PHOTOSYNTHESIS IN HIGHER PLANTS

Photosynthesis is a physico-chemical process by which green plants use light energy to drive the synthesis of organic compounds. It is an enzyme regulated **anabolic process.**

- Basis of life on earth as it is primary source of all food and is responsible for release of O_2 in the atmosphere.

$$6CO_2 + 12H_2O \xrightarrow{Light} C_6H_{12}O_6 + 6H_2O + 6O_2$$

Raw Material	Sources
CO2	Atmosphere
Chlorophyll	Green Parts of Plant
Sun Light	Sun
Water	Soil

Necessity of Chlorophyll (Green Pigment of Leaf)

- Take a potted plant with variegated leaf.
- **Destarching**- Keep the plant in dark for a day so that all the starch gets used.
- Now keep the plant in sunlight for 6 hrs
- Pluck the variegated leaf
- perform **starch test** –
    - Dip the leaf in boiling water for few mins
    - Now Boil the leaf in Alcohol (leaf will loses its colour)
    - Pour iodine solution on leaf
- Observation: Green part of variegated leaf turns blue black and non-green part do not.
- Conclusion : Green parts contain Chlorophyll that is essential for photosynthesis.

Necessity of Carbon Dioxide

- A part of leaf is enclosed in a test tube.
- The test tube contains KOH (it absorbs carbon dioxide) and the another half of leaf is exposed to light & air.
- Exposing light for about few hours, when starch test was done.
- Observation: Exposed part of leaf tested positive for starch while, the portion enclosed in the tube tested negative.
- Conclusion: CO_2 is also essential for photosynthesis.

Necessity of Light

- Take a potted plant & destarch it.
- Place a black strip on a leaf and keep it in sunlight for 6 hrs and perform starch experiment.
- Observation: Exposed part turns blue black and part of leaf covered with black strip do not.
- Conclusion: Starch is produced only in area that received light, shows that light is necessary for photosynthesis.

Necessity of Water

Through radio labelling of oxygen in water molecule, it is confirmed that the 02 released during photosynthesis comes from H_2O, not CO_2.

Early Experiments

Priestley/ Bell Jar Experiment

- In 1770 Joseph Priestley (1733-1804) performed his experiments
- A mouse kept in closed space get suffocated and die as candle extinguished.
- If a mint plant is kept in bell jar neither candle will extinguish nor will the mouse die.

- Conclusion: Foul air produced by animal is converted into pure air by plants hence discovered Oxygen gas in 1774.

Jan Ingenhousz (1730-1799)

- Using similar setup as of Priestley showed that sunlight is essential to the plant in the process that somehow purifies the air fouled.
- He showed that in aquatic plant in presence of bright sunlight, small bubbles were formed around the green parts while in the dark they did not.
- identified later bubbles to be of oxygen.

Julius Von Sachs

- In 1854 shows that green part in plants produces glucose which is stored as starch.

T.W.Engelmann (1843-1909)

- Used prism to split light and found Cladophora (an algae) placed in a suspension of aerobic bacteria.
- Observation: Bacteria accumulated in blue and red light of the spectrum where O_2 evolved.
- Conclusion: Photosynthesis depends on wave length of light. Occur mostly in blue and red region.
  Action spectrum of photosynthesis roughly resembles the absorption spectra of chlorophyll-a & b.

Cornelius Van Neil (1897-1985)

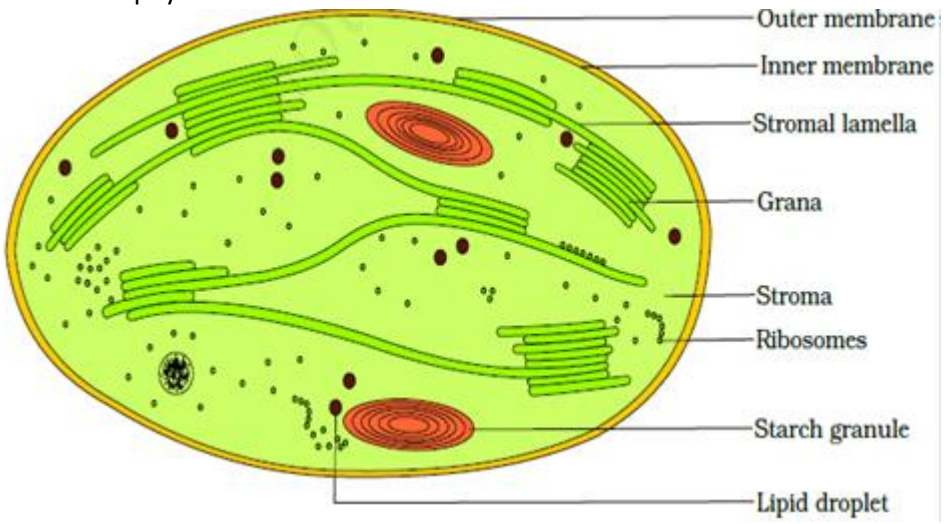
- On the basis of studies with purple and green sulphur bacteria showed that in photosynthesis hydrogen from an oxidisable compound reduces CO_2 to form carbohydrate.

$$2H_2A + CO_2 \xrightarrow{Light} 2A + CH_2O + H_2O$$

In green sulphur bacteria, when H_2S, instead of H_2O was used as hydrogen donor, no O_2 was evolved. He inferred that O_2 evolved by green plants comes from H_2O (proved by radio isotopes technique) but not from CO_2 as thought earlier.

