Unit 2: Plants

2.1 Characteristics of Plants

Plants are a diverse group of living organisms with a range of characteristics. Some of these traits are shared with other living things, while others are unique to plants. Understanding these characteristics helps us distinguish plants from other forms of life.

- **Living Organisms:** Like all living things, plants grow, reproduce, and respond to environmental changes.
- **Multicellular:** Plants are made up of many eukaryotic cells, each with a well-defined nucleus and membrane-bound organelles. Plant cells also have a rigid cell wall made of cellulose, which is unique to plants.
- **Autotrophic:** Plants are self-feeding, meaning they produce their own food through photosynthesis, a process facilitated by the green pigment chlorophyll. This makes them primary producers in ecosystems.
- **Sessile Nature:** Plants are stationary and anchored to the ground by roots. They do not move, but their parts, such as leaves, can orient toward light, and roots can grow toward water sources.
- **Reproduction:** Plants reproduce both sexually and asexually. Lower plants like mosses use asexual reproduction through spores, while higher plants like angiosperms use sexual reproduction involving gametes.

2.2 Flowering and Non-Flowering Plants

Plants are categorized into flowering and non-flowering groups based on their reproductive structures.

- **Non-Flowering Plants:** These include lower plants like mosses and liverworts, which are non-vascular and lack a transporting system for water and nutrients. They are small, seedless, and reproduce through spores. Gymnosperms are higher non-flowering plants that have well-developed roots, stems, and leaves but reproduce using cones instead of flowers. Their seeds are "naked," meaning they are not enclosed in fruits.
- **Flowering Plants (Angiosperms):** These are vascular plants with well-developed roots, stems, and leaves. They reproduce using flowers and produce seeds enclosed within fruits.

2.3 Structure and Function of Plant Parts

Plants have various structures, each performing vital functions necessary for survival.

- **External Structure of a Flowering Plant:** The plant body is divided into the shoot and root systems.
    - **Shoot System:** Includes the stem, branches, leaves, buds, flowers, and fruits. This system is responsible for photosynthesis, reproduction, and transport of nutrients.
    - **Root System:** Comprises the primary root, lateral roots, root hairs, and root cap. It anchors the plant and absorbs water and nutrients from the soil.
- **External Structure of a Leaf:** A typical leaf has a petiole (stalk), lamina (blade), midrib, margin, base, and tips. The lamina is broad and thin, maximizing the surface area for light absorption and gas exchange. The midrib contains veins for transporting nutrients and water.
- **Types of Roots:**
    - **Taproots:** Have a main vertical root with few lateral roots, providing deep anchorage and accessing water deep in the soil. Common in dicot plants.
    - **Fibrous Roots:** Consist of thin, branching roots that spread out from the base of the stem. They are efficient in absorbing surface water and preventing soil erosion. Common in monocot plants.

2.3.1 Internal Structure of a Leaf

The leaf's internal structure is designed for efficient photosynthesis.

- **Outer Layer (Epidermis):** The upper and lower epidermis protect the leaf and regulate water loss. The upper epidermis is covered by a waxy cuticle, while the lower epidermis contains stomata for gas exchange.
- **Middle Layer (Mesophyll):** Contains the palisade and spongy layers. The palisade layer, with tightly packed cells, captures sunlight for photosynthesis. The spongy layer, with loosely arranged cells and air spaces, facilitates gas exchange.

2.3.2 Internal Structure of a Stem

The stem's internal structure supports the plant and transports nutrients.

- **Epidermis:** The outermost layer, protected by a cuticle, minimizes water loss.
- **Hypodermis:** Provides mechanical strength to the stem.
- **Cortex:** Stores food and nutrients.

- **Endodermis:** Separates the cortex from the vascular bundles and stores food.
- **Vascular Bundles:** Composed of xylem and phloem, they transport water, minerals, and food throughout the plant.
- **Pith:** The central part of the stem stores food and helps in water movement.

2.3.3 Internal Structure of a Root

The root's internal structure is essential for water and nutrient absorption.

