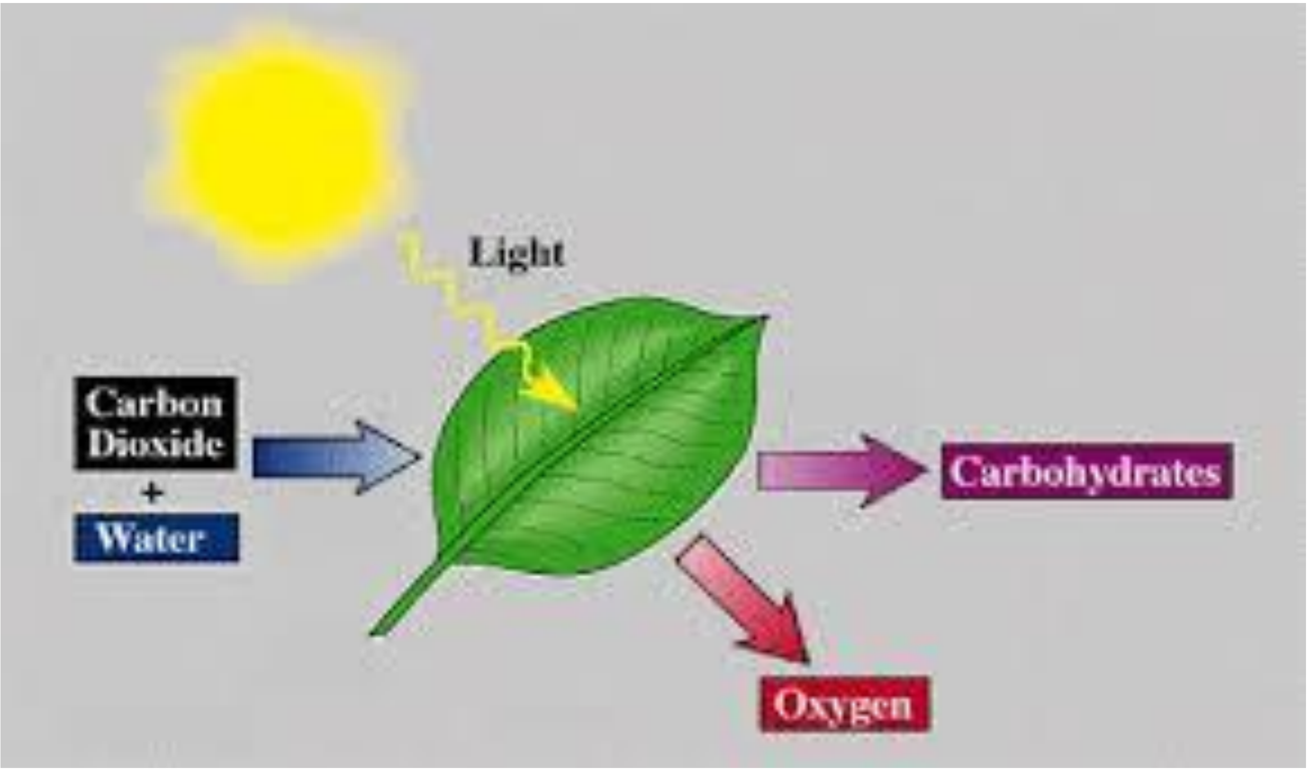
PHOTOSYNTHESIS

For B.Sc. Part II (Subs) Group C (Plant Physiology)



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Lecture No.04

Photosynthesis ????

"Photosynthesis is a photo-biochemical process **(anabolic & endergonic) in which organic compound (carbohydrates)** are synthesized from the inorganic **raw material (H_2O & CO_2) in presence of light & pigments. O_2 is evolved as a by** product".

- The term photosynthesis means literally "synthesis using light."

Photosynthetic organisms use solar energy to synthesize carbon compounds that cannot be formed without the input of energy.

- More specifically, light energy drives the synthesis of carbohydrates from carbon dioxide and water with the generation of oxygen:

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

- Energy stored in these molecules can be used later to power cellular processes in the plant and can serve as the energy source for all forms of life.

- The most active photosynthetic tissue in higher plants is the mesophyll of leaves.
- Mesophyll cells have many chloroplasts, which contain the specialized light-absorbing green pigments, the **chlorophylls.**
- **In photosynthesis,** the plant uses solar energy to oxidize water, thereby releasing oxygen, and to reduce carbon dioxide, thereby forming large carbon compounds, primarily sugars.
- The complex series of reactions that culminate in the reduction of CO_2 include the thylakoid reactions and the carbon fixation reactions.
- The **thylakoid reactions of photosynthesis take place in** the specialized internal membranes of the chloroplast called thylakoids.

