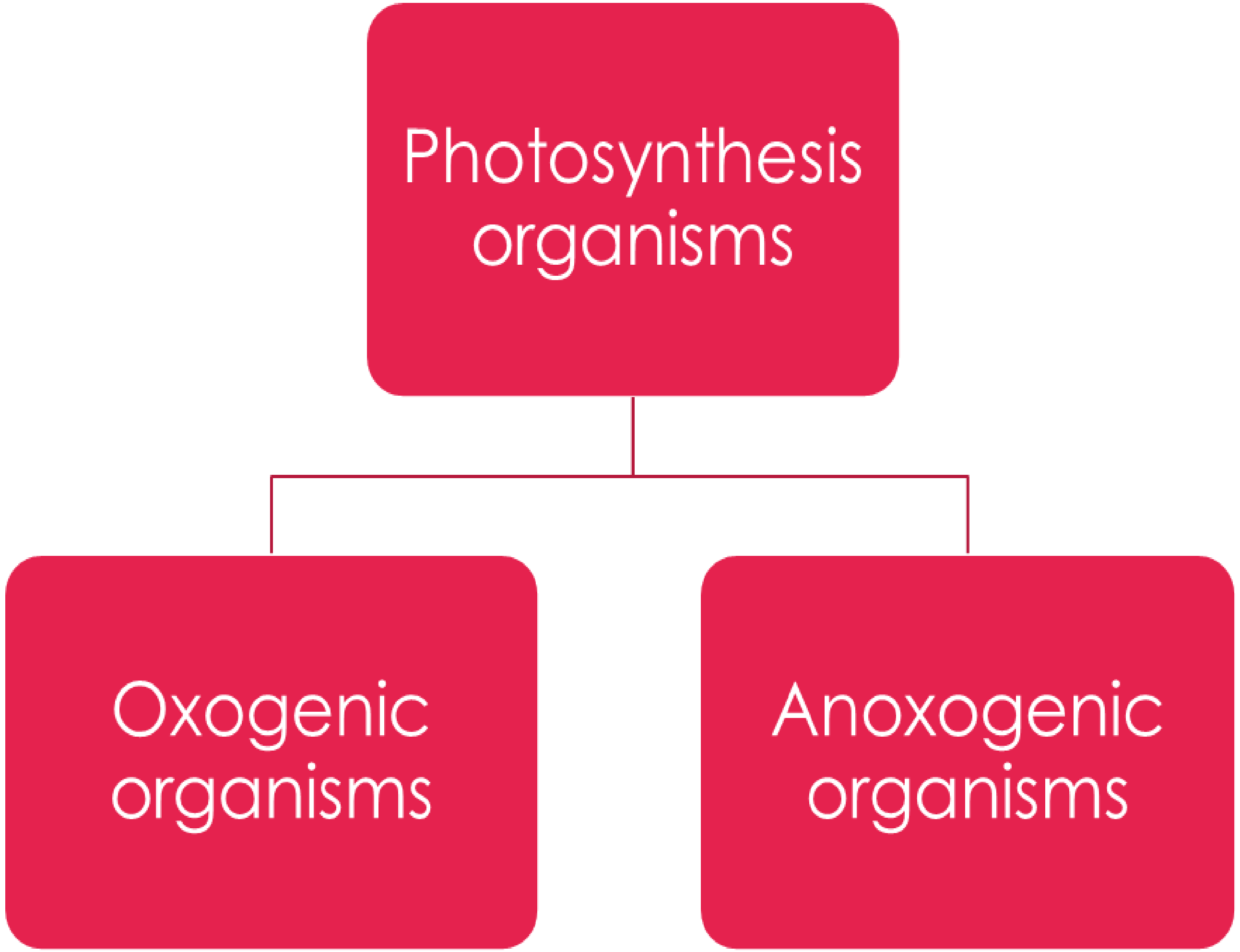
COURSE TITLE: Biomolecules and Microbial Metabolism

