chemical chitin.
- Fungi are heterotrophic and obtain their nutrients by releasing digestive enzymes into a food source.
- Fungi act either as decomposers or as parasites in nature.
- Many fungi causes disease in plant and animals.

❖ Kingdom Plantae

- Plants are eukaryotic, multicellular and carry out photosynthesis.
- The cells of plants have cell walls that contain the polysaccharide cellulose.
- Plant cells are specialized for different functions.
- Kingdom Plantae includes Thallophyta (Algae, Fungi, Bryophyte), Pteridophyta, Gymnosperms and Angiosperms.

Algae:

- Chlorophyll bearing thallophytic plant is called as ALGAE.
- There are about 100, 000 species of algae occurs in the world.
- Algae mainly occurs in water likes ponds, river, ocean, lakes. Many algae are edible.
- *Chlorella* is an example of edible algae.
- Many Algae is source of medicine.
- *Laminaria* is common example of medicinal algae.
- *Volvox, Chlorella, Spirogyra, Ulothrix* are the common examples of Algae.

Fungi:

- The thallophytic plant which do not have chlorophyll is called as Fungi.
- There are about five million species of algae occurs in the world.
- *Penecillum, Mucor* and *Aspergillus* are the common example of fungi.
- Some fungi are edible like Mushroom.
- The Antibiotics Penecillin used in medicine obtained from *Penecillium.*
- Some fungi causing disease in plants and animals.
- Many skin infection in human is due to fungi.
- Fungi are unicellular to multicellular.
- The meaning of unicellular is one cell
- The meaning of multicellular is more than one cells.
- Therea re four different classes of fungi, these are Phycomycetes, Ascomycetes, Basidiomycetes, and Zygomycetes.
- The body Multicellular fungi is a mycelium—composed of tubular filaments called hyphae**.**
- Hyphae cell walls have chitin.
- Some hyphae have incomplete cross walls or septa, and are called septate.
- Hyphae without septa are called coenocytic**.**
- Some hyphae have incomplete cross walls or septa, and are called septate.
- Hyphae without septa are called coenocytic.

- **Lichens:**
  - Lichens are the symbiotic Association of Algae and Fungi. It is the nature's Perfect Marriage.
  - Lichens is association of fungus and photosynthetic organism.
  - There are about 20000 species of algae occurs in the world.
  - Mostly Ascomycetes fungi associated with lichens.
  - The members of the algal class cyanophyceae or chlorophyceae associated in the lichens.

- Lichens can survive the harshest environmental condition.
- Lichens are very sensitive to toxic compounds. Hence, Lichens are the good indicators of air pollution.
- Many Lichens have medicinal properties.

Bryophyta:

- Bryophyta also possess thalloid body.
- True vascular tissue is absent in Bryophyta.
- Common example of Bryophyta is *Marchantia*.
- There are about 19000 species of Bryophyte occurs in world.
- Bryophytes reproduce asexually and sexually.
- Sexual reproduction takes place by fusion of male gametes and females gametes.
- The haploid or gametophyte or n is the major phase in the life cycle of a Bryophytic species.
- The Bryophytic plants mostly occurs near water or wet area.
- *Funaria* is a bryophytic plants occurs in Saudi Arabia
- The bryophytic plants require a constantly moist environment.
- The members of the Bryophytes have been three classes. These are **(**1) Hepatophyta (liverwort), (2) Anthocerophyta (Hornworts), (3) Moss (Hornworts).

Pteridophyta:

- Pteridophytic plant possess Root, Stem, Leaf and Vascular Tissue.
- Common example of Pteridophyta is *Pteris*.
- There are about 11000 species of Pteridophyta occurs in different parts of the world.
- The Sexual reproduction in Pteridophyta takes place with the help of spores.
- The diploid or sporophyte or 2n is the major phase in the life cycle of a Pteridophytic species.
- *Pteris* is a Pteridophytic plants occurs in Saudi Arabia.
- The broad leaves of the Pteridophytic plant are called fronds.
- The leaflets of the Pteridophytic plant are called pinnae.
- The Sporangium are formed on the underside of the fronds.
- The unfolding fronds are called fiddleheads.
- The spores are dispersed by the wind.
- The sporangium in the Pteridophytic plant are produces spores. the spores are diploid in nature. The spores germinate to produce gametophyte phase.
- The members of the Pteridophytic have been four classes. There are: (1) Psilophyta (Whisk Ferns), (2) Lycophyta (Spike Mosses), (3) Sphenophyta (Horsetails), (4) Pterophyta (True Ferns)