The end products of these thylakoid reactions are the high-energy compounds ATP and NADPH, which are used for the synthesis of sugars in the **carbon fixation reactions.**

- **These synthetic** processes (synthesis of sugar) take place in the stroma of the chloroplasts, the aqueous region that surrounds the thylakoids.
- In the chloroplast, light energy is converted into chemical energy by two different functional units called photosystems.
- The absorbed light energy is used to power the transfer of electrons through a series of compounds that act as electron donors and electron acceptors.
- The majority of electrons ultimately reduce NADP+ to NADPH and oxidize H2O to O2.
- Light energy is also used to generate a proton motive force across the thylakoid membrane, which is used to synthesize ATP.
- ✓ First true & oxygenic Photosynthesis started in cyanobacteria. (BGA).
- ✓ In the Cuscuta & Fungi Photosynthesis is absent. Euglena is Photosynthetic organism & is link between animal & plants.

✓ Roots of Tinospora & Trapa are assimilatory or Photosynthetic.

✓Absorption spectrum of Photosynthesis is blue & red light. (maximum absorbed part of spectrum).

✓ Action spectrum of Photosynthesis in red & blue light (most effective in reaction).

Photosynthetic pigments

Many pigment present in photosynthetic cells. PSU (Photosynthetic units) presents on thylakoid membrane, are made up of 230-240 molecules of various pigments, called Quantasome by Park & Biggins.

➢ The PS II is located in the appressed region of granal thylakooids and PS I in non appreassed region of grana and stroma thylakoids.

➢ PS I located - on both granum & intergrnum (Stroma thylakoid).

➢ PS II located - on only granum (P- 680, 680 nm non cyclic ETS).

- Chlorophyll - a $C_{55}H_{72}O_5N_4Mg$ (CH_3 group. at 3rd Carbon of 2nd pyrrole ring)
- Chlorophyll - b $C_{55}H_{70}O_6N_4Mg$ (CHO group at 3rd C of 2nd pyrrole).

Chlorophylls are magnesium porphyrin compounds. Porphyrin ring consists of four-pyrrole rings (Tetrapyroole).

- Chlorophyll molecule ahs a Mg-porphyrin head and alcoholic phytol tail. Head is hydrophilic and phytol tail is hydrophobic.
- Phytol tail is alcoholic with one double bond. Phytol part embedded in lipid layer.
- Chl - a and carotenes are universal pigment, which are found in all O_2 liberating cells.
- Chlorophlls are soluble only in organic solvents. Stroma lamellae/stroma thylakoids lack PS II and enzyme NADP reductase.