Course Code: 24MICCC2

Courser Teacher: Dr. R. Vijayakumar

INTRODUCTION

- ✓ Photosynthesis is a physiochemical process by which photosynthetic organisms uses light energy to drive the synthesis of organic compound.
- ✓ Photosynthesis is a process by which phototrophs convert light energy into chemical energy, which is later used to fuel cellular activities.
- ✓ The chemical energy is stored in the form of sugars, which are created from water and carbon dioxide.
- ✓ Energy in the form of nicotinamide adenine dinucleotide phosphate (NADP) and adenosine triphosphate (ATP) and later these chemical reduce to co2.
- $$6C_2O+6H_20 \longrightarrow C_6H_{12}O_6+60_2$$


Photosynthesis organisms
Oxogenic organisms
Anoxogenic organisms

Oxygenic photosynthesis

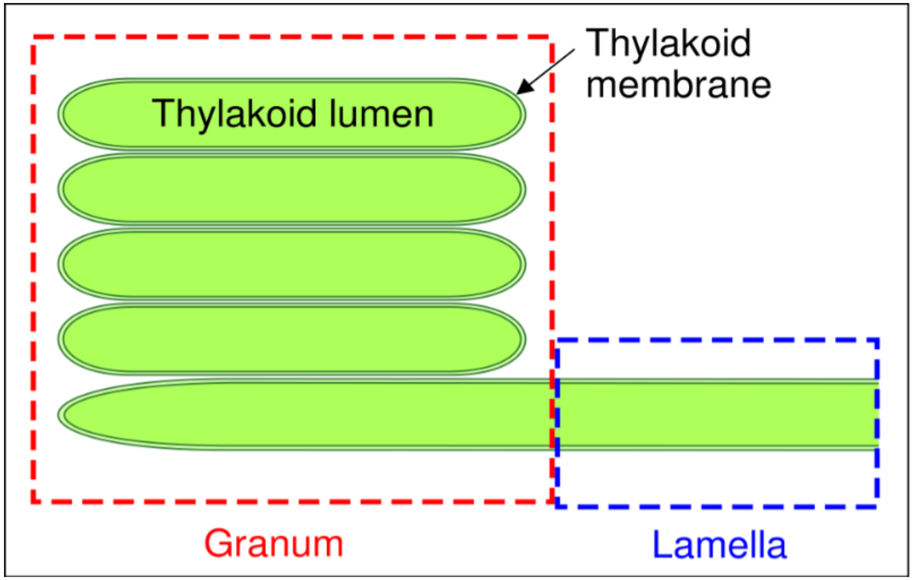
- Converting sunlight into chemical energy, by Splitting water to release oxygen, and Fixing carbon dioxide into sugar
- Although there are some differences between oxygenic photosynthesis in plants, algae, and cyanobacteria, the overall process is quite similar in these organisms.

Two types of photosystem are present

- Photosystem with **Fe-s** type of reaction centre is called Photosystem-I or PS1
- Photosystem with **Pheophytin-quinone** type reaction centre is called Photosystem-II PSII.

PHOTOSYSTEM I (PSI)

- Photosystem I (PSI) is a multi subunit protein complex located in the thylakoid membranes of green plants and algae
- It is a protein pigment complex that use light energy to mediate electron transfer from Quinone, Phylloquinones, Fe-s to Ferredoxin.
- It has Fe-s type reaction center.
- It is driven by light wavelength 700nm.



PHOTOSYSTEM II (PSII)

- Photosystem II is the first link that begins the chain of photosynthesis.
- PSII is known as p680 because it most effectively absorb light of wavelength 680nm
- Photosystem II (PSII), also known as Water-Plastoquinone Oxidoreductase
- It is a large membrane protein complex located in the **Thylakoid Membrane** of organisms ranging from cyanobacteria to higher plants
- In higher plant the reaction center contain Membrane protein D1& D2; Cytochrome b556 and other protein along with **chl a** molecules.