Gymnosperm:

- Gymnosperm possess well developed Root, Stem, Leaf and Vascular Tissue.
- The common example of Gymnosperm is *Cycas, Pinus, Taxus, Gnetum*
- There are about 1100 species of Gymnosperm occurs in the different parts of the world.
- The reproductive organs in Gymnosperm are called as cones.
- The diploid or sporophyte or 2n is the major phase in the life cycle of a Gymnosperm species.
- Gymonosperms are seed bearing plants.
- Seeds are naked in Gymonosperms.
- *Welwitschia* is a member of Gymnosperm occurs in desert condition.
- *Sequoiadendron giganteum* is a largest tree belongs to the Gymnosperms.
- *Juniperous* is a Gymnospermic plants occurs in Saudi Arabia.

- The members of Gymnosperms have been classified into four classes. These are: Conifers, Cycads, Ginkgos, and Gnetales

  - **Cycadophyta (Cycads)**
    - The plants of the members of Cycadophyta have large fernlike leaves.
    - The plants of the members of Cycadophyta is either males or females.
    - The plants of the members of Cycadophyta produce gametes in large strobilus

  - **Ginkgophyta (*Ginkgo biloba)***
    - Only one species in present day
    - Bear male and female cones on separate plants.
    - Male produces pollen in strobilus-like cones.
    - Female bears seed which develop a fleshy outer covering
    - Plants are resistant to air pollution

  - **Coniferophyta (Cone-bearing trees)**
    - The Coniferophyta are the **c**one bearing
    - The members of the Coniferophyta have needles with thick waxy covering
    - Stomata in cavities below surface.
    - Seeds are carried on the surfaces of cones.
    - Evergreen and adapted to cold and dry habitats.

  - **Gnetophyta**
    - There are three genera of Gnetophyta. These are: *Gnetum, Ephedra,* and *Welwitschia*.
    - *Gnetum* : A tropical climbing plant
    - *Ephedra* : (Shrub-like plants)
    - *Welwitschia :* (Desert dweller with large tuberous root). *Welwitschia* has only two leaves and may live 1000 years.

Angiosperms:

- The flowering plants are called as Angiosperms.
- All Angiospermic plant produce flowers. The flower is the sexual reproduction structures.
- There are two types of Angiospermic plants: Monocot Plants and Dicot Plants.
- Dates, Rice and Grass is a Monoct Plants.
- Mint and Cashew is a dicot plant.
- There are about 400,000 Angiosperms plants occurs in different parts of the world.
- The major phase in the life cycle of the Angiospermic plant is diploid or sporophyte or 2n.
- Flowering plants occurs in all the climatic condition such as very cold to very hot climatic condition.
- *Wolfia* is a smallest Angiosperms.
- There are several Angiospermic plants which occurs in water called as aquatic plants.
- *Nymphea* is an example of aquatic plants.
- *Agave* is a common example of monot angiosperms occurs in desert condition.
- In the flowering plants the seeds are within a layer of protective tissue
- Angiosperms are the main sources of food (cereals, pulses, vegetables) and medicine, timber.

  - **The life cycle of angiosperm**
    - The angiosperm plant may have male flower and female flower on same plant or on the different plant.
    - Monoecious plant: The male and female flower both on the same plant.

