

Chapter 2: Plant Physiology

2.1 Absorption of Water and Minerals by Roots

Plants absorb water and minerals from the soil primarily through the **roots**. This process involves various mechanisms:

- **Imbibition:** The initial absorption of water by dry tissues, leading to the swelling of cells.
- **Diffusion:** The passive movement of water or solutes from an area of high concentration to an area of low concentration.
- **Osmosis:** The movement of water across a semi-permeable membrane from an area of low solute concentration to an area of high solute concentration. It plays a critical role in water uptake by plant cells.
- **Osmotic Pressure:** The pressure exerted by the water inside the cell due to osmosis.
- **Root Pressure:** The pressure that pushes water upwards in the plant, created by osmotic movement of water into the roots.
- **Turgidity and Flaccidity:** Turgidity refers to the firmness of a plant cell due to water intake, while flaccidity refers to a lack of turgor pressure when the cell loses water.
- **Plasmolysis and Deplasmolysis:**
 - **Plasmolysis** is the shrinking of the cell membrane away from the cell wall due to water loss.
 - **Deplasmolysis** occurs when water re-enters the cell, causing it to swell again.

Water and minerals are absorbed through both **active** (energy-dependent) and **passive** (without energy) transport mechanisms.

2.2 Ascent of Sap

The ascent of sap refers to the upward movement of water and minerals from the roots to the xylem and leaves. Several forces are responsible for this process:

- **Capillarity:** The ability of water to move upwards in small tubes due to surface tension.
 - **Cohesion:** The attraction between water molecules that helps in the continuous column of water in the xylem.
 - **Adhesion:** The attraction between water molecules and the walls of xylem vessels, helping water to rise.
 - **Transpiration Pull:** The evaporation of water from the leaves creates a negative pressure that pulls more water upward from the roots through the xylem.
-

2.3 Transpiration – Process and Significance

Transpiration is the process of water vapor loss from the aerial parts of the plant, primarily through the **stomata**. It serves several purposes:

- It helps in the absorption of water and minerals from the roots.
- Transpiration creates a cooling effect, preventing overheating of the plant.
- It aids in maintaining turgidity and in the transport of nutrients.

Ganong's Potometer is an apparatus used to measure the rate of transpiration. However, it has certain **limitations**, such as not accounting for the absorption of water or the effects of environmental factors like humidity.

Factors Affecting Transpiration:

- Temperature
- Humidity
- Wind speed
- Light intensity

Experiments on Transpiration:

Experiments like **the potometer experiment** help demonstrate how various factors impact the rate of transpiration.

Guttation: The exudation of water droplets from the leaves, typically occurring when the soil is saturated with water.

Bleeding: The loss of sap from cut plant tissues, mainly observed in trees.

2.4 Photosynthesis – Process and Importance

Photosynthesis is the process by which plants convert light energy into chemical energy stored in glucose, which is used for growth and metabolism. The general process involves:

- **Light Reactions:** Occur in the thylakoid membranes of chloroplasts, where light energy is converted into chemical energy (ATP and NADPH).
- **Calvin Cycle (Dark Reactions):** Occurs in the stroma of the chloroplast, where ATP and NADPH are used to fix carbon dioxide into glucose.

Photosynthesis is vital for life on Earth as it provides the primary source of energy for nearly all living organisms. The process releases oxygen and forms the foundation of the **carbon cycle**.

Experiments to Show Necessity of Light, Carbon Dioxide, Chlorophyll:

1. **Light:** A plant in the dark will not perform photosynthesis, demonstrating the need for light.
 2. **Carbon Dioxide:** A plant in an environment lacking carbon dioxide will not produce glucose, proving its necessity.
 3. **Chlorophyll:** Without chlorophyll, plants cannot absorb light efficiently and photosynthesis will not occur.
 4. **Starch Formation and Oxygen Release:** Starch production in leaves (as an end product of photosynthesis) and the release of oxygen are crucial indicators of photosynthesis.
-

2.5 Chemical Coordination in Plants

Plants regulate their growth and development through chemical signals known as **plant hormones** or **phytohormones**. These hormones control various processes like growth, flowering, and responses to environmental stimuli. Major plant hormones include:

- **Auxins:** Involved in cell elongation and growth.
- **Gibberellins:** Promote stem elongation and flowering.
- **Cytokinins:** Stimulate cell division and delay aging.
- **Ethylene:** Regulates fruit ripening and leaf abscission.
- **Abscisic Acid:** Plays a role in stress responses and dormancy.

These hormones help coordinate processes such as tropic movements (responses to environmental stimuli) and the overall growth of the plant.

2.6 Tropic Movements in Plants

Tropic movements are directional growth responses of plants to external stimuli. These movements are classified based on the type of stimulus:

- **Phototropism:** Growth in response to light. Plants tend to grow towards light.
- **Gravitropism (Geotropism):** Growth in response to gravity. Roots exhibit positive gravitropism (grow downwards), while stems show negative gravitropism (grow upwards).
- **Thigmotropism:** Growth in response to touch or physical contact (e.g., climbing plants).
- **Hydrotropism:** Growth in response to water.

These movements allow plants to optimize their growth and survival in various environmental conditions.

2.7 Forces Responsible for Ascent of Sap

The ascent of sap (water and minerals) is facilitated by several interconnected forces:

- **Transpiration Pull:** The primary driving force for the movement of water from the roots to the leaves.

- **Cohesion and Adhesion:** These forces help maintain a continuous column of water in the xylem and prevent it from breaking under tension.
- **Capillary Action:** The ability of water to rise through narrow tubes, such as the xylem vessels, due to surface tension.

Together, these forces ensure the effective transport of water and nutrients from the roots to the leaves, where it is used for photosynthesis and other metabolic processes.