Photosynthesis

Photosynthesis is the process by which green plants use carbon dioxide (CO_2) and water (H_2O) in the presence of sunlight to synthesize their food. Through the process of photosynthesis, the photons are obtained from light energy and converted to chemical energy.

The overall reaction of photosynthesis is;

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

(Raw materials) — Glucose — (waste product)

Carbon dioxide and water are the raw materials for photo synthesis. CO_2 is obtained from air whereas H_2O is obtained from soil. chlorophyll has got an ability to trap sunlight which provide energy for chemical reaction. As the result of chemical reaction, simple sugar like glucose is formed as a product. The glucose is further changed into stored carbohydrate such as starch.

Oxygen gets evolved as a by-product of photosynthesis.

Site of photosynthesis

The entire process of photosynthesis takes place in the cytoplasmic organallae called the chloroplast. Chloroplasts are the green plastids with discoidal or convex-shaped bodies. Internally, a chloroplast contains a fluid called stroma or matrix which is similar to cytoplasm. The stroma contains DNA, RNA, ribosomes, enzymes, for CO_2 assimilation, proteins, etc.

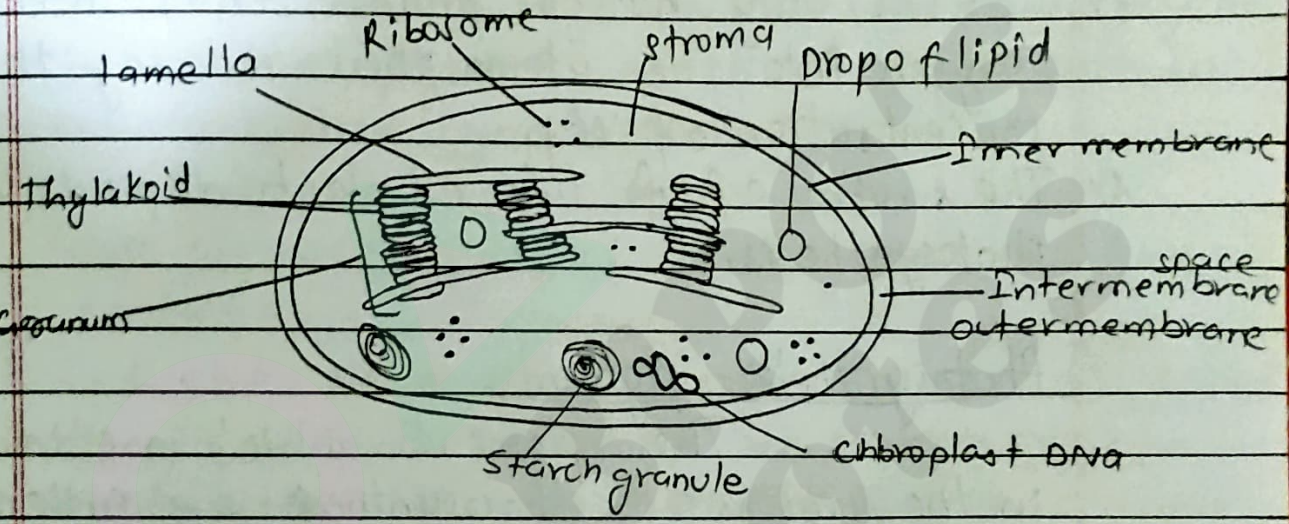


fig:- str of chloroplast molecle.

chloroplast is bound by two unit membrane consisting of lipid & protein. Chloroplast contains matrix known as stroma which include grana. Each granum consist disc shaped green lamella placed one above the other like the stack of coin. A granum may have 20-50 thylakoid discs. The thylakoid membranes contain photosynthetic pigments that help in trapping light energy from the sun. The grana portion is responsible for light reaction and the stroma portion is

responsible for dark reaction of photo synthesis.

