Photosynthesis

Reduction of CO_2 into sugar in presence of light is called photosynthesis. It is often referred as conversion of radiant energy into chemical energy by plants.

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

MECHANISM OF PHOTOSYNTHESIS

In photosynthesis CO_2 is reduced with the help of NADPH and ATP. Generation of NADPH and ATP takes place in presence of light so, it is called **light reaction**.

Reduction of CO_2 does not require light. So, it is called **dark reaction.**

Light reaction:

— takes place in presence of light

— occurs in lamellar system of chloroplasts.

— Generates NADPH and ATP which represent assimilatory power.

— Their generation takes place in following manner.

a. Non cyclic photophosphorylation and

b. Cyclic photophosphorylation.

Photoreduction (NADPH synthesis) and photophosphorylation in photosynthesis:

Energy captured by antenna pigments of PSII or of associated LHC II is funnelled to reaction centre. When the energy reaches a pair of P680 a photoexcited electron is then passed to pheophytin, which is pr. electron acceptor. To absorb photons repeatedly oxidized P680 must be reduced each time an electron is lost to PQ. To replenish electrons PS II includes an oxygen evolving complex (OEC) that catalyses oxidation of water to molecular oxygen. Two water molecules donate four electrons one at a time to oxidized P680. In the process four H^+ and one O_2 molecule are released within thylakoid lumen. The protons contribute to an **electrochemical proton gradient** across the membrane and oxygen diffuses out of the chloroplasts.

Each photo excited electron passes from the primary electron acceptor of PS II to PS I via an electron transport chain. The electron transport chain between PS II and PS I is made up of plastoquinone (PQ), a cytochrome complex and a copper containing protein called plastocyanin (PC).

The flow of electron from pr. electron acceptor of PS II to oxidized reaction centre of PS I is exergonic. The free energy released in this flow is utilized to drive phosphorylation of ADP into ATP.

— In the meantime light energy was transferred to reaction centre of PS I, which excites an electron of one of two P700 molecules.

— The photo excited electron was captured by PS I's primary electron acceptor. Evidence indicates that one of the early acceptors is a chlorophyll molecule (A_0) and another is a quinone species, phylloquinone (A_1). Additional electron acceptor are Fe-S proteins or bound ferrodoxin (also known as Fe-S centre). Electrons are transferred through Fe-S centres to Fd which is small water soluble iron sulphur protein.

— The oxidized P700 gets the electron from PS II through electron from PS II through electron transport chain.

— The final step in the photoreduction pathway is e^- transfer from Fd to $NADP^+$ which is catalysed by enzyme ferredoxin $NADP^+$ reductase (FNR).

— Continuous unidirectional flow of electron from water to $NADP^+$ with the help of both photosystems and other component of ETS is called **non cyclic electron flow.** The e^- flow is often called **Z-scheme**, because of its overall form.

The overall reaction is as follows:

4 photons at PS II + 4 photons at PS I + $2H_2O$ + $6H^+s_{troma}$ +$2NADP^+ \rightarrow 8H^+_{\ lumen} + O_2$ + 2NADPH.

Thus, every **eight photons** absorbed **two NADPH** molecules are generated and the e^- flow is coupled to unidirectional proton pumping across thylakoid membrane. Thus, solar energy is captured and stored in two forms: **the reductant NADPH** and **an electrochemical proton gradient.**

Proton gradient across the thylakoid membrane generates proton motive force. [pmf (Δp)]. PMF is the driving force for ATP-formation. It is the sum of proton chemical potential and transmembrane electric potential.

ATP synthesis is catalysed by ATP synthase/coupling factor/ATPase of CF_0-CF_1. Its hydrophobic membrane bound portion called CF_0 and a portion that sticks out into the stroma is called CF_1. Passive flow (facilitated diffusion) of H^+ through ATP synthase provides energy for synthesis of ATP formation. Light driven phosphorylation of ADP into ATP is called **photophosphorylation**. It was reported by **Arnon** *et. al*.

Cyclic photophosphorylation: When NADPH consumption is low, an optional pathway diverts the reducing power generated at PSI into ATP synthesis instead of reduction of $NADP^+$ into NADPH.

Reduced Fd generated by PS I can pass electrons to cyt b_6f complex instead of donating them to $NADP^+$. By a mechanism that (involves plastoquinone) the exergonic flow of e^- from reduced Fd to PC is coupled to proton pumping across thylakoid membrane. From PC e^- returns to an oxidized P700 molecule in PSI, completing a closed circuit and allowing P700 to absorb another photon. This is referred as cyclic e^- flow and ATP synthesis that it supports is called cyclic photophosphorylation. No water is oxidized and no O_2 is released, since the flow of e^- from PSII is bypassed.