THE ELECTRON TRANSPORT

- The electron transport chain unfurls as an orchestrated sequence of electron carriers, traversing a downhill trajectory that bequeaths energy at each juncture. This liberated energy becomes the architect of an electrochemical proton gradient, a crucial architect in the symphony of synthesizing ATP.
- Delineating its course based on the electron's journey, photophosphorylation takes on two distinct personas—non-cyclic and cyclic photophosphorylation. These pathways encapsulate the dynamic interplay of electrons, unveiling a captivating narrative of energy transfer and transformation in the realm of photosynthesis.

Splitting of Water

- The vital replenishment of electrons, necessitated by their exodus from PS II, unfolds through the spectacular ballet of water splitting. This aqueous spectacle takes center stage in the grand theater of photosynthesis, with the water splitting complex, or oxygen evolving complex (OEC), choreographing this elemental dance alongside PS II.
- Nestled on the inner sanctum of the thylakoid membrane, PS II orchestrates the split of water into a trio of entities—H+, [O], and electrons. The liberated protons and oxygen gracefully find refuge within the lumen of the thylakoids, contributing to the intricacies of this aqueous performance. As a grand denouement, oxygen emerges as a luminary protagonist, destined to be one of the crowning achievements of the photosynthetic process.
  The aquatic alchemy thus manifests:

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

Cyclic and Non-cyclic Photo-phosphorylation

- **Cyclic Photophosphorylation:** In the mystical domains of photosynthesis, cyclic photophosphorylation unfolds its mesmerizing dance, orchestrated solely by the enigmatic Photosystem I (PS I). This captivating spectacle transpires within the stroma lamellae membrane, where PS I reigns supreme. In this cyclic rendezvous, electrons embark on a celestial journey within the confines of PS I, circulating through the photosystem in a rhythmic loop, bestowing the gift of phosphorylation upon each cyclic revolution.

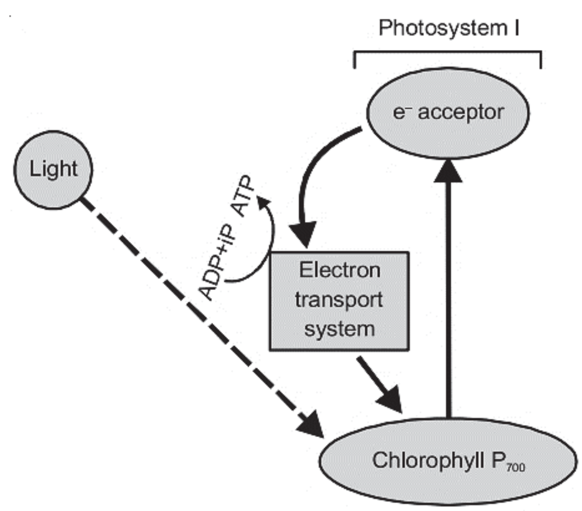

Fig. : Cyclic photophosphorylation

- Within the grana's membrane, both Photosystem I and Photosystem II coexist harmoniously. However, the stroma lamellae membranes, devoid of PS II and the NADP reductase enzyme, set the stage for the exclusive performance of cyclic photophosphorylation. Here, the electrified electrons eschew their traditional path toward NADP+, retracing their steps back to the PS I complex through the electron transport chain, perpetuating the cyclic flow of electrons. This cyclical dance also unfurls its vibrant hues when only light of wavelengths beyond 680 nm tenderly caresses the photosynthetic apparatus, breathing life into the excitation process.
- **Non-cyclic Photophosphorylation:** The saga of non-cyclic photophosphorylation unveils a symphony of cooperation between Photosystem I and Photosystem II, acting in tandem. These two luminous entities gracefully engage in a sequential partnership, commencing with the grand overture by PS II, followed by the resounding echoes of PS I. A captivating electron transport chain seamlessly connects these two photosystems, crafting a melodious rhythm that orchestrates the synthesis of both ATP and NADPH + H^+.