- **Peliferous Layer:** The outer layer with root hairs for water absorption.
- **Cortex:** Stores food and water.
- **Endodermis:** Regulates the flow of water and nutrients into the xylem.
- **Pericycle:** Originates lateral roots.
- **Vascular Bundles:** Xylem and phloem transport water and nutrients.
- **Pith:** Present in young roots, it stores nutrients.

2.4 Reproduction in Plants

Plants reproduce through both asexual and sexual means.

- **Non-Flowering Plants (Gymnosperms):** Gymnosperms, like pine trees, reproduce using cones. Male cones release pollen, which fertilizes the eggs in female cones, leading to seed formation. These seeds are dispersed to grow into new plants.
- **Flowering Plants (Angiosperms):** Angiosperms reproduce using flowers, which contain the reproductive organs. Pollination leads to fertilization, after which seeds develop within fruits, ensuring the continuation of the plant species.

Pollination and Plant Reproduction

Pollination is the transfer of pollen grains from the anther (male part) to the stigma (female part) of a flower. This process can occur within the same flower (self-pollination) or between different flowers (cross-pollination). Pollination often involves agents like insects or wind.

1. **Pollen Tube Formation:** When pollen grains land on the stigma, they form pollen tubes that grow down the style towards the ovule, where the male gamete will unite with the female gamete.
2. **Fertilization:** The male gamete (sperm) and female gamete (egg) combine in the ovule to form a zygote, which develops into a seed embryo. Additionally, a second fertilization event forms the endosperm,

which provides nourishment to the embryo. This process is known as double fertilization, characteristic of angiosperms (flowering plants).
3. **Seed and Fruit Formation:** After fertilization, the ovule matures into a seed, while the ovary develops into a fruit. Therefore, the seed is a matured ovule, and the fruit is a matured ovary.
4. **Seed Dispersal:** Seeds are scattered away from the parent plant to reduce competition. Dispersal agents include animals, wind, and water. For example, seeds may stick to animal fur, be carried by the wind, or float in water.
5. **Seed Dormancy and Germination:** Seeds may remain dormant until conditions are favorable. When a seed absorbs water and the right conditions are met, it breaks dormancy and begins to germinate. The embryo grows into a seedling, with the radicle forming the root and the shoot developing towards the light.

Seeds

A **seed** is a fertilized ovule containing three parts:

1. **Seed Embryo:** Includes the radicle (future root), epicotyl, hypocotyl, and plumule (future shoot).
2. **Cotyledon/Endosperm:** Food-storing tissues. Cotyledons are the first leaves of the embryo, while endosperm provides additional nourishment.
3. **Seed Coat:** Protects the seed.

Types of Seeds:

- **Dicot Seeds:** Have two cotyledons, fleshy cotyledons storing food, and an absent endosperm. They develop a primary root with lateral roots.
- **Monocot Seeds:** Have one cotyledon, a thin cotyledon, and a well-developed endosperm. They have adventitious fibrous roots.

Seed Dispersal and Germination

Seed Dispersal: Ensures seeds are spread to minimize competition. Seeds can be dispersed by:

- **Animals:** Seeds cling to fur or are ingested and excreted.
- **Wind:** Seeds with wings or hairs are carried by the wind.
- **Water:** Seeds float and are transported by water.

Seed Germination: The process where a seed develops into a new plant. Essential conditions include:

- **Water:** Activates enzymes and increases permeability for oxygen.

- **Oxygen:** Needed for aerobic respiration.
- **Temperature:** Requires optimal warmth.

Experiment to Demonstrate Germination Needs:

1. **Moisture:** Use cotton wool to show water's role.
2. **Temperature:** Use ice cubes to show the effect of cold.
3. **Air:** Use oil to demonstrate the need for oxygen.

Photosynthesis

Photosynthesis is the process by which plants produce food using sunlight. It occurs in the chloroplasts of plant cells.

1. **Photosynthetic Apparatus:**
    - **Granum:** Stacks of thylakoids containing chlorophyll where light reactions occur.
    - **Stroma:** The fluid-filled space where carbon fixation occurs, leading to sugar production.
2. **Light Absorption:** Chlorophyll absorbs light mainly in the blue (400-500 nm) and red (600-700 nm) regions, reflecting green light, which is why leaves appear green.
3. **Mechanism:**
    - **Light Reaction:** Takes place in the granum, where chlorophyll absorbs light, splits water molecules, and produces ATP and oxygen.
    - **Dark Reaction:** Occurs in the stroma, where ATP and hydrogen convert carbon dioxide into glucose.

