BOTANY SEMESTER-IV Plant Physiology and Metebolism

Unit-3 (3.1) PHOTOSYSTEMS- I and II

Photosystems are functional and structural units of protein complexes involved in photosynthesis that together carry out the primary photochemistry of photosynthesis i.e. the absorption of light and the transfer of energy and electrons. Each photosystem consists of core complexes (i.e. polypeptides containing chlorophylls, a reaction centre, electron donors and acceptors) and a light harvesting Complex (i.e. antenna Complex). The light harvesting complexes contain antenna pigments associated with proteins. Their main function is to harvest light energy and transfer it to their respective reaction centres. The core complexes consist of their respective reaction centres associated with proteins including electron donors and acceptors. Photosystems are found in the thylakoid membranes of plants, algae and cyanobacteria. They are located in the chloroplasts of plants and algae and in the cytoplasmic membrane of photosynthetic bacteria. There are two kinds of photosystems: II and I.

Photosystem I

Photosystem I or PSI can be defined as a pigment protein complex capable of light induced generation of weak oxidant that can oxidise plastocynin and a strong reductant capable of transferring electrons to ferredoxin. It is located in the thylakoid membrane and is a multi-subunit protein complex found in green plants and algae. The first initial step of trapping solar energy and then conversion by light driven electron transport. PS- I is the system where the chlorophyll and other pigments get collected and absorb the wavelength of light at 700nm. It is the series of reaction, and the reaction center is made up of chlorophyll a_{700} (P_{700}).

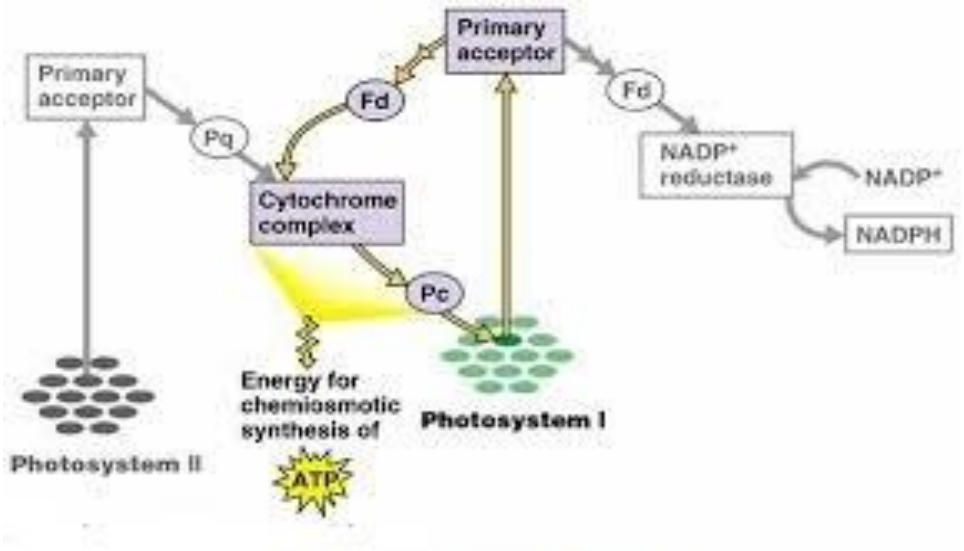
The subunits of PSI are larger than the subunits PS II. This system also consists of the Chlorophyll a_{670}, Chlorophyll a_{680}, Chlorophyll a_{695}, Chlorophyll b, and carotenoids. The

absorbed photons are carried into the reaction center with the help of the accessory pigments. The photons are further released by the reaction center as high energy electrons that undergo a series of electron carriers and finally used by $NADP^+$ reductase. The NADPH is produced through $NADP^+$ reductase enzyme from such high energy electrons. NADPH is used in the Calvin cycle.

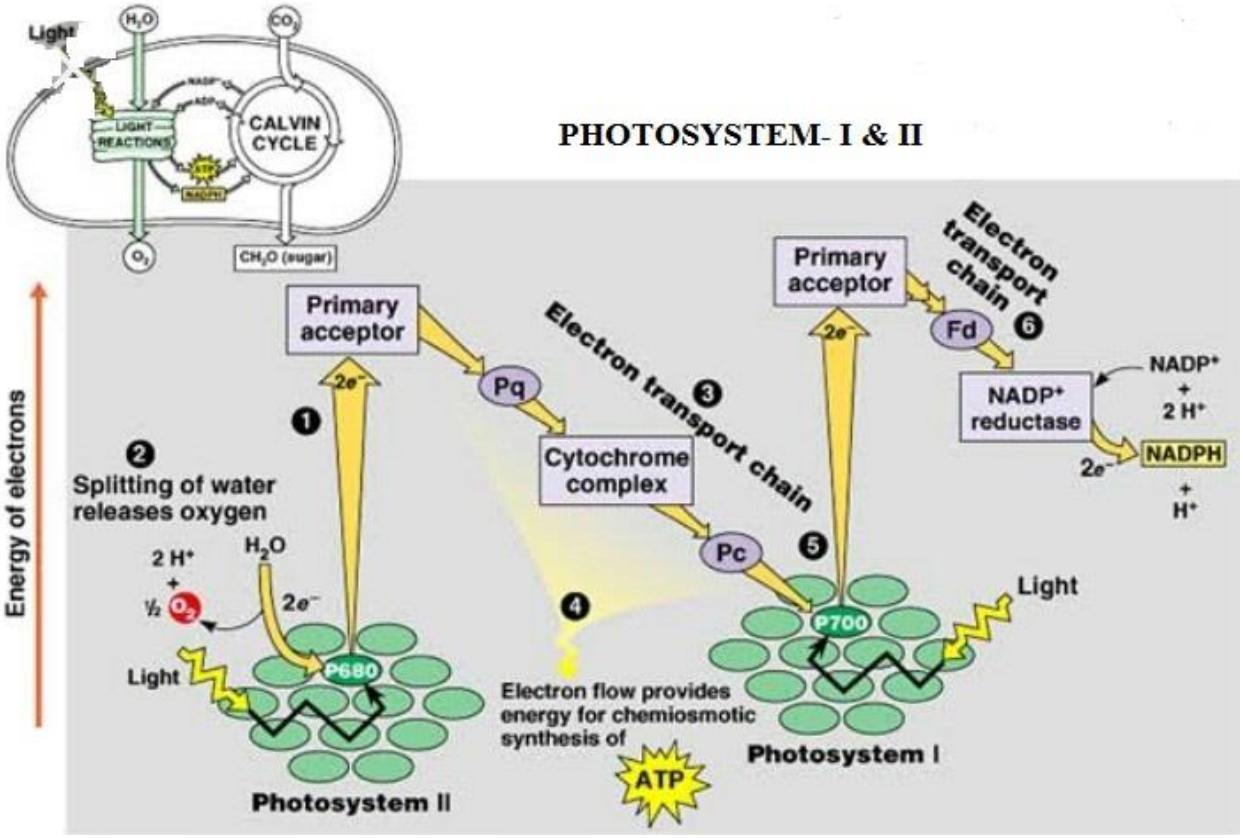
Therefore, the main aim of the integral membrane protein complex that uses light energy is to produce ATP and NADPH. Photosystem-I is active both in red and far red lights. It is associated with both cyclic and non-cyclic electron transport and drives electron from Photosystem-II to NADP $^+$. It can carry out the cyclic electron transport independently and is not associated with photolysis of water.