Photosynthetic Electron Transport Chain

- The photosynthetic electron transport chain consists of photosystem II, the cytochrome b6f complex, photosystem I and the free electron carriers plastoquinone and plastocyanin
- Light-driven charge separation events occur at the level of photosystem II and photosystem I, which are associated at one end of the chain with the oxidation of water followed by electron flow along the electron transport chain and concomitant pumping of protons into the thylakoid lumen, which is used by the ATP synthase to generate ATP.
- At the other end of the chain reducing power is generated, which together with ATP is used for CO2 assimilation.

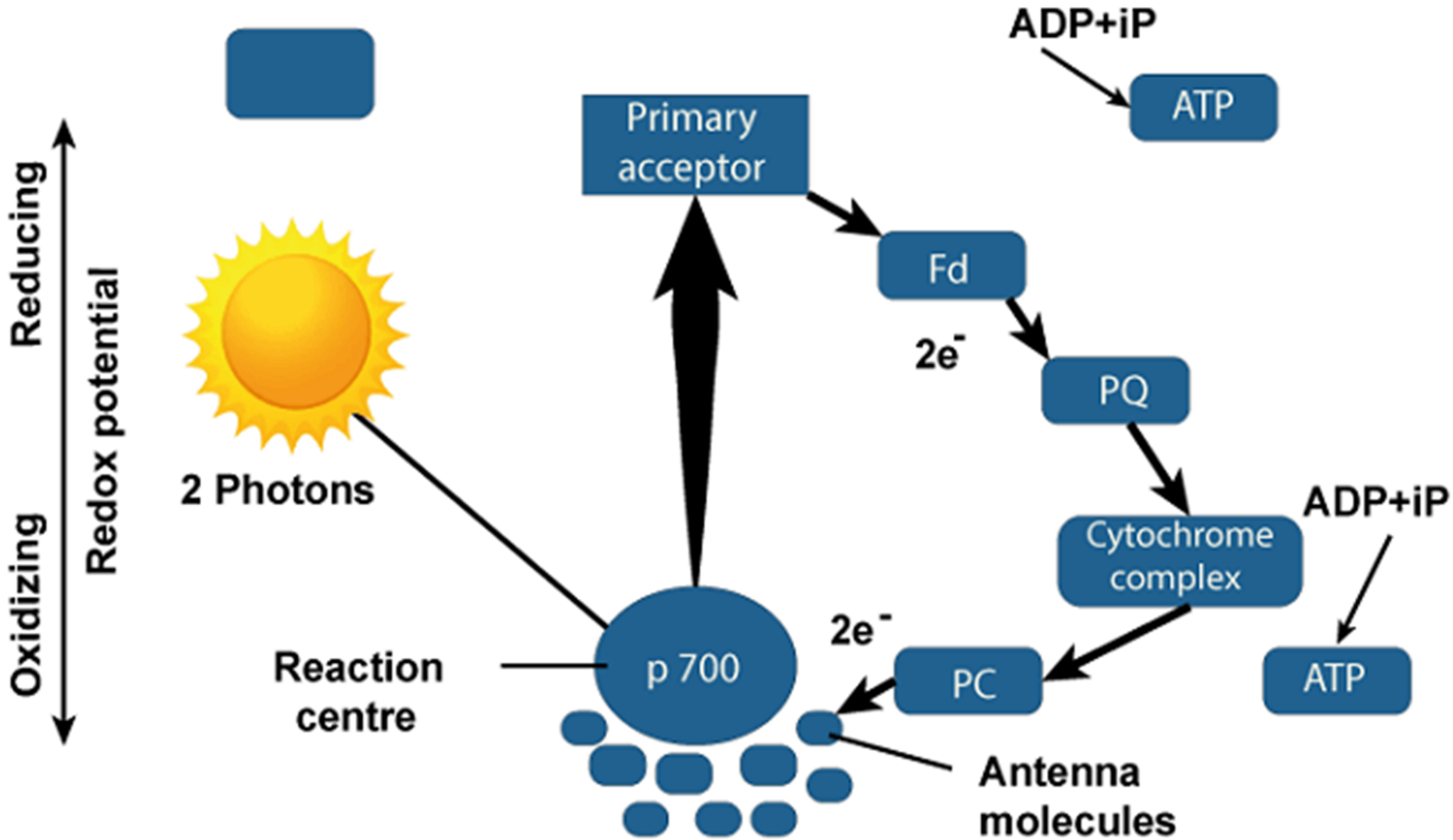
LIGHT REACTION

- Light reaction in the photosystem starts election flow.
- In green Plants, flow of electron is of **Two Types**;
  - **Cyclic Electron Flow**
  - **Non cyclic Electron Flow**

CYCLIC ELECTRON FLOW

- In Cyclic Electron Flow **PSI** Was involved.
- In cyclic electron Flow Photoexcited electron from P700 of PSI & move through the b6f complex and back to P700.
- This cyclic electron flow is coupled to Proton pumping into the STOMAL LUMEN.
- When Protons flow down their electrochemical gradient through ATP synthase complexes. ATP synthesis occurs

- The formation of ATP due to light- induced cycle election flow is called **Cyclic Photophosphorylation.**
- There is **No Production of NADPH** and **No release of oxygen** in cyclic electron Flow.
