CHAPTER – 13

PhotoSynthesis In Higher Plants

The Photosynthesis is defined as an enzymatic anabolic process in which synthesis of organic compounds (food) inside the chlorophyll containing cells utilizing CO_2 & H_2O in presence of sunlight as a source of energy.

Site for Photosynthesis —

1. Maximum Photosynthesis will occur in the mesophyll tissues of the leaves.
2. chloroplast are the actual site of photosynthesis
3. The thylakoids have Quantasomes which trap the light energy to produce ATP and NADPH
4. Light reaction takes place in the grana and stroma carries out dark reaction in a chloroplast.
5. Mechanism of Photosynthesis.

It involves two major steps / phases namely
a) Light reaction (b) Dark reaction

Light Reaction :–

1. It is light dependent reaction occurs in grana
2. Only water is involved in this reaction
3. The ATP & $NADPH_2$ the assimilatory powers needed for Dark reaction is produced here.

The 3 steps of light reaction are
1) Photo excitation of the Chlorophyll
2) Photo ionisation or Photolysis of H_2O
3) Photo phosphorylation.

I Photo excitation of Chlorophyll —

The chlorophyll molecules absorbs the light energy (Photon) and emit energy rich electoons and the chlorophyll gets excited from the ground state It becomes unstable. The electoons are sent to reaction centres.

II Photolysis / Photoionisation of H_2O —

It is the Process of splitting of H_2O molecules to produce electrons, Protons and oxygen in the reaction centre of the chlorophyll.

$$2H_2O \longrightarrow 4H^+ + 4e^- + O_2\uparrow$$ Atmos

III Photo phosphorylation :—

It is the formation of ATP from ADP and iP (inorganic phosphate) in presence of light.

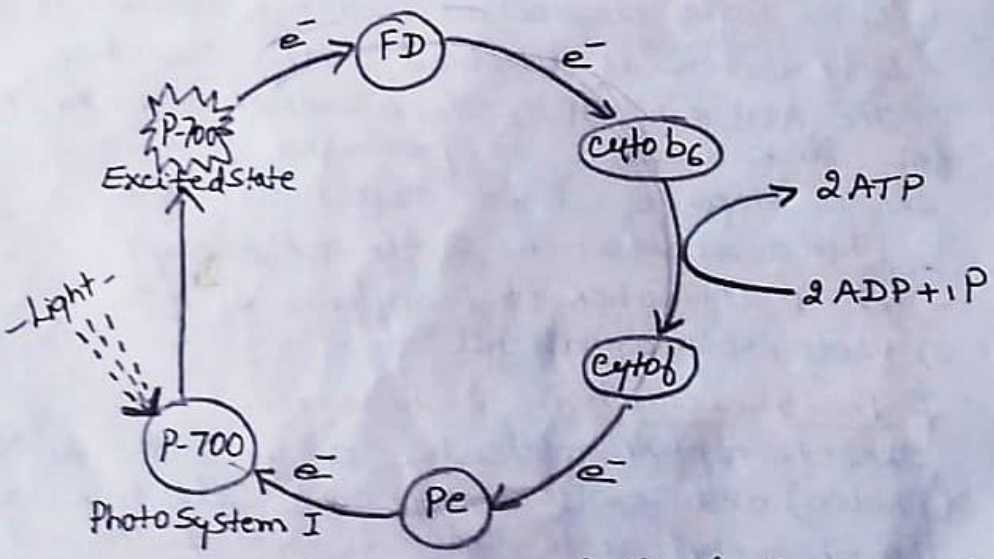
a. cyclic Photophasphorylation

b. Non-cyclic photophosphorylation.

a. Cyclic Photophosphorylation :-

It is the Process of formation of ATP from ADP by the cyclic transfer of energy-rich electrons through a series of electron acceptors.