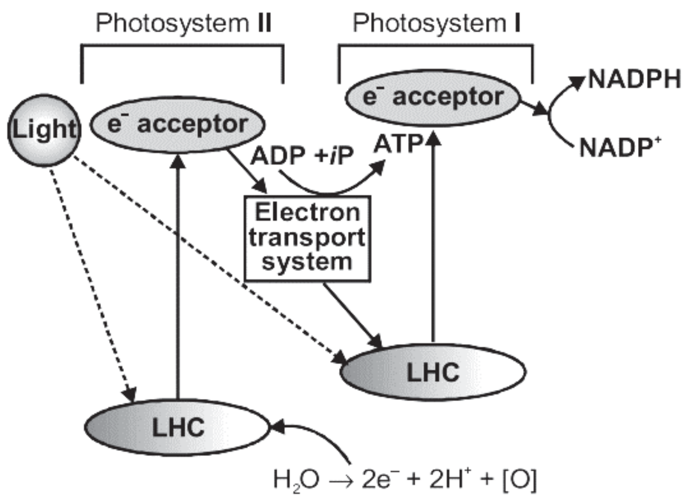

Fig. : Z scheme of light reaction

- The narrative unfolds with PS II's P680 molecule capturing the enchanting 680 nm wavelength of red light, propelling electrons into an orbit farther from the atomic nucleus. With graceful elegance, these electrons are passed to an electron acceptor, initiating a downhill descent along the redox potential scale through the cytochromes' electron transport system. Simultaneously, PS I's P700 electrons are stirred to excitement by the caress of 700 nm wavelength light, gracefully traversing to another acceptor with a superior redox potential. This exquisite interplay culminates in the reduction of NADP+ to the majestic NADPH + H^+.
- The grand choreography, spanning from PS II's uphill electron transfer to the final descent to NADP+, adopts the name Z-scheme, a visual embodiment of the carriers' sequential arrangement on the redox potential scale, casting a luminous glow upon the intricate dance of energy transformation.

Some important differences between Cyclic and Non-cyclic Photophosphorylation

Cyclic Photophosphorylation	Non-Cyclic Photophosphorylation
It is performed by photophosphorylation I independently.	It is performed by collaboration of both photosystems II and I.
An external source of electrons is not required.	The process requires an external electron donor.

It is not connected with photolysis of water. Therefore, no oxygen is evolved.	It is connected with photolysis of water and liberation of oxygen occurs.
It synthesises ATP only	It is not only connected with ATP synthesis, but also with production of NADPH.
It operates under low light intensity, anaerobic condition or when CO_2 availability is poor.	Non-cyclic photophosphorylation takes place under optimum light, aerobic conditions and in the presence of carbon dioxide.
The system does not take part in photosynthesis except in certain bacteria.	The system is connected with CO_2 fixation in green plants.
It occurs mostly in stroma lamellae membrane.	It occurs in the granal thylakoids.

Chemiosmotic Hypothesis: In the mystifying realm of photosynthesis, the Chemiosmotic Hypothesis, elucidated by the visionary P. Mitchell, unravels the intricate dance of energy transformation within the chloroplast. This ingenious mechanism unveils the secrets behind ATP synthesis, intricately linking it to the establishment of a proton gradient across the thylakoid membrane. The enchanting ballet of protons, orchestrated towards the lumen, unfolds a captivating narrative.

- **Photolysis of Water in Thylakoid Lumen:** The overture begins with the enchanting photolysis of water molecules on the inner side of the membrane, casting a spell that produces hydrogen ions (protons). These protons gracefully amass within the lumen of the thylakoids, setting the stage for the forthcoming acts.
- **H^+ Transfer from Stroma to Lumen during Electron Transport:** The dance continues with electrons traversing through photosystems. The primary electron acceptor, poised towards the outer membrane, engages in a delicate exchange with a H+ carrier. This molecular partner, in turn, liberates a proton from the stroma while gracefully ferrying an electron. The ensuing transfer of this electron to an inner membrane electron carrier releases the H+ into the lumen, enhancing its protonic ballet.
- **NADPH Reductase Reaction in Stroma:** The performance reaches a crescendo as the NADP reductase enzyme, positioned on the stroma side of the membrane, orchestrates the reduction of NADP+ to NADPH + H+. Protons, essential for this reduction, bid adieu to the stroma, joining the protonic symphony within the lumen.