- In Plants, the cyclic flow of electrons is utilized only when the concentrative of NADPH is sufficient but still ATP needs, to Power other activities in the chloroplast.
- This Phosphorylation is more Productive as compared to non-cyclic Photophosphorylation With regard to ATP Synthesis.
- The absorption of 4 Photons by PSI results in the release of 8 Protons into the **LUMEN** by the **Cyt b6f complex**.
- These Protons flow through ATP Synthase to yield **2molecules of ATP**.
- However, ATP is a highly reactive molecule and hence cannot be readily stored within the cell.



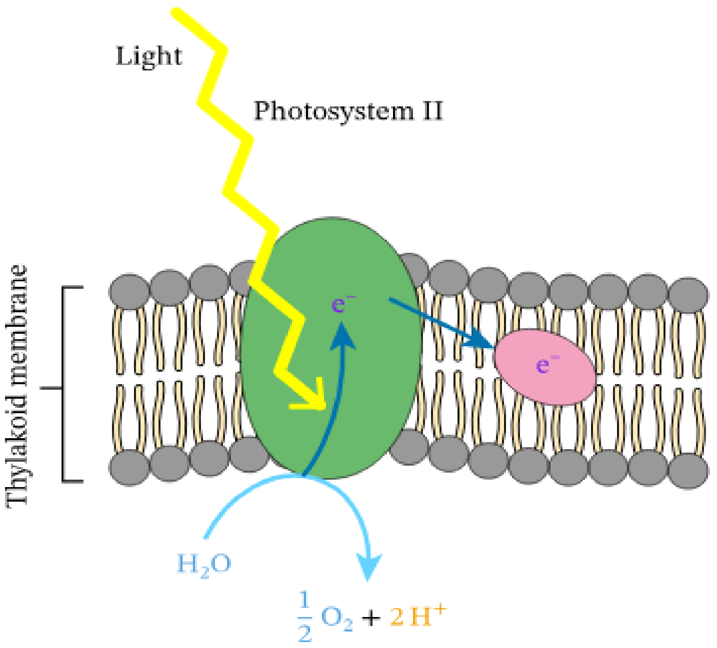
Cyclic photophosphorylation

MECHANSM OF CYCLIC PHOTOPHOSPORILATION

1.Only PS 1 or P is involved in the process.
2.Chlorophyll dimers of the reaction center absorb light rays of wavelength more than 680 nm.
3.After absorbing light in the form of a photon, an electron is released, leading to the oxidation of the reaction center.
4.The reaction center becomes positively charged and the electron released now forms Ferredoxin Reducing Substance (FRS).
5.The electron is carried by the electron carriers like Quinone (Q), Plastoquinone (PQ), FeS protein and finally Ferredoxin (Fd).then electron, from Fd, returns to P700, via **Cyt b6f and Plastocyanin**.
6.The electron creates a proton gradient which leads to the formation of 2 ATP molecules from 2ADP and Pi.
7.Due to the absence of photolysis of water, O_2 and NADPH are not produced.