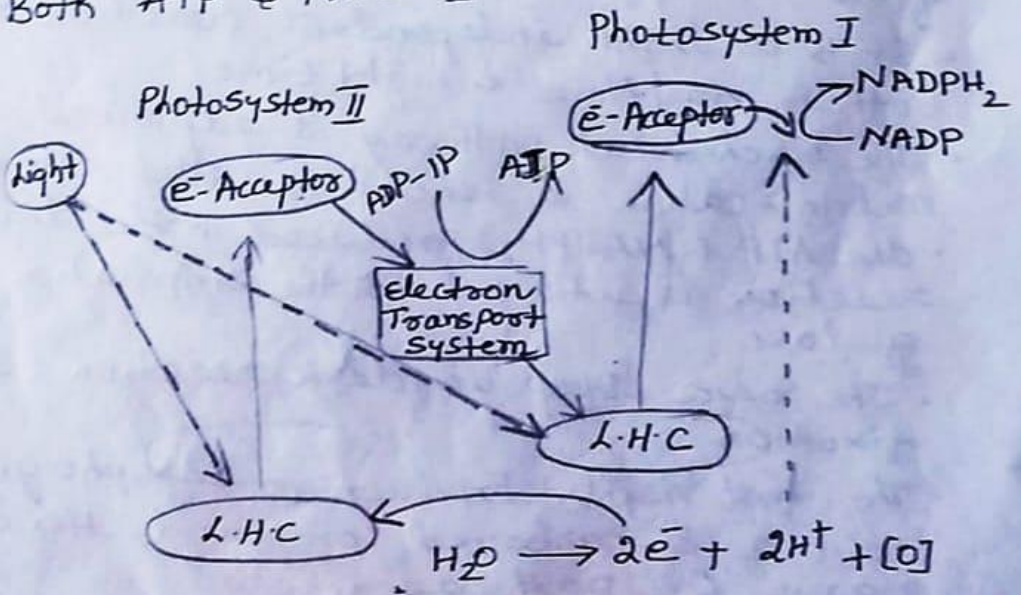
1. The cyclic flow involves Photosystem I (P-700)
2. Each cycle forms 2 molecules of A.T.P.
3. This is the alternate method of light reaction occur during certain circumstances.



4. The emitted electron comes back to the same molecule Hence it is cyclic Path. / Photophosphorylation.

Non - cyclic Photophosphorylation

1. Here two reaction centres ie Photosystem I and Photosystem II are involved.
2. The reaction centre of P.S I is P-700 and P.S II P-680
3. The energy rich electrons which are expelled from P.S. II will go to P.S I and never come back to the same centre. Hence it is said to be non-cyclic.
4. The grana of the chloroplast are the sites of activity.
5. P.S. II absorbs the photon at the wavelength of 680nm and becomes excited. The electrons expelled are accepted by various acceptors, finally reaches P.S. I
6. During this process ATPs are released.
7. Simultaneously P.S I also excited at 700nm & the electrons are transfered to $NADP^+$ to produce $NADPH_2$. For this H^+ is donated by H_2O & e^- by P.S. I
8. The electrons flows in the shape of 'Z', it is also called 'Z' scheme.
9. P.S I accepts the electrons from H_2O to become stable.
10. Both ATP & $NADPH_2$ are Produced here.



Differences between cyclic and non-cyclic electron transport and Photophosphorylation