Significance of photosynthesis:-

1) Photosynthesis help in preparing food utilizing inorganic raw materials.
2) The sugar and other metabolites prepared the process of photosynthesis are transported from the chloroplast toall the different parts of plant.
3) It is only natural process that releases oxygen into the atmosphere reducing the concentration of CO_2.
4) The survival of life of plants depends upon photosynthesis.

Photosynthetic pigments:

The pigments which are involved in the process of photosynthesis are called photosynthesitic pigments.

There are 3 types of photosynthetic pigments, they are:-

1) chlorophylls:-

They are green photosynthetic pigments most abundant in green plants. They are made up of magnesium and porphyrin molecule. Five types of chlorophylls that occur in plants except bacteria are chlorophyll-a, chloryphyll-b, chlorophyll-c, chlorphyll-d, and chlorophyll-e. Among these, chlorophyll-a and chlorphyll-b molecules occur in higher plants.

2) Carotenoids.

These are the yellow, brown to reddish photosynthetic pigments. Along with chlorophyll-b, the carotenoids are called accessory pigments because they handover the energy absorbed by them to the chlorophyll-a.

3) Phycobilins:

They are phycoerythrin (red) and phycocyanin (blue) pigments which are found both in red algae and cyanobacteria.

Two pigments systems (photosystem) and Rxn centre:

Light energy is trapped by photosynthetic pigments arranged in the centres called photosystems (PS). In each PS, several hundred chlorophyll molecules and accesory pigments (carotene and xanthophylls) harvest light energy.

The discovery of Emerson effect clearly indicated that two groups of pigments are involved in photosynthesis. Such pigment systems present in chloroplasts are described below:

1) Pigment system I

It absorbs the wavelengths which are shorter as well as longer than 680nm. The important pigments of this system are chlorophyll-a 670, chl-a 680, chl-a 695, P-700 and carotenoids. Among them, P700 acts as the

reaction centre of photosystem I.
It involved in th cyclic electron transport.

2Y **Pigment system II**

It absorbs wavelengths which are shorter than 680 nm. The important pigments of this system are chlorophyll-a 670, P680, chl-b and phycobilins. Among these, P-680 acts as the reaction centre of photosystem II. It is involved in non-cyclic electron transport.

Diff. betn photosystem I and photosystem II.

	PS I	PS II
1Y	PS I consists of the pigment molecules which absorb both longer and shorter wavelengths of light.	PS II consists of the pigment molecules which absorb only shorter wavelengths of light.
2Y	The reaction centre is P_{700}.	The reaction centre is P680.
3Y	PS I lies on the outer surface of the thylakoids.	PS II occurs on the inner surface of the thylakoids
4Y	In this system, molecular oxygen is not released.	In this system, molecular oxygen is released by photolysis of water.
5Y	Participates in both cyclic as well as noncyclic flow of	It is involved only in non-cyclic flow of electrons.

Mechanism of photosynthesis:-

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

The process of photosynthesis is a complicated oxidation - Reduction process resulting ultimetly in the oxidation of water and reduction of CO_2. The mechanism of photosynthesis can be studied under 2 phases:-

1. Light Reaction
2. Dark Reaction

Light Rxn:-

It is a 1st step of photosynthesis for which light is essential. light reaction is also called hill reaction as it was proposed by Robin hill in 1937. In this phase chemical energy like $NADPH_2$ & ATP are produced which are necessary in dark phase. It occurs in granna membrane of chloroplast. It includes in the following stage.

Photo exitation of chlorophyll-A:-

The light energy is trapped by photosynthesis pigments present in the green leafs. The pigments are arranged in the centre called photosystem or photocentres. In each photosystem 100 of chlorophyll molecules as well as accessory pigment absorb light energy & transfer to the single chlorophyl molecules known as reaction

of chlorophyll A. There are 2 types of photosystem present in thylakoid membrane of chloroplast that is photosystem I and II.

Photosystem I

It has a reaction centre of chlorophyll A molecules with maximum light absorption in 700 nm wave length. It is also called P_{700}.