  The chloroplast, now a stage of dynamic transformations, witnesses a decline in protons within the stroma, while the lumen experiences a balletic accumulation. This ballet manifests as a reduction in pH within the lumen, crafting a protonic gradient across the thylakoid membrane.

  The pivotal moment arrives as the gradient succumbs to the enchanting movement of protons. Through the transmembrane channel of the CF (Coupling Factor) within the ATP synthase enzyme, protons waltz across the membrane, bidding farewell to the lumen, and gracefully making their way to the stroma.

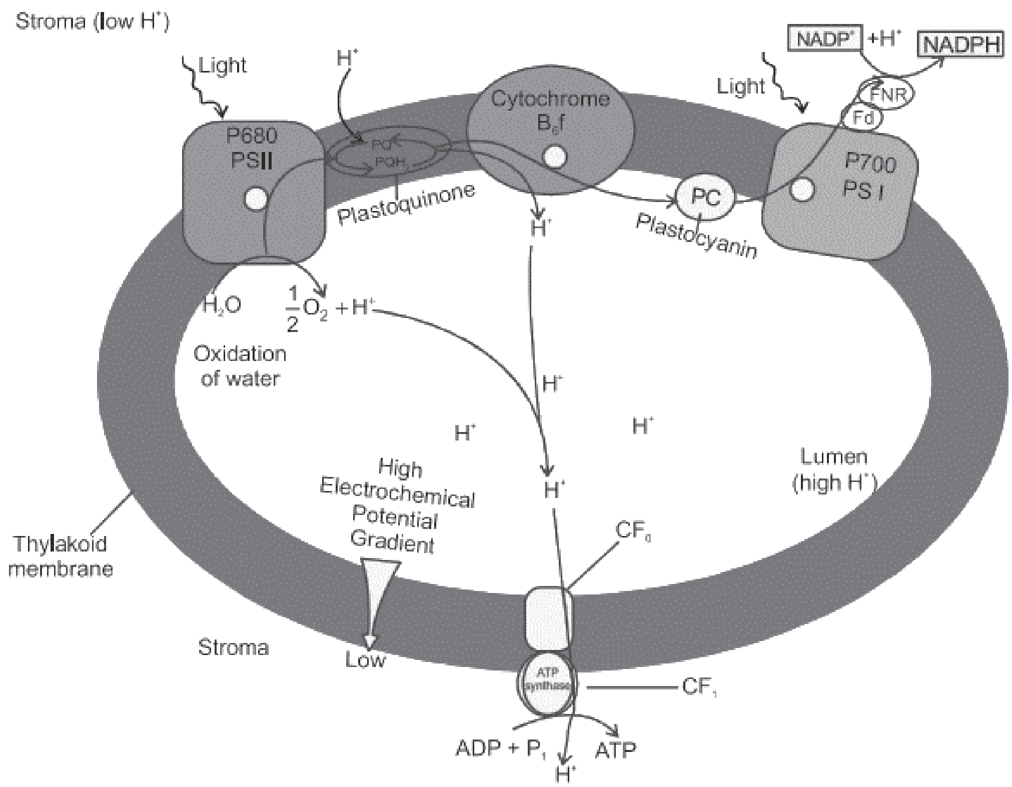

Fig. : ATP synthesis through chemiosmosis

- The ATP synthase, a symphony of two components, the CF embedded in the membrane facilitating proton diffusion, and the protruding CF on the thylakoid membrane's outer surface, witnesses a conformational ballet. This elegant conformational change, fueled by the breakdown of the protonic gradient, triggers the synthesis of multiple ATP molecules. The grand finale of this ballet cascades in a shower of synthesized ATP, the culmination of the chloroplast's symphony of chemiosmosis.