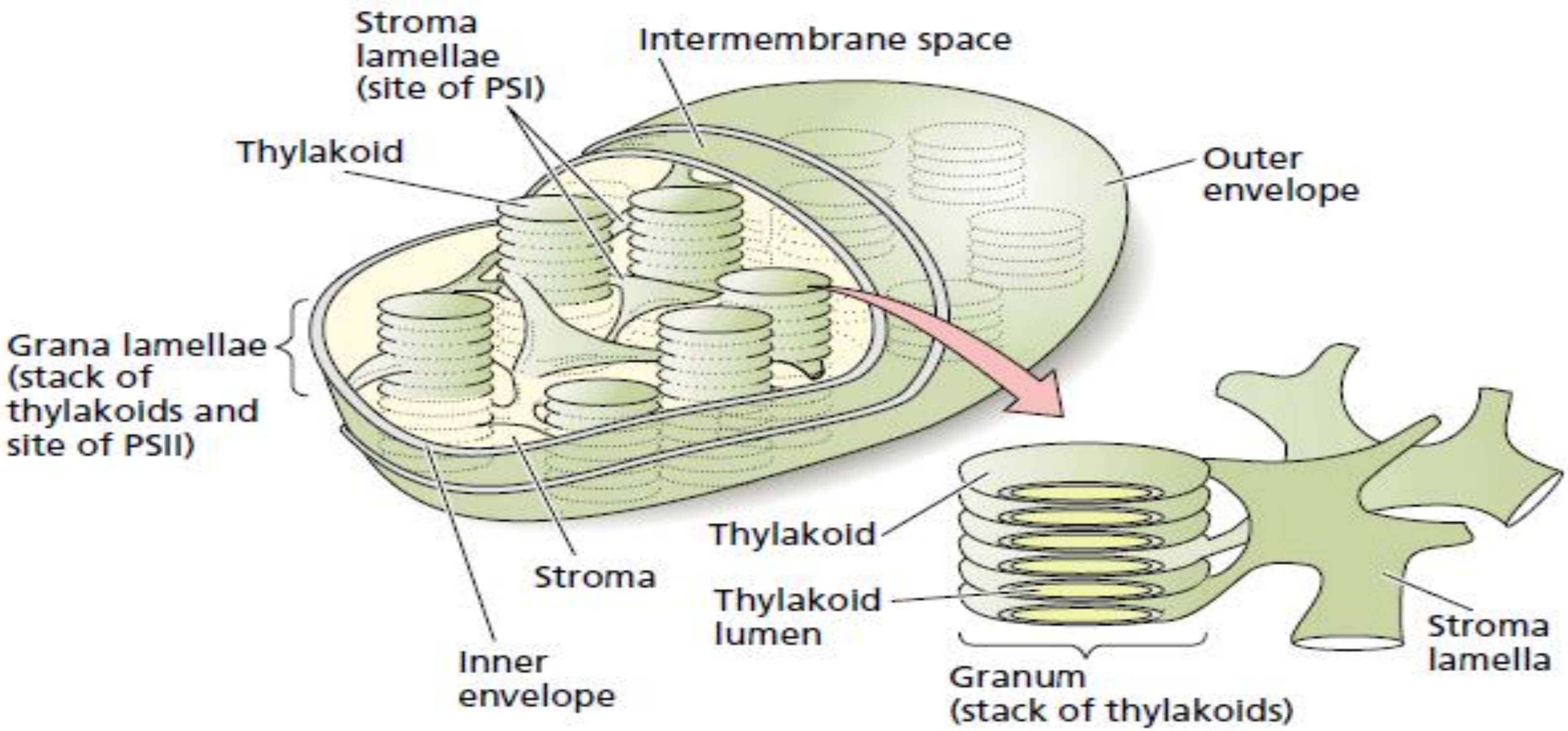
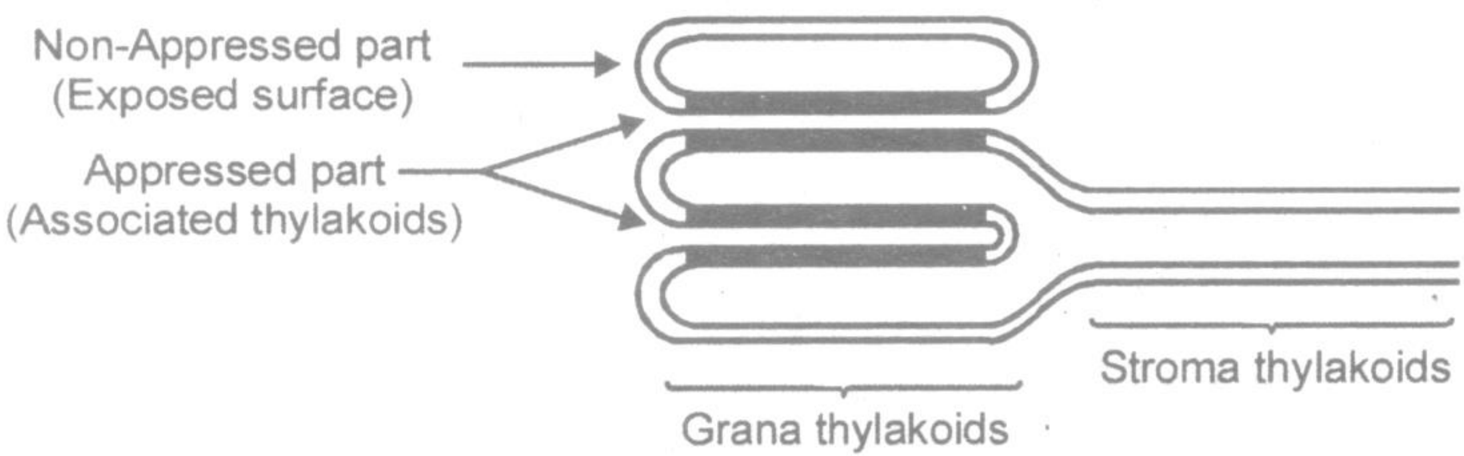


Figure: Organization of membranes in the Chloroplast



Photosynthesis Takes Place in Complexes Containing Light-Harvesting Antennas and Photochemical Reaction Centers

- A portion of the light energy absorbed by chlorophylls and carotenoids is eventually stored as chemical energy via the formation of chemical bonds.
- This conversion of energy from one form to another is a complex process that depends on cooperation between many pigment molecules and a group of electron transfer proteins.
- The majority of the pigments serve as an **antenna complex,** collecting light and transferring the energy to the **reaction center complex, where the chemical oxidation and** reduction reactions leading to long-term energy storage take place.

