LESSON-11
PHOTOSYNTHESIS

Photosynthesis (Photo = light; synthesis = to join) is the single most important process on earth on which depends the existence of human beings and almost all other living organisms. It is a process by which green plants, algae and chlorophyll containing bacteria utilize the energy of sunlight to synthesize their own food (organic matter) from simple inorganic molecules.

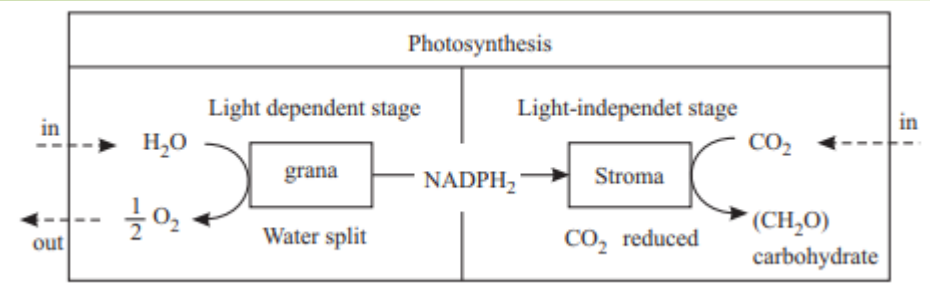
- Green plants are capable of synthesizing carbohydrates from CO2 and H2O in the presence of light, by the process of photosynthesis
- During photosynthesis 'light energy', which is captured by the photosynthetic pigments (chlorophyll, carotenoids and xanthophylls) present in the chloroplasts, is converted into chemical energy.
- Photosynthesis is represented by the following overall chemical equation:

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

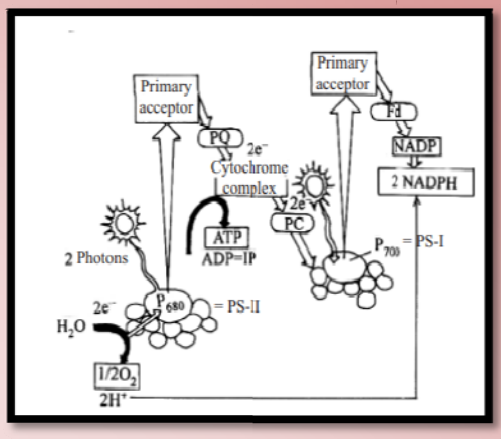
- Chlorophyll-a (a special type of chlorophyll) is the main pigment that traps solar Plants and animals energy and converts it into chemical energy.
- Chl-a is called the essential photosynthetic pigment responsible for representing the reaction centre.
- These pigments, that is the reaction centres (Chl-a) and the accessory pigments (harvesting centre) are packed into functional clusters called **photosystems**.
- Photosystems are of two types **PSI and PSII.**

	PSI	PSII
1.	PS I has a reaction centre of chlorophyll 'a' molecule with maximum light absorption at 700 nm wavelength. This reaction centre is referred to as P700.	PS II has a reaction centre of chlorophyll 'a' molecule with maximum light absorption at 680 nm. This reaction centre is also referred to to as P680.
2.	Primary electron acceptor is an iron protein (Fe-S-protein	Primary electron acceptor, pheophytin is a modified chlorophyll-a molecule with 2 hydrogen atoms in place of magnesium ion
3.	A set of electron carriers are plastocyanin, ferredoxin and cytochrome	A set of electron carriers are pheophytin plastoquinone, cytochromes.

- Photosynthesis occurs maximum in blue and red region of spectra. Photosynthesis is very little in green and yellow light, because these rays are reflected back from the leaf.
- The entire process of photosynthesis takes place inside the chloroplast. The structure of chloroplast is such that the **light dependent (light reaction)** and **light independent (Dark reaction)** reactions take place at different sites in the same organelle.
- Light reactions: which take place in grana or thylakoids of chloroplasts only in the presence of light with the help of two functional units, photosystem-I and photosystem-II.