Overall Equation of Photosynthesis: $6CO_2+6H_2O+\text{Sunlight}\rightarrow C_6H_{12}O_6+6O_2$

Testing for Starch: To demonstrate photosynthesis, test a leaf for starch using iodine. The leaf must first be boiled to soften it, then treated with alcohol to remove pigments, and finally exposed to iodine to reveal the presence of starch as a blue-black color.

Transport in Plants

Transport Systems:

- **Xylem:** Transports water and minerals from roots to leaves.
- **Phloem:** Transports food from leaves to other parts of the plant.

Water and Mineral Uptake: Water enters roots through root hairs by osmosis and diffusion. It is then pulled up through xylem vessels by transpiration pull.

Organic Matter Transport: Food (sugars) is transported through phloem from sources (leaves) to sinks (storage organs). The ringing experiment can demonstrate this, as removal of phloem will cause a buildup of sugars above the cut area, showing the role of phloem in food transport.

These processes collectively ensure the survival and reproduction of plants, highlighting their complex yet fascinating life cycle and functions.

2.9 Response in Plants

2.9.1 Tropism as Growth Response

Tropism refers to a plant's growth response to an external stimulus, where it bends either towards (positive tropism) or away (negative tropism) from the stimulus. This growth response is due to a unilateral stimulus, which means the stimulus comes from only one direction. This causes an unequal distribution of growth hormones, particularly **auxin**, resulting in uneven growth on different sides of the plant.

- **Auxin** is a key plant growth hormone that regulates cell elongation. It is produced at the tips of shoots and roots and is transported to the regions of active growth.
- **Shoot and root responses to auxin**:
    - **Shoots**: In response to unilateral light, auxin accumulates on the shaded side, promoting cell elongation and causing the shoot to bend towards the light (positive phototropism).
    - **Roots**: In contrast, auxin inhibits cell elongation on the shaded side of the root, causing the root to bend away from the light (negative phototropism).

Phototropism

Phototropism is the growth response of plants towards light. The shoot exhibits positive phototropism by bending towards the light source. This response was first observed by Charles Darwin, who found that the bending of a shoot towards light occurs due to the distribution of auxin. When the shoot tip is removed or covered, the bending does not occur, indicating that the tip is essential for this response.

Hydrotropism

Hydrotropism is the growth response of roots towards moisture. Roots exhibit positive hydrotropism by growing towards areas with higher water content. This is crucial for the plant's survival as it ensures that roots can access water and nutrients needed for growth and photosynthesis.

Geotropism

Geotropism is the growth response to gravity:

- **Roots**: Display positive geotropism by growing downward towards gravity.
- **Shoots**: Exhibit negative geotropism by growing upward against gravity.

In a horizontally placed seedling, the root bends downward and the shoot bends upward to maintain an upright position.

Clinostat: A clinostat is a rotating device used to neutralize the effects of gravity. By rotating the clinostat, gravity acts equally on all sides, which allows the seedling to grow straight.

2.10 Medicinal Plants

Medicinal plants are crucial for treating various diseases and infections. Over 60% of the global population relies on traditional plant-based medicines, especially in developing countries. In Ethiopia, plants such as **Ruta chalepensis**, **Zingiber officinale**, and **Hagenia abyssinica** are used to treat conditions like abdominal pain, tonsillitis, and tapeworms.

Unit Summary

- **Plants** are multicellular, autotrophic, and exhibit both asexual and sexual reproduction.
- **Gymnosperms** and **angiosperms** are the two main types of vascular plants. Gymnosperms have cones and naked seeds, while angiosperms have flowers and produce seeds within fruits.
- **Photosynthesis** is the process where plants convert sunlight into chemical energy.
- **Tropism** includes phototropism (response to light), hydrotropism (response to water), and geotropism (response to gravity). Shoots and roots respond differently to these stimuli.
- **Medicinal plants** are used globally and locally to treat various ailments and are a key component of traditional medicine.