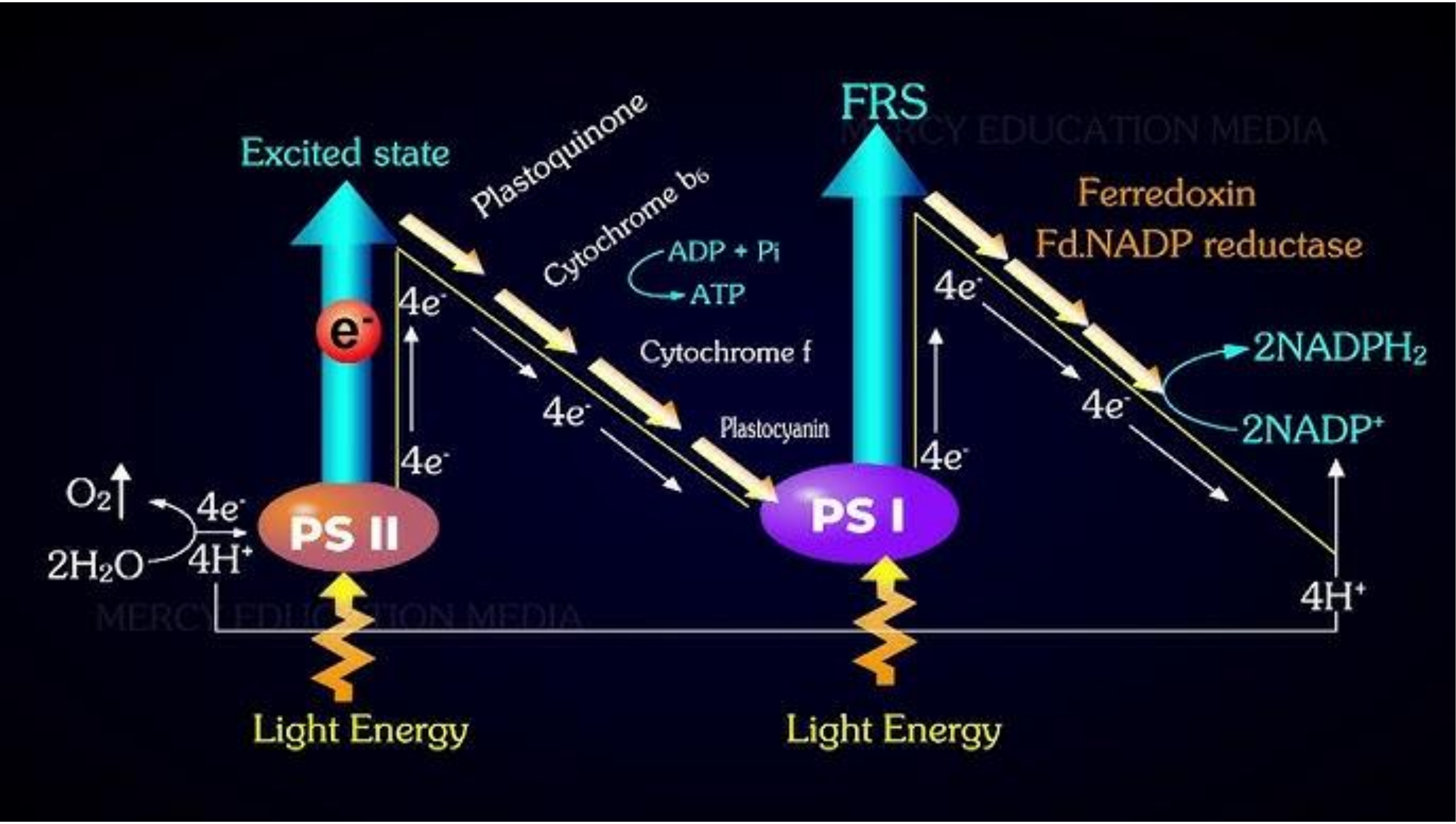
Non cyclic photophosphorylation

- Non cyclic photophosphorylation is a two stage process involving in chlorophyll photosystem II
- Being a light reaction non cyclic photophosphorylation occurs in the thylakoid membrane
- First a water molecule is break down into 2H+ +1\2 O2 +2e- by a process called **Photolysis**
- Two electron from the water molecules are kept in the photosystem II, while the 2H+ and 1\2 o2 are left out for future use.



- Then a Photon is absorbed by chlorophyll Pigments surrounding the reaction core Center of the Photosystem.
- The light excites the electrons of each pigment, causing a chain reaction that eventually transfers energy to the core of photosystem II, exciting the two electrons that are transferred to the **Primary electron acceptor**, Pheophytin.
- The deficit of electrons is replenished by taking electrons from another molecule of water.
- The electrons transfer from **Pheophytin to Plastoquinone** which takes the 2e from Pheophytin, and two H' Ions from the stroma and forms PQH2, which later is broken into PQ, the 2e is released to Cytochrome b6f complex and the two H-ions are released into thylakoid lumen. The electrons then pass through the Cyt b6 and Cyt f.

- Then they are passed to **Plastocyanin** providing the energy for hydrogen ions (H) to be pumped into the thylakoid space.
- H ions flow back into the stroma of the chloroplast, providing the energy for the regeneration of ATP.
- The photosystem II complex replaced its lost electrons from an external source; however, the two other electrons are not returned to photosystem II as they would in the analogous cyclic pathway.