- **Non-cyclic photophosphorylation** where electrons flow from water molecule to PSII and then to PSI and ultimately reduce NADP to NADPH2. Since the electron flow is unidirectional and the electrons released from one molecule do not return to the same molecule, it is called non-cyclic photosphorylation
- **Cyclic photophosphorylation** occurs in photosynthetic bacteria which lack PS-II, and it involves PSI only. During this process electrons from PSI are not passed on to NADP. Instead the same electrons are returned to the oxidised P700 molecule. During this downhill movement of electrons ATP formation takes place. Thus this is termed as cyclic photophosphorylation



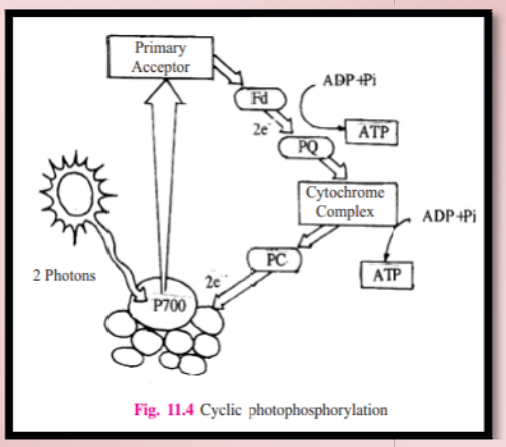
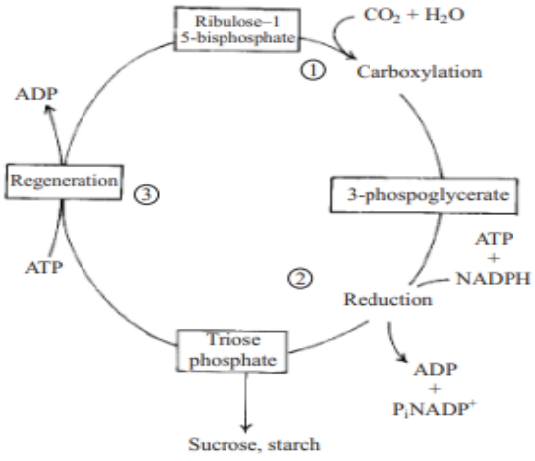


Fig. 11.4 Cyclic photophosphorylation

- During dark reactions CO2 is accepted by Ribulose biphosphate (RuBP) and the first stable product. 3-PGA (3 phosphoglyceric acid) is formed, which by further cyclic reactions (Calvin Cycle) leads to the formation of carbohydrates as well as in regeneration of RuBP.



Calvin Cycle

- In C4 plants like maize, jawar, bajra, the primary acceptor of CO2 is in mesophyll cells and the first detectable product of dark reaction is oxaloacetic acid (OAA), whereas in the bundle sheath cells CO2 fixation occurs through Calvin cycle.

✓ Occurrence of dimorphic chloroplasts in C4 plants is known as "**Kranz anatomy**" and is characterized by the presence of a sheath of parenchyma cells around a vascular bundle (bundle sheath). Cells of this sheath have larger chloroplasts which lack grana and are filled with starch grains. In contrast mesophyll cells contain chloroplasts which are smaller but have well developed grana.

	C_3 Plants	C_4 Plants
Carbon dioxide fixation	Occurs once	Occurs twice, first in mesophyll cells, then in bundle sheath cells.
Carbon dioxide acceptor	Only one acceptor, RuBP which occurs in all green cells of the plant	In Mesophyll cells, PEP (Phosphoenol Pyruvic acid), 3-C, compound is CO_2 acceptor, but in the bundle sheath cells-RuBP, 5C, compound, is the CO_2 acceptor
Carbon dioxide fixing enzymes	RuBP carboxylase, which is not efficient when CO_2 conc is low	PEP caboxylase which is very efficient, even if CO_2 conc. is low RuBP carboxylase, works efficiently because carbon dioxide concentration is high.
First product of photosynthesis	The first stable product is 3-C compound phosphoglyceric acid	The first product is 4-C compound oxaloacetic acid
Concentration of CO_2	Higher CO_2 conc. promotes photosynth]esis	Photosynthetic efficiency is high even if CO_2 conc. is low
Leaf anatomy	Only one type of chloroplast Kranz' anatomy is absent	Two types of chloroplasts (dimorphic) or Kranz' anatomy, i.e., two types of cells. each with its own type of chloroplasts are present.
Photorespiration	Occurs; excess of oxygen is an inhibitor of photosynthesis	Photorespiration is absent. The photo synthetic efficiency is further increased
Efficiency	Less efficient plotosynthesis than C_4 plants. Yields usually much lower.	More efficient photosynthesis as compared to that of the C_3 plants. Yields usually much higher.

Test Yourself

1. Write down the difference between PSI and PSII.
2. Write short notes on (i) C3 and C4 Plants (ii) Calvin Cycle.
3. Mention the steps involved in the light reaction of photosynthesis?