Photosystem II

It has a reaction centre of chlorophyll A molecules with maximum light absorbtion in 680 nm wave length. It is also called P_{680}.

Photolysis of water:-

The spilliting of water into hydrogen ion & oxygen atom using awater spliting enzymes by solar energy traped by chlorophyl molecules is called photosynthesis of water. The by-product of photosynthesis i.e. O_2 is produce during this process and release into the atmosphere.

Reduction of NADP:-

chloroplast contain the naturaly occuring electron exceptor NADP with the addition of hydrogen ions from photolysis of NADP i.e. reduced to $NADPH_2$

4) Photo-phosphorylation:-

It is the process of synthesis of ATP from ADP using light energy trapped by ~~chloro~~ chlorophyll. This reaction is catalyse by an enzyme called ATP synthesis or ATP. The formation of ATP occurs both in photosystem I & photosystem II. However the formation of $NADPH_2$ is occurs photosystem II only. In this process of electron cyclic & non-cyclic photo phosphorylation. ~~group~~ shows graphic representation which is like an English alphabet Z and hence, is known as Z-scheme. Two types of photophosphorylation are:-

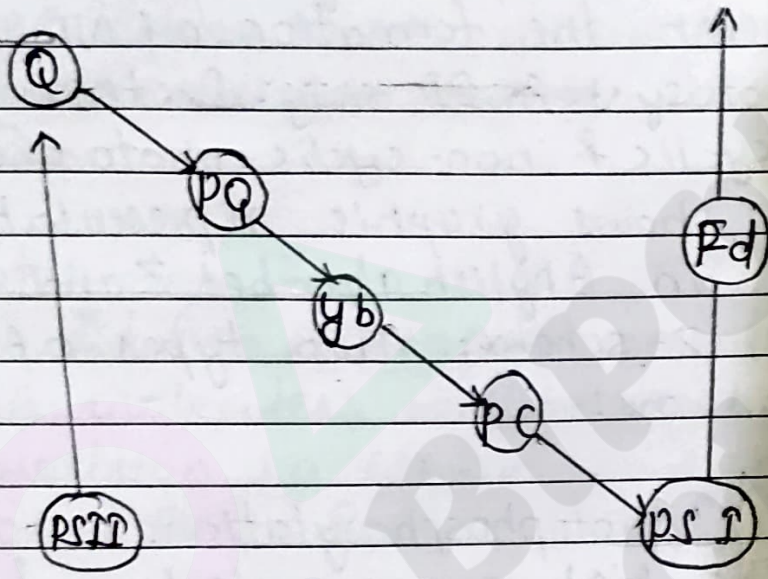
1) Non-cyclic photophosphorylation.

The high energy electrons that provide energy called ATP synthesis are moved from P_{680} to P_{700} but they donot back to P_{680}. So they are called non-cyclic photophosphorylation. So, the system involves both PSI & PSII. The high energy electron released from photolysis phase are expelled from ~~PS+ fr~~ P_{680} of PSII and accepted by an electron acceptor by Q. The energy rich electron required by Q now passes downhill along the series of electron carries through plastoquinone (PQ), cytochrome complex, plastocyanin (pc), & finally to PSI.

The electron given by PSI are taken by primary electron acceptor ~~Ferredoxin~~ (Fd),