- Dioecious plant: The male and female flower both on the same plant.
- Monoecious flower: The male and female flower parts both on the same flower.
- Dioecious plant: The male is different and the female flower is different.
- Date is dioecious plants. Male flowers comes in male plant and the female flowers comes in female plant.
- The male flower produce pollen grains. And the female plant produce egg.
- The pollen grains are produce in anther.
- The pollen grains are haploid because the pollen grains are produced after meiosis cell division in the anther.
- The Anther is a part of male flower.
- The transfer of pollen grain from anther to stigma is called as pollination.
- Stigma is a part of female flower.
- After pollination, the pollen grains produce sperms.
- The egg is the part of the female flower.
- The egg is the haploid because the egg is produce after meiosis cell division in the ovule.
- The ovule is part of the female flower.
- The sperm fuse with egg. The process of fusion of sperm and egg is called fertilization.
- The zygote is formed after the fertilization.
- The zygote is the diploid / sporophyte.
- The zygote develops into seed.
- The seed on germination gives new plant.

❖ Kingdom Animalia

- Animals are multicellular, eukaryotic, and heterotrophic.
- Animal cells have no cell walls.
- Most members of the Animal Kingdom can move from place to place.
- Fish, Birds, Reptiles, Amphibians, and mammals-including humans belong to the Kingdom Animalia.
- This Kingdom also includes sponges, jellyfish, worms, sea stars, and insects.

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Section 6: Plant Systematics

- The four main groups of plants contains millions of species, this huge number of species needs a scientific name for the identification and classification.
- The Scientific Names are necessary because the same common name is used for different plants in different areas of the world.
- **Taxonomy**: The science of classification.
- **Plant taxonomy**: The science of classification of plants.

❖ Binomial Nomenclature

- Swedish Botanist Carolus Linnaeus introduced Binomial Nomenclature.
- Binomial nomenclature uses two Latin words to indicate the genus and the species. The first word is the genus and the second word is the species.
- Example- the botanical name of dates is *Phoenix dactylifera*
- Carolus Linnaeus published the book 'Species Plantarum' in 1753.
- Carolus Linnaeus classified the plants based on the plant's method of reproduction and structure of reproductive parts.
- The name of the plants must should be written in italics. For example *Phoenix dactylifera*

Morphology to Molecules in the classification of plants

- About 300 years back the plant taxonomy that practices the identification and classification of organism started from plant morphology. The plant taxonomy advances with the development of different fields like Anatomy, Palynology, Photochemistry, Cytology and Molecular Biology. Now these days, DNA data is being used in Molecular taxonomy for the identification and classification of plants.

❖ Species Concept

- Species is the basic unit of classification.
- Plants in the same species consistently produce plants of the same types.

Plant Collecting and Documentation

- A **HERBARIUM** is a collection of dried plants systematically named and arranged for ready reference and study.
- To make a herbarium specimen, the plant is collected, and notes are made about it. The plant is then pressed until dry between blotters that absorb moisture and mounted onto a herbarium sheet with a suitable label.
- The **FLORA** is the main Resources of Taxonomic Information.
- Flora is the documentation of plants occurring in a particular region.

❖ Some important taxonomic terminology used in plant taxonomy

- There are three main different habit of the plant. These are Herbs, Shrubs and Tree.
- There are mainly two types of Roots. These are Tap Root and Adventitious Root.
- There are large number of terminology of leaf based on Margin, Apex, Base, Venation, Arrangement, and Petiole.
- **Inflorescence:** An inflorescence is an arrangement of one or more flowers on a floral axis.
- The type of the inflorescence is determined by Number of flowers, Positional relationships, Degree of the development of their pedicels, Nature of their branching pattern.

- There are two different types of inflorescence. They are Simple Inflorescence and Compound Inflorescence.
- Terminal is a type of Simple Inflorescence. In the Terminal type of Simple Inflorescence the flower at the tip of a stem. The common example of this type of inflorescence is *Hibiscus coccineus*
- In the Compound Inflorescences there are two or more flowers in every inflorescence. For example Sunflower. Spike, Catkin, Raceme, Umbel, corymb, Panicles and head are the different types of compound inflorescence.
- **Spike**: elongate inflorescence; flowers are sessile, dense, or remote from one another.
- **Catkin**: A spike like inflorescence of unisexual flowers; found only in woody plants.
- **Raceme**: an elongate inflorescence of pedicellate flowers on an unbranched rachis.
- **Umbel**: a flat-topped or somewhat rounded inflorescence in which all of the pedicels arise from a common point at the tip of the peduncle.
- **Corymb**: a flat-topped or somewhat rounded inflorescence in which the pedicels of varying length are inserted along the rachis.
- **Panicle**: a much-branched inflorescence with a central rachis which bears branches which are themselves branched.
- **Head (Capitulum):** is a short dense spike in which the flowers are borne directly on a broad, flat peduncle, giving the inflorescence the appearance of a single flower.