In 1932, Robert Emerson and William Arnold performed a key experiment that provided the first evidence for the cooperation of many chlorophyll molecules in energy conversion during photosynthesis.

- They delivered very brief (10–5 s) flashes of light to a suspension of the green alga *Chlorella pyrenoidosa* and measured the amount of oxygen.
- The flashes were spaced about 0.1 s apart, a time that Emerson and Arnold had determined in earlier work was long enough for the enzymatic steps of the process to be completed before the arrival of the next flash. The investigators varied the energy of the flashes and found that at high energies the oxygen production did not increase when a more intense flash was given: The photosynthetic system was saturated with light.
- In their measurement of the relationship of oxygen production to flash energy, Emerson and Arnold were surprised to find that under saturating conditions, only one molecule of oxygen was produced for each 2500 chlorophyll molecules in the sample. We know now that several hundred pigments are associated with each reaction center and that each reaction center must operate four times to produce one molecule of oxygen—hence the value of 2500 chlorophylls per O2.

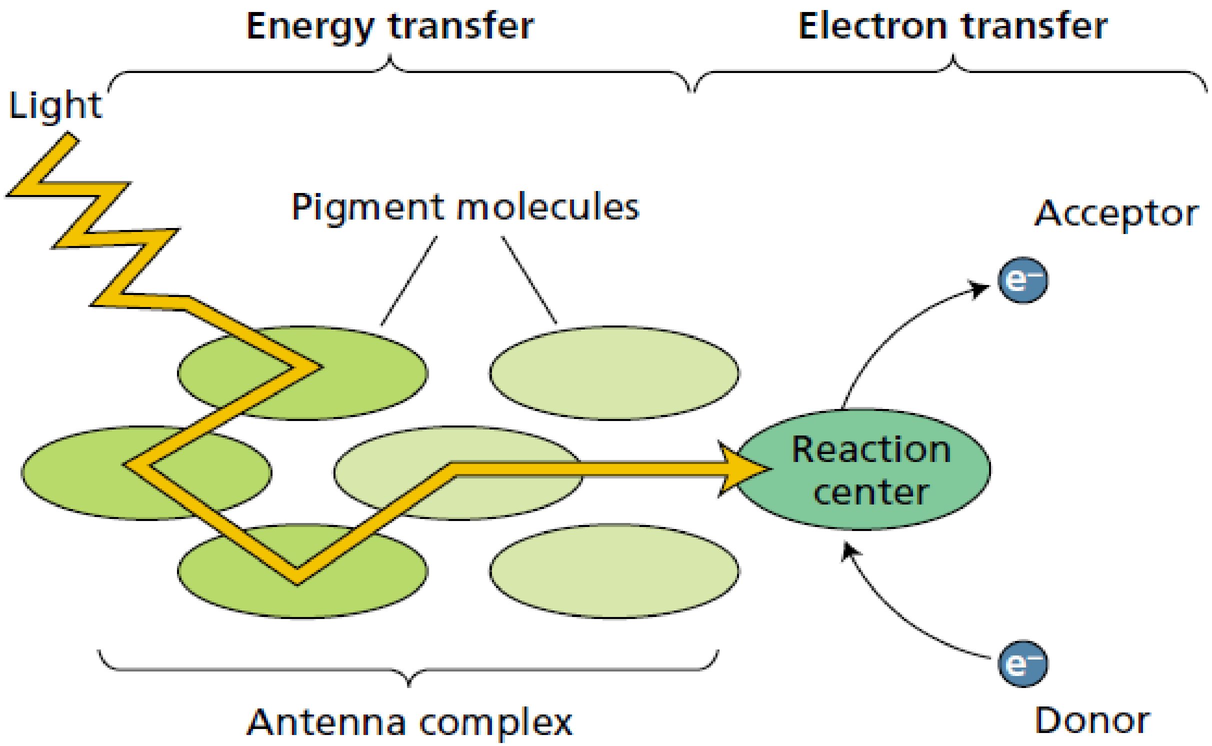


Figure: Energy transfer during photosynthesis

Light reaction/Hill reaction/Photochemical reaction: …………..will be discussed in next lecture

Thank You !!