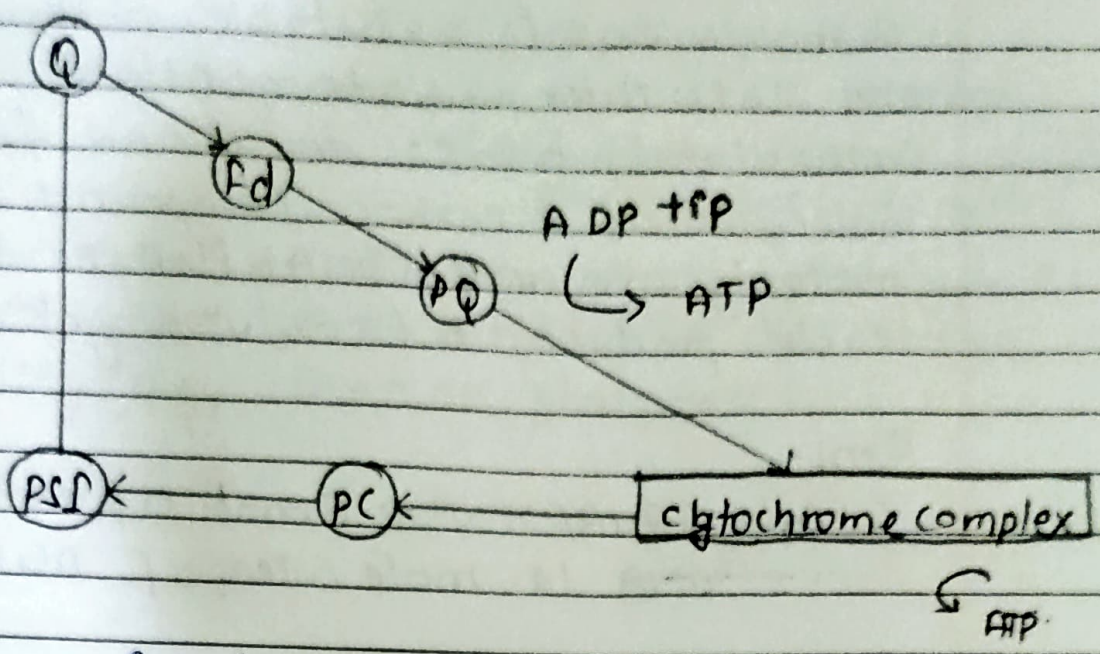
ultimately passed to NADP and the electron combined with NADP and formed $NADPH_2$.

$$4H_2O \longrightarrow 6H^+ + 4OH^-$$
$$4OH^- \longrightarrow 2H_2O + O_2 + 4e^-$$



27. Cyclic phosphorylation.

It can be defined as the synthesis of ATP with electron transport activated by photosystem I. The pigment molecules of PS I absorb light energy and becomes excited. The excited light energy are expelled by PS I & PS accepted by the 1st electron acceptor. The energy rich electron now passes through a series of electrons carries - ferredoxin (Fd), Plastoquinone (PQ), plastocyanin (PC), & finally back the same pigment molecule where they are originated. During this process 2 ATP molecules are formed.



Dark Reaction.

It is the final phase of photosynthesis for light is not required, it occurs in stroma region of chloroplast. In this stage, CO_2 is converted to carbohydrate and it utilize ATP and NADPH produced during light reaction. The CO_2 coming from the atmosphere are accepted by RUBP (Rubilose-1,5-biphasphate). This phase was invented by 'Calvin' in 1954 on green algae so, it is also called Calvin cycle.

Calvin cycle can be divided into following steps:-

1) Carboxylation:-

It is the process of fixation of CO_2 by RUBP. In the presence of an enzyme Rubisco (Rubilose biphosphate carboxylase).

During this process, 6 molecules of CO_2 are accepted by 6 molecules of RUBP to form

6 molecules of 6 unstable carbon compound. This intermediate unstable compound immediately breaks down and form 12 molecules of 3 carbon compound called photoglyceric acid (PGA). PGA is the first stable product of calvin cycle.

Rxn:-

$6CO_2 + 6RUBP \longrightarrow$ 6 mol. of 6 carbon comp. $\longrightarrow$ 12 molecules of PGA.

2) Glycolytic Reversal:-

It is the process of conversion of PGA to Glucose molecules which involves the following steps:-

a) 12 molecules of phosphoglyceric acid are phosphorylated by 12 molecules of ATP with the help of enzyme triosephosphate kinase into 12 molecules of 1,3, -di phosphoglyceric acid.