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BOT 102 (GENERAL BOTANY)

Section 7: Ecology & Environmental Biology

- **ECOLOGY**: Ecology is the study of living organisms in relation to their habits and habitats.
- **HABITAT**: The zone in which the organism (plants and animals) lives and where it can find food, shelter, protection and mates for reproduction.
- **HABIT**: Habit is the aspects of behavior or structure.
- **ENVIRONMENT**: Environment is the interactions among the abiotic (physical and chemical) and biological component
- **Environmental science**: Environmental science is an interdisciplinary academic field that integrates physical, biological and information sciences (including ecology, biology, physics, chemistry, zoology, mineralogy, oceanology, soil science, geology, atmospheric science) to the study of the environment, and the solution of environmental problems.
- **Biosphere (sphere of life):** Biosphere is the total portion of lithosphere, hydrosphere and atmosphere that supports the life of organisms.

Levels of organization in Ecology

In ecology, the levels of organization include: Individuals, Populations, Communities, Ecosystems and Biomes.

- **Individuals**:- The fundamental functional units.
- **Populations**: - Members of the same species co-occurring in space and time and sharing the same resources.
- **Communities**:- Populations of organisms living together in the same environment.
- **Ecosystems**:- Dynamic systems of organisms interacting with each other and their environment.
- **Biomes**:- Regional ecosystem types with similar communities.

Ecosystem

- All organisms along with physical environment in a single location.
- **Biosphere**: Various ecosystems make up the largest life unit called biosphere.

Structure of Ecosystem:

- All the ecosystem consists of two components. They are Abiotic components and Biotic components

Abiotic components

  - Energy - solar energy
  - Physical factors - temperature, light, wind, etc.
  - Chemicals - inorganic substances (oxygen, carbon, etc.) and organic substances (carbohydrates, proteins, etc.)

Biotic components: There are three type of biotic components in any ecosystem.

  - Producers - green plants (autotrophs)
  - Consumers - animals (heterotrophs)
    - Herbivores (primary consumers)
    - Carnivores (primary, secondary, tertiary, etc. consumers)
    - Omnivores (generalists)-can feed on both plants and animals.
    - Scavengers (top carnivores)-utilize the dead remains of animals
  - Decomposers
    - Bacteria and Fungi

Food Chain

- A linear energy and chemical flow through organisms.
- In food chain, there is transfer of food from one trophic (feeding) level reaches to the other trophic level.
- In the classical food chain: Plants are eaten only by primary consumers, then the primary consumers are eaten by secondary consumers, the secondary consumers are eaten by tertiary consumers, and so on.

Food Web

- The natural interconnection of food chains is called as food web.
- An organism may obtain nourishment from many different trophic levels, and thus gives rise to a complex and interconnected series of energy transfers.

Zonobiomes (Biomes)

Zonobiomes (Biomes) is the regional ecosystem types with similar communities. There are 9 different Zonobiomes (Biomes). These are:

- Equatorial diurnal climate
- Tropical
- Subtropical (Desert)
- Mediterranean
- Warm temperate
- Temperate
- Arid temperate (Continental)
- Cold temperate
- Arctic (Tundra)

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Section 8: Biotechnology

Biotechnology is a field that entails applying technology on life (plants).

Plant Biotechnology

- Plant biotechnology is a field that entails applying technology on plants.
- Micropropagation or plant tissue culture is a collection of techniques used to grow plant cells, tissues or organs under sterile conditions on a nutrient culture medium of known composition.

Advantage of Micropropagation:

- Produces large number of genetically identical plants very quickly.
- Produces species that are hard to grow in other ways.
- Genetic modification can be made in a small number of plants which the give thousands of plants carrying the desired changes.
- Helps in conservation Rare, Threatened and Endangered species.

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