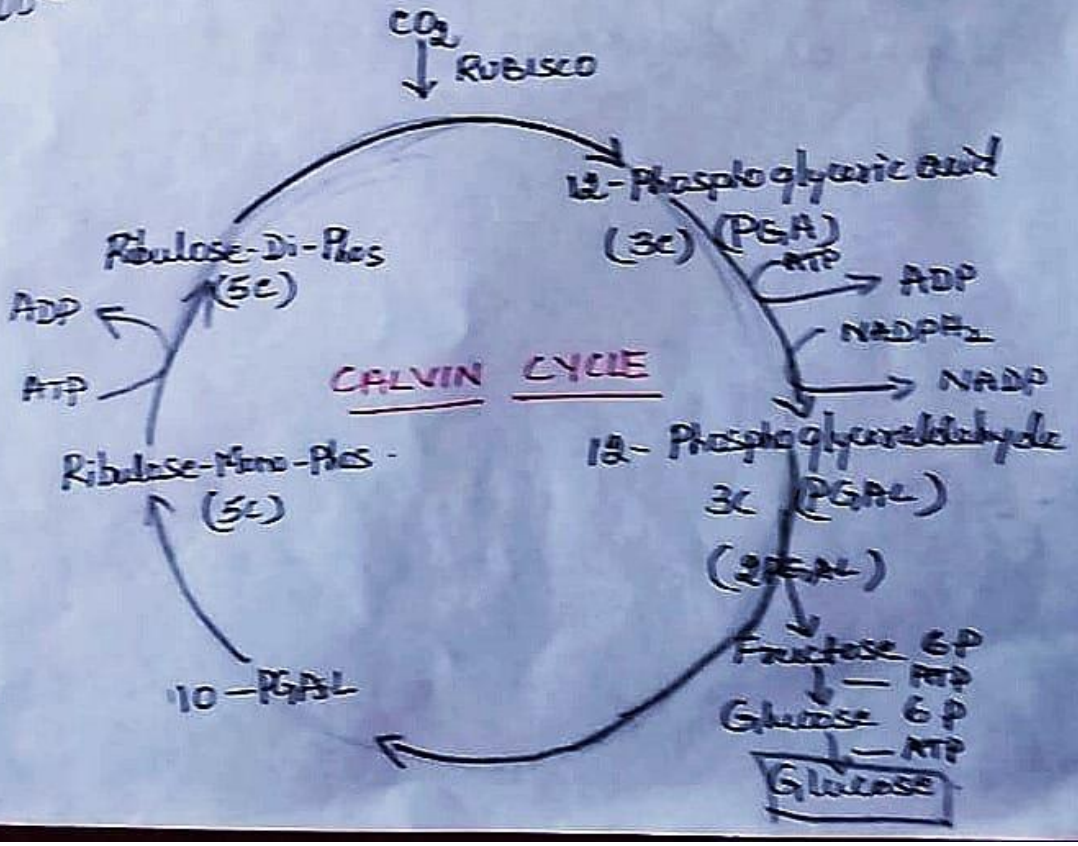
cyclic photophosphorylation	Non-cyclic P.P^{N}
① It is associated with PSI	① It is with P.SI & P.S.II
② The electron expelled from chlorophyll molecule is cycled back	② Electrons are not cycled back, but compensated by the electrons from photolysis of H_2O.
③ No Photolysis of H_2O & Evolution of oxygen.	③ There is Photolysis of H_2O, Evolution of oxygen.
④ 2 ATPs are released	④ only one ATP is released
⑤ NADP is not reduced	⑤ NADP is reduced to $NADPH_2$.

II Calvin cycle or Dark Reaction or C_3 Pathway or BioSynthetic Phase :—

- Dark reaction takes place in the Stroma (matrix of the chloroplast.
- It is a light independent reaction & occurs both in day-time & night time.
- The biochemical pathway is explained by Melvin-calvin & hence it is called calvin cycle.
- The ATP & $NADPH_2$ produced in the light reaction is utilised for the preparation of glucose.
- The major step in dark reaction is CO_2 fixation.
- The first visible Product is Phospho glyceric acid a 3-carboned compound, Hence the name C_3 pathway.

- Dark reaction takes place in 4 steps. Carboxylation, Reduction, Synthesis and Regeneration.
- Synthesis of One molecule of glucose requires 18 ATP and 12 $NADPH_2$ molecules
- For the formation of 1 molecules of glucose six molecules of CO_2 need to be fixed.
- C_4 pathway (Hatch and Slack cycle)

During C_4 pathway the CO_2 is assimilated by phospho enol pyruvic acid (PEP) and produce the first stable compound oxaloacetic Acid (OAA) which is a 4c compound. Hence this path-way is called C_4 pathway & plants C_4 plants. This pathway was traced by Hatch & Slack. The leaf anatomy is called Kranz anatomy. The C_4 plants are photosynthetically more efficient than C_3 plant.



Factors affecting Rate of Photosynthesis

The Photosynthesis is influenced by internal factors and external factors.
Internal factors are the Anatomy of the leaf, distribution of the chlorophyll in the mesophyll.
The external factors are H_2O availability, light CO_2 concentration and temperature.

Blackmann's Law of Limiting Factor :-

The rate of photosynthesis decreases with the pace of a slowest factor.
EG.- If all the above said factors are available but intensity of light is less, then it limits the synthesis of food. It is considered as the slowest factor. The same thing holds good for H_2O, temperature & CO_2 conc^n.
This condition was explained by Blackmann in the year 1905. & the law is named after him as Blackman's law of limiting Factor.