- Photosynthesis
- Harness light energy and use it to move electrons through an electron transport chain.
- Electron carriers are arranged, in order of increasing electro positivity within a membrane.
- Through this process, a proton motive force is created that is used to produce ATP.

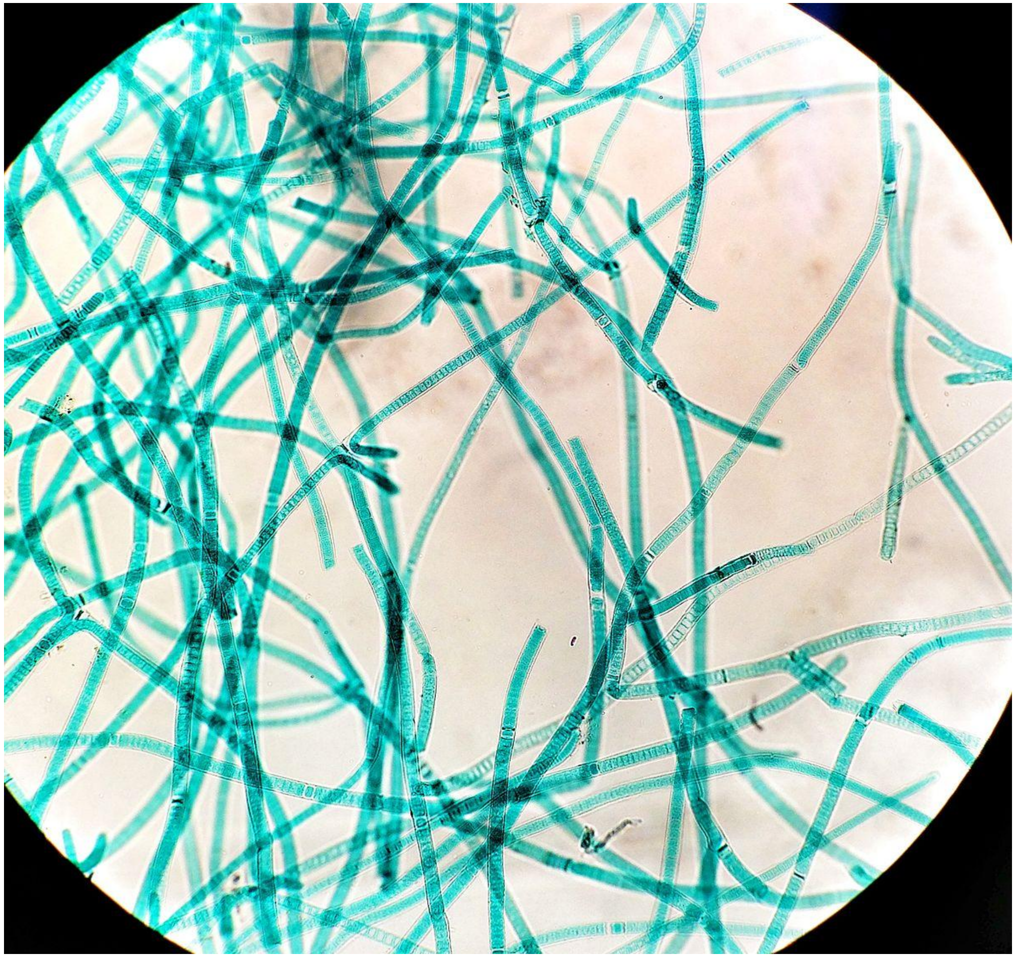
- The compounds used to carry electrons include
- pheophytin (chlorophyll without the magnesium ion (Mg^{2+}) center),
- quinones,
- cytochromes,
- plastocyanins (copper-containing proteins),
- nonheme iron sulfur proteins,
- ferredoxin, and
- flavoproteins

TYPES

- ***Oxygenic*** (generates O_2)
- oxygenic photosynthesis is used by the cyanobacteria, the algae, and by plants.

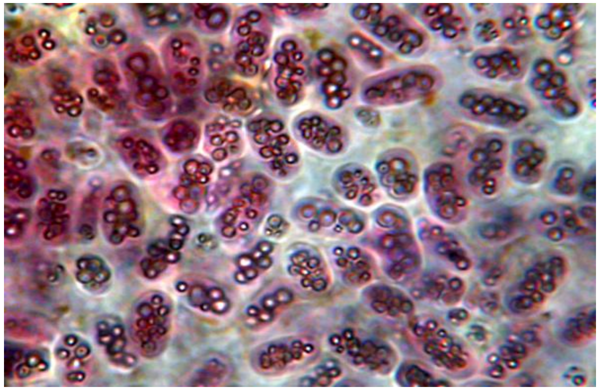
- ***Anoxygenic*** (doesn’t generate O_2).
- anoxygenic photosynthesis is used mainly by the purple bacteria, the green sulfur and nonsulfur bacteria, the heliobacteria and the acidobacteria.

