Brain Builders Coaching Center

Photosynthesis

Class- X ICSE

Plants – self food producers

- All living organisms need food.
- Animals depend on plants for food.
- **Green plants prepare their own food** through *photosynthesis*.

What is photosynthesis?

- It is a process by which green plants synthesize food (glucose and starch) using carbon dioxide, water, sunlight, and chlorophyll.
- Plants release oxygen as a waste product.

Photosynthesis is the process by which living plant cells, containing chlorophyll, produce food substances (glucose and starch), from carbon dioxide and water, by using light energy. Plants release oxygen as a waste product during photosynthesis.

Importance of Photosynthesis

1. **Food for all** – Directly (herbivores) and indirectly (carnivores & omnivores).
2. **Oxygen** – Only biological process releasing O_2.
3. **Purifies the atmosphere** – Removes CO_2, adds O_2.
4. **Maintains energy flow** – It is the base of food chains and food webs.

Chlorophyll – The Vital Plant Pigment

- Green pigment found in chloroplasts.
- Chloroplasts have **thylakoids** arranged in stacks called **grana**.
- **Grana** – Site of light reaction of photosynthesis.
- **Stroma** – Site of dark reaction.

Stomatal Opening For Letting In Co_2

- Main function of stomata = intake of CO_2.
- Stomata are present on the lower surface of leaves.

Theories of Stomatal Opening:

1. **Sugar Concentration Theory:**
    - Sugar production increases osmotic pressure.

- Guard cells absorb water, become turgid, and open stomata.
- When sugar reduces, cells lose water and stomata close.

2. **Potassium Ion (K^+) Theory:**
   - K^+ actively pumped into guard cells using ATP.
   - Osmotic pressure increases → water enters → stomata open.
   - Reverse happens when K^+ leaves → stomata close.

Process Of Photosynthesis

- Takes place in **mesophyll cells** of leaves.

Main Events:

1. **Carbon dioxide** enters via stomata.
2. **Water** absorbed by roots, transported to leaves.
3. **Light** energy absorbed by chlorophyll.
4. **Glucose** is synthesized.
5. **Oxygen** is released.

Equation:

$$6CO_2 + 12\ H_2O \xrightarrow{\text{Sunlight, Chlorophyll}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

Two Main Phases Of Photosynthesis

(A) Light-dependent phase (photochemical phase)

- Occurs in grana (thylakoids).
- Requires light, chlorophyll, water.

Steps:

1. **Activation of chlorophyll** – Chlorophyll absorbs light and gets excited.
2. **Photolysis of water** – Light splits water into:
   - $2H_2O \rightarrow 4H^+ + 4e^- + O_2\uparrow$

End Products:

- **Oxygen** → Released into air.
- **ATP** and **NADPH** → Used in next phase.

(B) Light-Independent Phase (Biosynthetic / Dark Phase)

- Occurs in **stroma**.
- Does **not** require light.
- Uses ATP & NADPH to convert **CO_2 into glucose**.

- Involves **polymerisation** of glucose to form starch.

Highly Simplified Summary

Light Reaction (in grana):

- Light + $H_2O \rightarrow O_2$ + ATP + NADPH

Dark Reaction (in stroma):

- CO_2 + ATP + NADPH → Glucose ($C_6H_{12}O_6$)

Adaptations in leaf for photosynthesis

1. **Large surface area** – absorbs more light.
2. **Leaf arrangement** – at correct angle to receive maximum light.
3. **Cuticle & upper epidermis** – transparent and waterproof.
4. **Numerous stomata** – for gas exchange.
5. **Thinness of leaf** – allows light penetration.
6. **Chloroplasts in upper layers** – capture light efficiently.
7. **Vascular system** – transports water and food.

End products of photosynthesis

1. **Glucose** – Used in:
    - Immediate energy
    - Stored as starch
    - Converted to sucrose
    - Used in proteins, lipids synthesis
2. **Water** – Can be reused in photosynthesis.
3. **Oxygen** – Released into air, supports life.

Factors affecting photosynthesis

External Factors:

1. Light Intensity

Higher light intensity increases the rate of photosynthesis up to a certain limit, beyond which it becomes constant as other factors become limiting.

2. Carbon Dioxide Concentration

An increase in CO_2 concentration boosts photosynthesis, but only till a saturation point, after which it no longer increases the rate.

3. Temperature

Photosynthesis rate rises with temperature up to about 35°C, after which enzymes get denatured and the rate drops.

4. Water Content

Water is essential for photosynthesis; less water causes stomatal closure, reducing CO_2 intake and slowing down the process.

Internal Factors:

1. **Chlorophyll** – Its deficiency lowers photosynthesis.
2. **Protoplasm** – Dehydration lowers photosynthesis.
3. **Structure of Leaf** – Stomata size and distribution affect CO_2 intake.

Experiments On Photosynthesis

(1) Destarching a Leaf:

- Keep plant in dark for 24–48 hrs to remove existing starch.

(2) Iodine Test:

- Boil the leaf → Dip in alcohol to remove chlorophyll.
- Test with iodine solution → Turns blue-black in presence of starch.

Experiment 1: Chlorophyll is Necessary

- Use a variegated leaf (green and non-green).
- After destarching, expose to sunlight.
- Only green parts turn blue-black with iodine.

Experiment 2: Sunlight is Necessary

- Cover leaf part with black paper.
- After exposure to sunlight, covered part remains brown, uncovered turns blue-black.

Experiment 3: CO_2 is Necessary

- Use a leaf in flask with KOH (absorbs CO_2).
- Other half exposed to air.
- Only half exposed to CO_2 shows starch presence.

Importance of Photosynthesis

1. **Food Source:**
   Photosynthesis provides food for all living organisms, directly for herbivores and indirectly for carnivores and omnivores.
2. **Oxygen Supply:**
   It is the only biological process that releases oxygen into the atmosphere, essential for respiration in all aerobic organisms.
3. **Carbon Dioxide Control:**
   It helps maintain atmospheric balance by absorbing carbon dioxide and releasing oxygen.
4. **Energy Flow in Ecosystem:**
   Photosynthesis is the base of all food chains and drives the energy flow in ecosystems.

Photosynthesis and Carbon Cycle

- During photosynthesis, plants absorb CO_2 from the atmosphere and convert it into glucose.
- This carbon is passed through the food chain and returns to the atmosphere through respiration, decay, or combustion, maintaining the carbon cycle.