Photosystem II

Photosystem II or PS II is the membrane-embedded-protein-complex (a pigment- Protein-complex), which is capable of light induced reduction of plastoquinone and which can generate a strong oxidation that recovers electrons from water. The light harvesting complex of PS II generally consists of pigments absorbing at shorter wave lengths of light (viz., chlorophyll a, Chl b and carotenoids). Core complex portion of PS II consists of Chl a_{680} i.e. P_{680} as reaction centre, two or more electron donors acting on oxidizing side of complex(unknown), an intermediate electron acceptor (probably a pheophytin) and two bound quinones (Q_A and Q_B) acting as primary and secondary electron acceptors of PS II respectively. PS II absorbs light at 680 nm, and enters at high-energy state. The P_{680} donates an electron and transfer to the pheophytin, which is the primary electron acceptor. As soon as the P_{680} loses an electron and gains positive charge, it needs an electron for replenishment which is fulfilled by splitting of water molecules. It is located only in the stacked part/appressed regions of grana thylakoids towards the inner surface of the membrane. The PS II complex is active far-red light (beyond 680mμ It is associated with the non-cyclic electron transport, photolysis (splitting) of water and evolution of molecular oxygen.



Photosystem I and II



COMPARISON CHART

PHOTOSYSTEM-I AND PHOTOSYSTEM-II

BASIS FOR COMPARISON	PHOTOSYSTEM-I	PHOTOSYSTEM-II
Meaning	Photosystem- I or PS- I uses light energy to convert NADP to $NADPH^{++}$. It involves the P_{700}, chlorophyll and other pigments	Photosystem-II or PS-II is the protein complex that absorbs light energy, involving P_{680}, chlorophyll and accessory pigments and transfer electrons from water to plastoquinone and thus works in dissociation of water molecules and produces protons and O_2.
Location	It is located on the outer surface of the thylakoid membrane	It is located on the inner surface of the thylakoid membrane.
Reaction Centre	P_{700} (Chl a_{700})	P_{680} (Chl a_{680})
Absorbing wavelength	The pigments in the photosystem-I absorb longer wavelengths of light which is 700 nm (P_{700}).	The pigments in the photosystem- II absorb shorter wavelengths of light which is 680 nm (P_{680}).
Photophosphorylation	This system is involved in both cyclic as well as non-cyclic photophosphorylation.	This system is involved only in cyclic photophosphorylation
Photolysis	No photolysis occur, hence molecular oxygen is not evolved	Photolysis occurs, hence, this system is responsible for breakdown of water and evolution of molecular oxygen.
Pigments	Photosystem -I or PS- 1 comprises of about 200 to 400chlorophylls, 50-carotenoids, one molecule of reaction centre P_{700} (Chl_{700}) and	Photosystem-II or PS- II comprises of about 200 chlorophylls,50-carotenoids, one molecule of reaction P_{680} (Chl a_{680}), quencher compound Q (quinnone), Mn^{++}, Cl^- and an unknown

	two iron containing proteins similar to ferredoxin (Fe-S proteins).	oxidizing enzyme.
Function	The primary function of the photosystem- I is in NADPH synthesis, where it receives the electrons from PS II.	The primary function of the photosystem -II is in the hydrolysis of water and ATP synthesis.

In conclusion, both Photosystem –I and Photosystem-II are important in photosynthesis as they succeed each other, any one of them laging behind decreases photosynthetic yield.

Reference /Syllabus Books (For material & diagrams)

1. A Text Book of Plant Physiology by H. S. Srivastava (Rastogi Publication)
2. A Text Book of Plant Physiology by S. K. Verma (S. Chand & Company Ltd.)
3. Plant Physiology and Metabolism by Dr. H.N. Srivastava (Pradeep Publications)
4. Plant Physiology and Metabolism by Dr. Kamaljit & co-workers (S. Vinesh & Co.)
5. Plant Physiology and Metabolism by Dr. B.B. Arora (Modern Publishers).