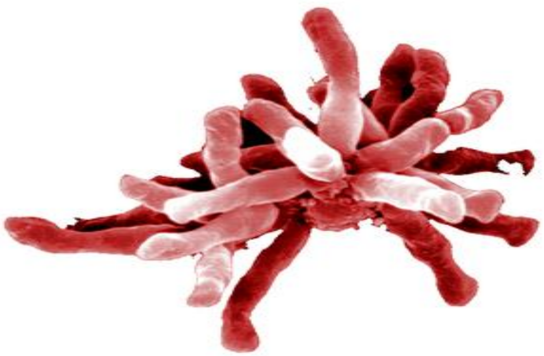
Oxygenic -cyanobacteria,

- 

Anoxygenic- Purple sulphur bacteria

Rhodospirillum

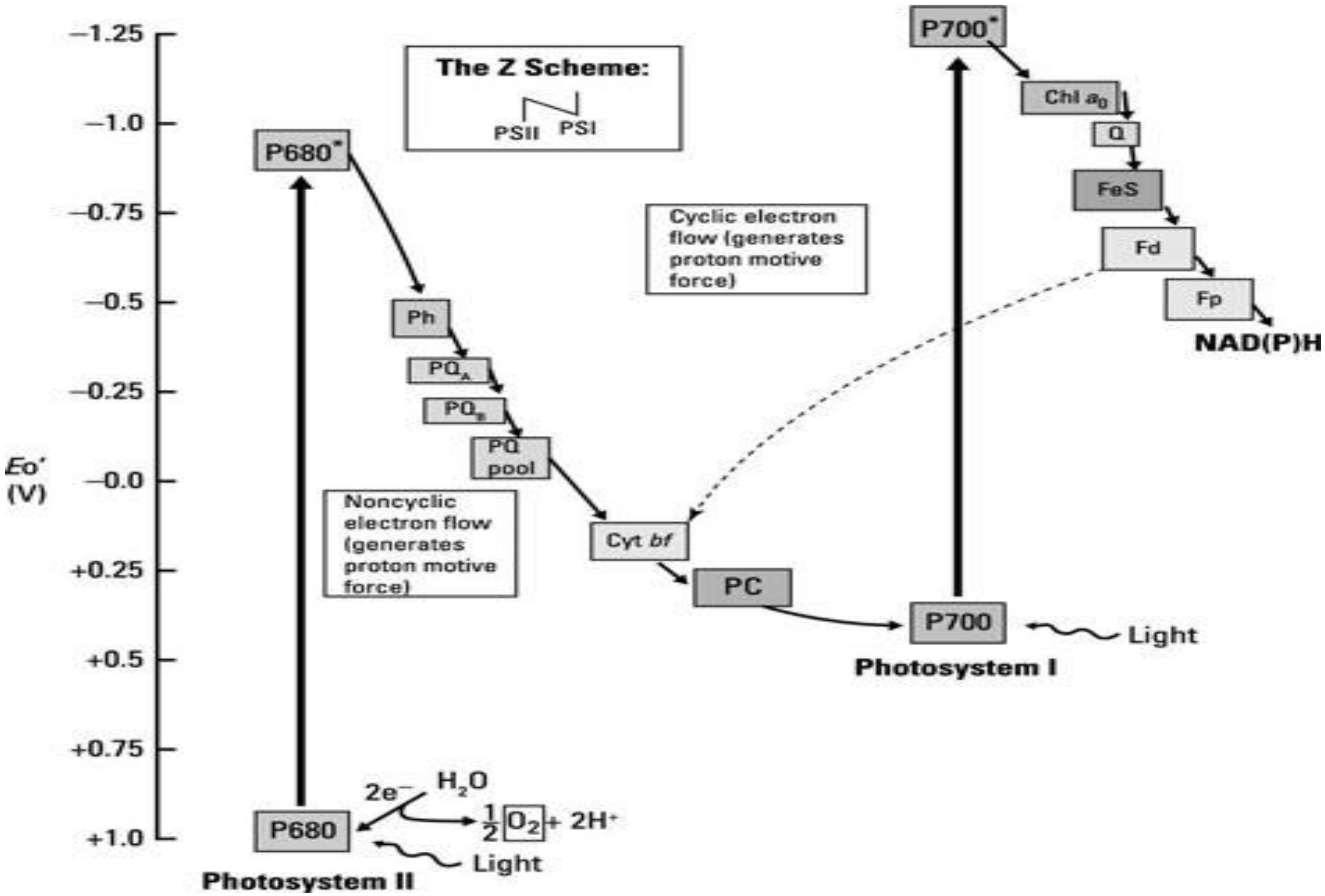




Oxygenic photosynthesis

- eukaryotic algae and cyanobacteria
- the same mechanism is at work in both.
- Electron flow happens through two different electron transport chains that are connected;
- together, these electron transport chains are called the *Z scheme*.
- The stars of each chain are photosystem I (PSI) and photosystem II (PSII),
- each contain chlorophyll reaction centers surrounded by antenna pigments

noncyclic photophosphorylation



- for the wavelengths of light each absorbs most efficiently
- The chlorophyll in PSI is called P700,
- the chlorophyll in PSII is called P680,

- 1. Light energy (a photon of light) is absorbed by PSII, exciting P680 and making it into a good electron donor that reduces the first member of the electron transport chain, pheophytin.

- 2.PSII is normally very electropositive and it would just remain reduced unless excited by light.

- 3.Water is split to generate electrons used to reduce P680 back to its resting state.
- The protons (H^+) from water act to create the proton motive force, whereas the oxygen is released (giving the pathway its name).

- 4.The electrons travel through several electron carriers until eventually reducing P700 in PSI.
- P700 is already oxidized after having absorbed light and donated an electron to the next electron transport chain..

- 5.After passing through a series of electron carriers, the last step in the process is the reduction of $NADP^+$ to NADPH.

- 6.Aside from the production of NADPH, electron transport functions to create the proton motive force, which is used by ATP synthase to generate ATP