12 PGA + 12 ATP $\xrightarrow{\text{Triose phosphate kinase}}$ 12 molecules of 1,3-diphospho glyceic acid + 12 ADP.

b) 12 molecules of 1,3-diphosphoglyceric acid are reduced by NADPH. In the presence of enzyme dehydrogenase to produce 12 molecules of 3-phosphoglyceral dehyde.

12 molecuse of 1,3- diphosphoglyceric acid dehydrogenase → 12 molecules of ~~DiHAP (Dihydroxy Acetone phosphate)~~ Phosphoglycel dehyde.

c) Five molecules of 3- phosphoglyceraldehyde is isomerised into 5 molecules of DiHAP (Dihydroxy Acetone phosphate).

5 molecules of 3 PGAL ⟶ 5 molecules of DiHAP

d) 3 molecules of 3-PGAL (phosphoglyceraldehyde) and 3 molecules of DiHAP condense in the presence of enzyme Aldolase. to form 3 molecules of fructose-1,6- diphosphate.

3 molecules of 3-PGAL + 3 molecules of DiHAP —Aldolase→ 3 molecules of fructose-1,6-diphosphate.

e) 4 molecules of xylulose -5-phosphate converts into 4 molecules of Ribulose-5- phosphate in the presence of enzyme Isomerase

4 molecules of xylulose-5-phosphate —Isomerase→ 4 molecules of Ribulose-5-phosphate

f) 2 molecules of Ribose- 5- phosphate converts into 2 molecules of Ribulose- 5-phosphate in the presence of enzyme Isomerase..

2 molecules of Ribose -5- phosphate Isomerase
2 molecules Ribulose - 5- phosphate.

7. Finally, 6 molecules of Ribulose - 5- phosphate converts into 6 molecules of Ribulose -1,5- biphosphate in the presence of enzyme kinase.

6 molecules of Ribulose -5-phosphate —kinase→ 6 molecules of Ribulose - 1,5- biphosphate (RUBP).

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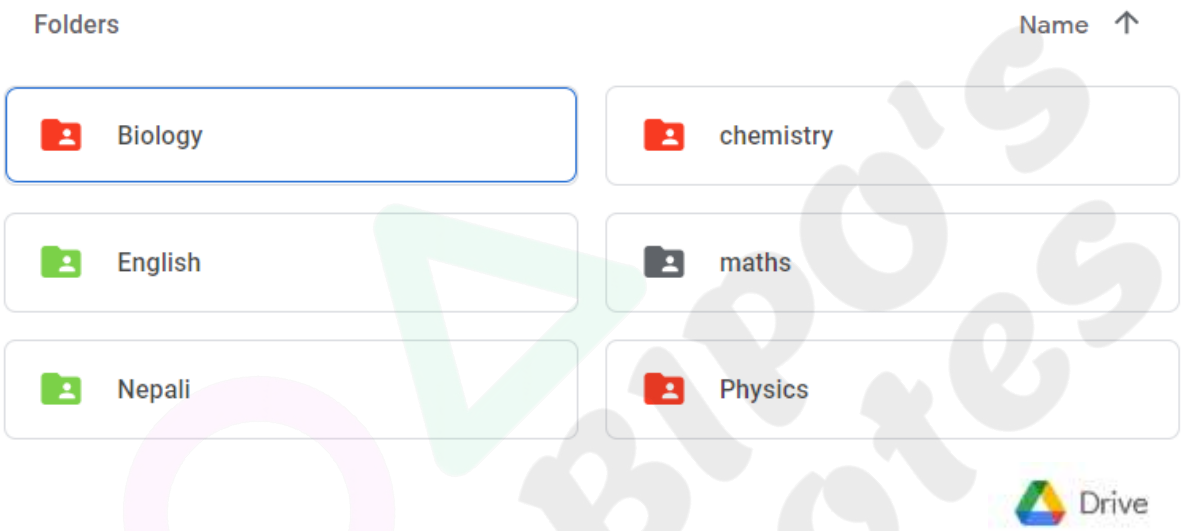
Class 12 complete notes and paper collection.



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