- Instead, the still-excited electrons are transferred to a photosystem I complex, which boosts their energy level to a higher level using a second solar photon.
- The highly excited electrons are transferred to the acceptor molecule, but this time is passed on to an enzyme called Ferredoxin-NADP+ reductase which uses them to catalyze the reaction.



Excited state
Plastoquinone
Cytochrome b6
ADP + Pi
ATP
Cytochrome f
Plastocyanin
FRS
MERCY EDUCATION MEDIA
Ferredoxin
Fd.NADP reductase
2NADPH2
2NADP+
4e-
4e-
4e-
4e-
4e-
4e-
4e-
e-
O2
2H2O
4e-
4H+
PS II
PS I
4H+
MERCY EDUCATION MEDIA
Light Energy
Light Energy

Points of difference	Cycilc photophosphorylation	Non-cyclic photophospho relations
1. Photosystem involved	PS 1 is involved independently.	Both PS 1 and PS 2 work in coordination with each other
2. Source of electrons	No external source of electron is required, as the same electron moves within the cycle.	An external source of electron is required (generally water in this case).
3. Water splitting	Splitting of H_20 is not involved in this process, so oxygen is not liberated here.	Splitting of H_20 is involved in this process, hence oxygen is liberated here.
4. Products formed	2 molecules of ATP are synthesised	1 molecule of ATP and 1 molecule of NADPH are synthesised.
5. Conditions required	Low light intensity, low concentration of $C0_2$ and anaerobic conditions	Adequate amount of light and adequate concentration of 0_2
6. Participating organisms	Some bacteria.	All photosynthetic organisms during carbon assimilation.
7. Reaction site	Takes place in stromal thylakoid and internal thylakoid membrane	Takes place in grana thylakoid.
8. Wavelenght of light	700 nm	680 nm