- THIS PATHWAY IS CALLED

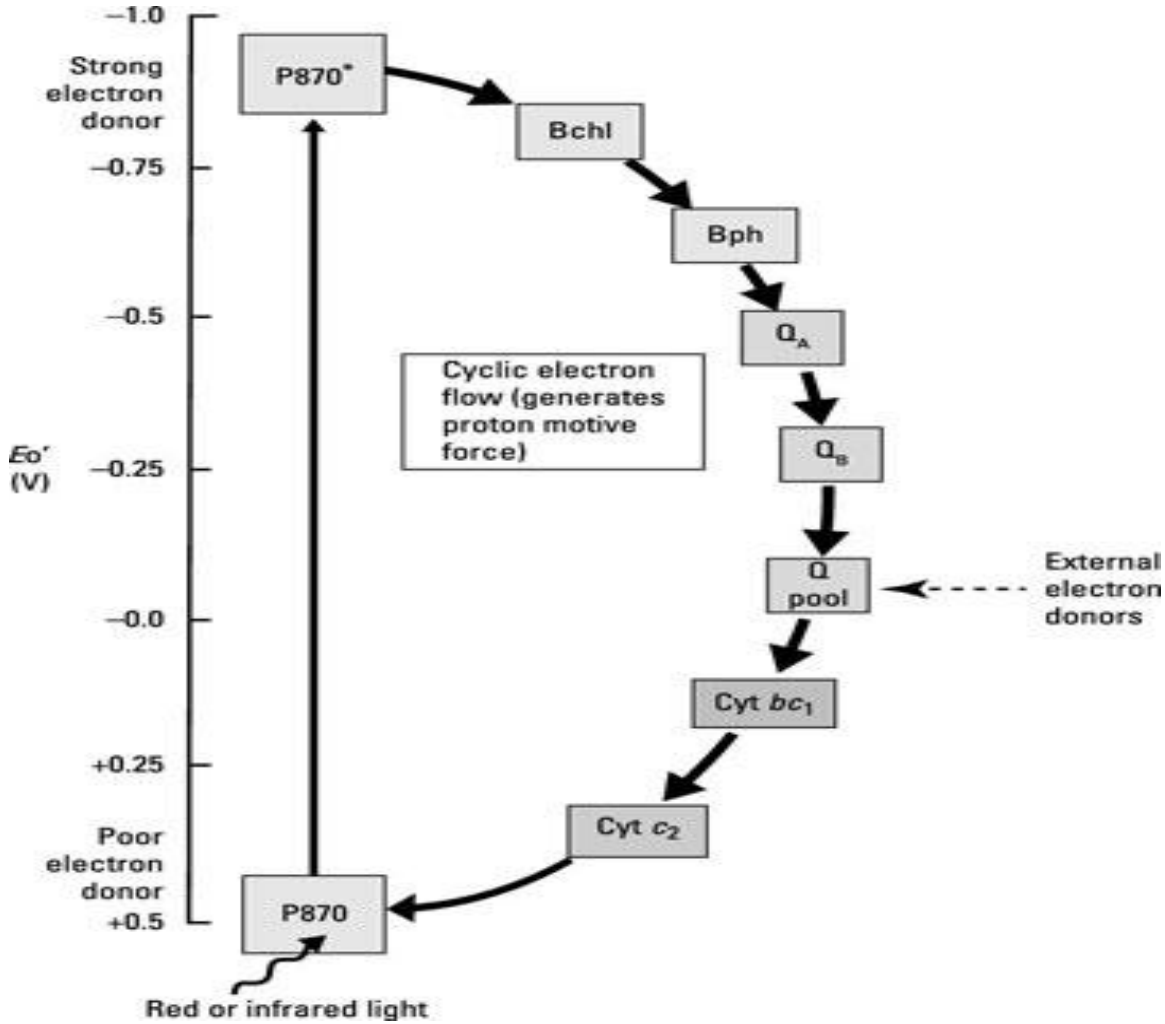
  NON CYCLIC PHOTOPHOSPHORYLATION,

  SINCE ELECTRONS DON'T CYCLE BACK TO REDUCE THE ORIGINAL ELECTRON DONOR,

- If things are ideal and enough reducing power (extra electrons) is available,
- some of the electrons do travel back to reduce P700 and
- in the process add to the proton motive force that generates ATP (or *phosphorylation*).
- When this happens, it's called *cyclic photophosphorylation.*

ANOXYGENIC PHOTOSYNTHESIS

- Many of the steps in anoxygenic photosynthesis are the same as those for oxygenic photosynthesis.
- light excites the photosynthetic pigments,
- causing them to donate electrons to the electron transport chain and
- ATP is again generated from the proton motive force created by electron transport



−1.0
Strong electron donor
−0.75
−0.5
Eo' (V)
−0.25
−0.0
+0.25
Poor electron donor
+0.5
P870*
Bchl
Bph
Q_A
Q_B
Q pool
External electron donors
Cyt bc_1
Cyt c_2
P870
Cyclic electron flow (generates proton motive force)
Red or infrared light

- The main ways that anoxygenic photosynthesis differs from oxygenic photosynthesis:
- Oxygen is not released because P680 of PSII is not present.
- Water is too electropositive to act as the electron donor for the photosystem.
- Depending on the species, the reaction center can consist of chlorophyll,
  bacteriochlorophyll, or
  other similar pigments.
- The reaction center in purple bacteria is called P870

- Some of the carriers within the electron chain are different, including bacteriopheophytin,
- which is bacteriochlorophyll without Mg^{2+} ion.

- Electrons cycle back to reduce P870,
