Photosynthesis – Provider of Food for All

Photosynthesis

Photosynthesis is a physiological process by which plant cells containing chlorophyll produce food in the form of carbohydrates by using carbon dioxide, water and light energy. Oxygen is released as a by-product.

Chlorophyll – The Vital Plant Pigment

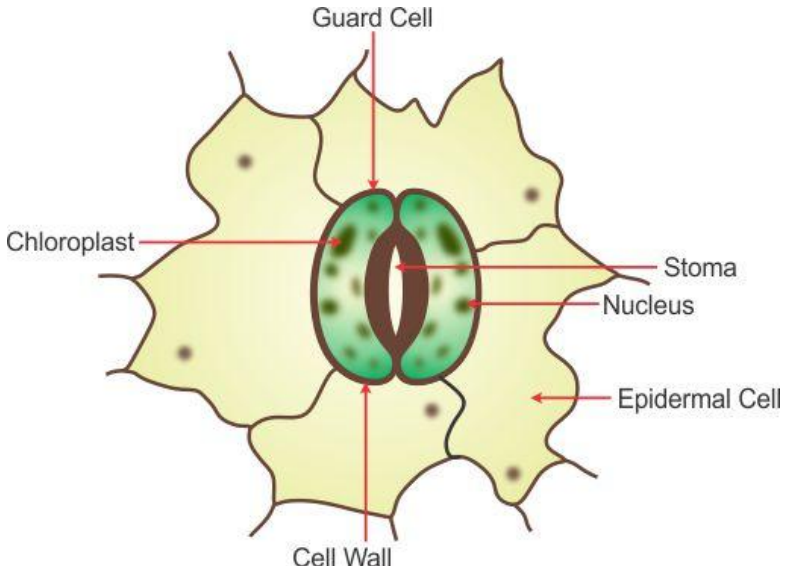
Chlorophyll is the green pigment found in green plants.
It is found in a cell organelle called **chloroplast**.
It absorbs light of red and blue wavelengths and reflects light of green wavelength. Therefore, a leaf appears green.

Chloroplast

The chloroplast is a membrane-bound, oval cell organelle.
It is enclosed by a double membrane. Its interior contains closely packed flattened sacs called **thylakoids**. Chlorophyll is present in the thylakoids.
These thylakoids are arranged in piles called **grana** lying in a colourless ground substance called **stroma**.

Regulation of Stomatal Opening

Stomata are minute openings present in the epidermal layers of leaves. They are responsible for the exchange of gases during photosynthesis.



There are two theories for opening and closing of stomata:

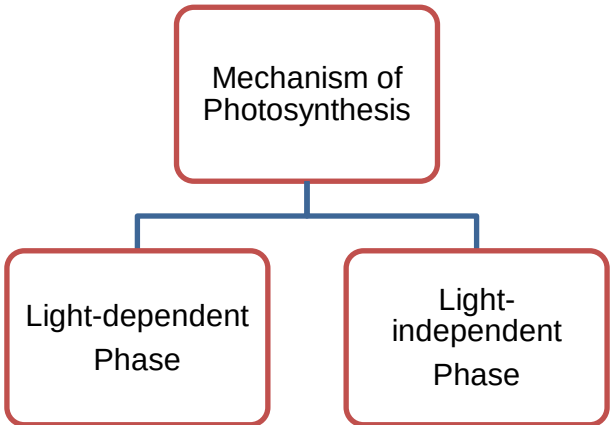
1. Sugar Concentration Theory: During the day time, as guard cells photosynthesise and produce sugar, the cells become turgid. This causes the stomata to open.
2. K^+ Ion Concentration Theory: The stomatal opening and closing depends on the generation of a potassium ion gradient.
   Increase in K^+ ion concentration inside the guard cells causes stomata to open.

Process of Photosynthesis

The palisade layer is the centre for photosynthesis. Light energy is trapped in the chlorophyll of mesophyll cells of the palisade layer of leaves.
The chemical equation for photosynthesis is

$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6H_2O + 6O_2 \uparrow$$

Two main phases are involved in the mechanism of photosynthesis:



Light-dependent Phase

The light-dependent phase is also known as the **Hill reaction** or **photochemical reaction**.
This phase takes place in the thylakoids of the chloroplast.
On exposure to light, chlorophyll becomes excited and absorbs light energy.
Energy absorbed is used in splitting of water molecules into hydrogen ion (H^+) and hydroxide ion (OH^-).
NADP picks up the hydrogen ion and is reduced to NADPH.
Molecular oxygen is released during photosynthesis.

Inter-conversion of Glucose and Starch

As soon as glucose is formed, several molecules of glucose are transformed to produce one starch molecule; this process is called **polymerisation**.
At night, starch is reconverted into soluble glucose which is transported to other parts through the phloem.
This process of transporting sugar to different parts of the plant is known as **translocation**.

Adaptations in Leaf for Photosynthesis

Large Surface Area	Leaves are broad with large surface area
Leaf Arrangement	Leaves are at right angle to the light source to obtain maximum light.
Cuticle and Upper Epidermis	Cuticle and upper epidermis are transparent.
Numerous Stomata	A large number of stomata allow the rapid exchange of gases.
Thinness of Leaves	The thinness of leaves facilitates rapid transport.
Chloroplast	Chloroplasts are concentrated in the upper layers of the leaf.
Extensive Vein System	An extensive vein system allows rapid transport to and from the mesophyll cells.

Factors Affecting Photosynthesis

External Factors

- **Light Intensity:** The rate of photosynthesis increases with the light intensity up to a certain limit and then it stabilises.
- **Carbon Dioxide:** The rate of photosynthesis increases with increase in the concentration of carbon dioxide up to a certain limit and then it stabilises.
- **Temperature**: The rate of photosynthesis increases with the rise in temperature, usually up to the optimum temperature 35°C.
- **Water Content:** The scarcity of water due to excessive transpiration or reduced absorption by roots decreases the rate of photosynthesis.

Internal Factors

- **Chlorophyll:** More amount of chlorophyll results in increase in the rate of photosynthesis.
- **Protoplasm:** Dehydration of protoplasm or accumulation of carbohydrates in the protoplasm reduces the rate of photosynthesis.
- **Structure of Leaf:** Thickness of cuticle, distribution of stomata and the size of leaf influence the rate of photosynthesis.

Experiments on Photosynthesis

Destarching

The plants used for the experiment must be destarched 24–48 hours before. During these 24–48 hours, all the starch from leaves is removed, and they do not show the presence of starch.
The blue-black colour indicates the presence of starch. (The brown colour indicates the absence of starch).

Factors necessary for photosynthesis are chlorophyll, sunlight and carbon dioxide which can be proved by performing experiments.

Importance of Photosynthesis

- **Provides Food:** All animals are directly or indirectly dependent on plants for their food. Hence, photosynthesis is an important physiological process.
- **Provides Oxygen:** Oxygen is present in a free state in the atmosphere because of photosynthesis. Almost all organisms need oxygen for respiration.

Carbon Cycle

The carbon cycle is a series of chemical reactions in which carbon is absorbed from the atmosphere in the form of CO_2, used by living organisms for their body processes and is finally returned to the atmosphere.