Where Does Photosynthesis Takes Place?

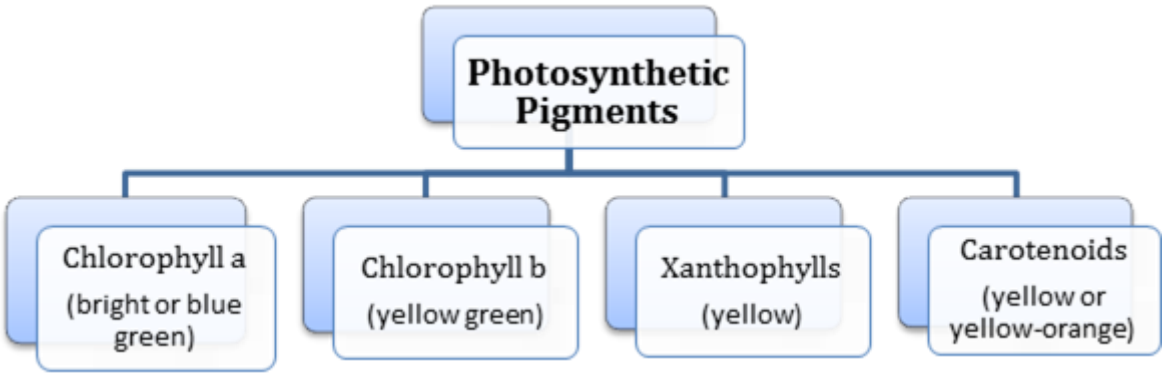
- Chloroplasts are **green plastids** which function as the site of photosynthesis in eukaryotic photoautotrophs.
- Chloroplast is semiautonomous, double membrane organelle in which division of labour takes place.
- Within the chloroplast there is a membranous system consisting of grana, the stroma lamellae and the fluid stroma.
- Under Stress/ Low light condition chloroplast will align parallel while in noon it would be perpendicular to the mesophyll walls.

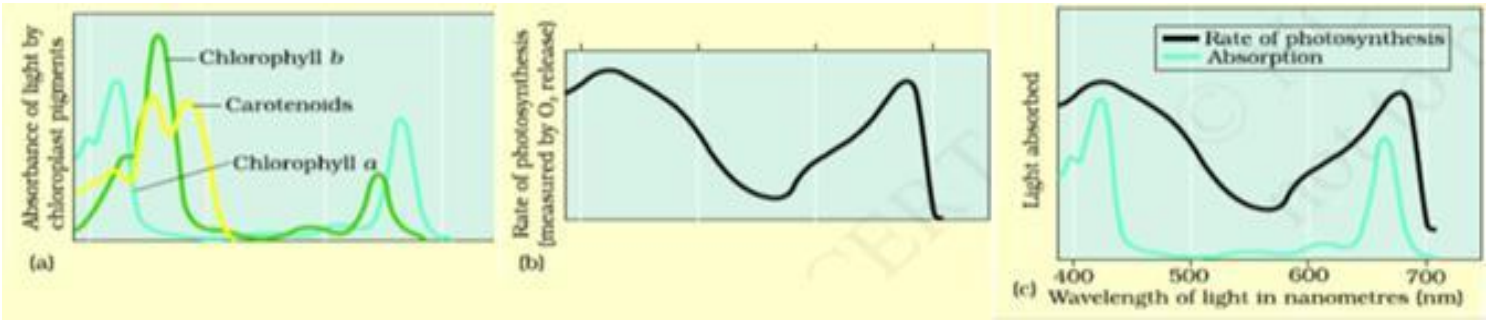


- The membrane system is responsible for synthesizing light energy for the synthesis of ATP and NADPH. In stroma enzymatic reactions incorporate CO_2 in plants leading to synthesis of sugar.
- The reaction in which light energy is absorbed by grana to synthesis ATP and NADPH is called **light reaction**.

- The later part of photosynthesis takes place in stroma in which CO_2 is reduced to sugar, light is not necessary and is called **dark reaction**.

Pigments involved in Photosynthesis – Chromatographic separation of leaf pigments are as follows-





Maximum absorption by chlorophyll a occurs in blue and red regions having higher rate of photosynthesis.
Hence, **chlorophyll a (blue green)** is the chief pigment.

- Other thylakoid pigments like **chlorophyll b** (yellow & green), xanthophyll (yellow) and carotenoids (yellow to yellow-orange) are called **accessary pigments** that absorb light and transfer energy to chlorophyll a and protect them from photo-oxidation.
- Energy is inversely proportional to Wavelength.
- White light spectrum- VIBGYOR (Max Wavelength/ Minimum Energy = Red)

Light reaction

- Light reaction(photochemical phase) includes:

1. Light absorption
2. Water splitting
3. Oxygen release
4. Formation of high energy chemical intermediates (ATP and NADPH).

- The pigments are organized into two discrete LHC(light harvesting complex) within photosystem I (discovered first) and photosystem II (discovered later) .
- LHC are made up of hundreds of pigments molecules containing all pigments except single chlorophyll a also called antenna.
- Single chlorophyll a molecule makes the **reaction centre**.
- In PS I reaction centre has highest peak at 700nm, hence called P700.
- In PS II reaction centre has highest peak at 680 nm, so called P680.