- so this is a cyclic electron transport chain leading to generation of ATP through cyclic photophosphorylation

- Unlike in oxygenic photosynthesis, where NADPH is the terminal electron acceptor,
- no NADPH is made because electrons are cycling back into the system.

- Without NADPH, cells generate the reducing power necessary to drive the Calvin cycle for carbon fixation through oxidization of inorganic compounds.

- The electrons donated are added to either the quinone pool (purple bacteria) or

- donated to iron-sulfur proteins (the green sulfur and nonsulfur bacteria, and the heliobacteria).

- When the electron acceptor is not sufficiently electronegative (as in the case of quinone), then *reverse electron flow* is needed to get the necessary reducing power.

- Reverse electron flow uses the proton motive force to push electrons to reduce $NADP^+$.

- This mechanism is used frequently in other situations, where several turns of the electron transport cycle are necessary to generate enough power to reduce one molecule of NAD^+ or $NADP^+$.

- In some phototrophs, (Chloroflexi,) both
- ATP and reducing power(electron donors like NADH or NADPH)
- are produced from the light reactions,

- whereas in others like the purple bacteria
- the light reaction produce ATP
- reducing power from separate reactions like oxidizing inorganic compounds.

- All known organisms that carry out anoxygenic photosynthesis are obligate anaerobes. Several groups of bacteria can conduct anoxygenic photosynthesis: green sulfur bacteria (GSB), red and green filamentous phototrophs (FAPs e.g. Chloroflexi), purple bacteria, Acidobacteria, and heliobacteria.

- There are two main types of anaerobic photosynthetic electron transport chains in bacteria.
- The type I reaction centers found in GSB, Chloracidobacterium, and Heliobacteria and
- The type II reaction centers found in FAPs and Purple Bacteria

- **Type I Reaction Centers**
- The electron transport chain of green sulfur bacteria , Chloracidobacterium, and Heliobacteria
- - reaction centre -bacteriochlorophyll pair, P840.
- When light is absorbed by the reaction center, P840 enters an excited state with a large negative reduction potential, and
- so readily donates the electron to bacteriochlorophyll 663 which passes it on down the electron chain.
- The electron is transferred through a series of electron carriers and complexes until it is used to reduce NAD^+.
- P840 regeneration is accomplished with the oxidation of sulfide ion from hydrogen sulfide (or hydrogen or ferrous iron) by cytochrome

- **Type II Reaction Centers**
- the type II reaction centers are structurally and sequentially analogous to Photosystem II (PSII) in plant chloroplasts and cyanobacteria,

- known organisms that exhibit anoxygenic photosynthesis do not have a region analogous to the oxygen-evolving complex of PSII.

- The electron transport chain of purple r bacteria , FAPs
- begins when the reaction centre- bacteriochlorophyll pair, P870,
- becomes excited from the absorption of light.
- Excited P870 will then donate an electron to bacteriopheophytin,
- which then passes it on to a series of electron carriers down the electron chain.
- In the process, it will generate an electro-chemical gradient which can then be used to synthesize ATP by chemiosmosis.
- P870 has to be regenerated (reduced) to be available again for a photon reaching the reaction-center to start the process anew.
- Molecular hydrogen in the bacterial environment is the usual electron donor.

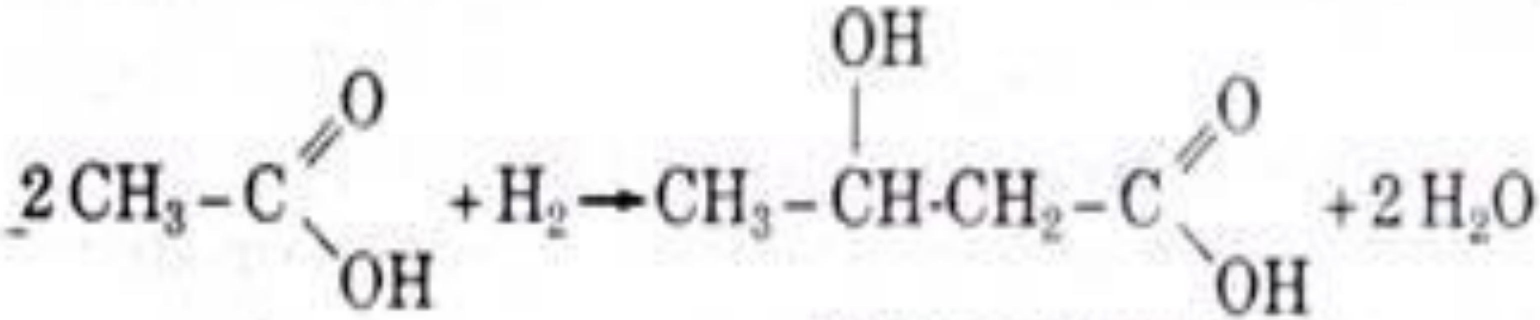
- Photosynthesis in prokaryotic organisms occurs in la-mellar membrane systems called chromatophores.
- The chromatophores contain the pigments for the photochemical reactions but none of the subsequent biosynthetic enzymes.
- The pigment system includes the chlorophylls, carotenoids, and in some cases phycobilins.
- However, in the purple and green bacteria, bacteriochlorophyll is the ultimate light-trapping molecule (not chlorophyll a).
- Only the cyanobacteria have chlorophyll a.

- The most important distinction between plant and bacterial photosynthesis is that water is not used as the reducing agent and oxygen is not an end product.
- The power to reduce CO_2 may come from molecular hydrogen, H_2S, or organic compounds.
- Two major groups of bacteria that carry out photosynthesis are the green and purple sulfur bacteria;
- these organisms utilize H_2S and produce sulfur and sulfate,

- During photosynthesis, sulfur accumulates as gran-ules of elemental sulfur and may be further metabo-lized later.
- Non-sulfur purple bacteria use organic compounds such as acetic acid as electron donors.
- The acetic acid is anaerobically oxidized via the Krebs cycle reactions.
- Acetic acid can also be reduced to hydroxybutyric acid.
- Certain members of the sulfur and non-sulfur purple bacteria can use molecular hydrogen to reduce either $C0_2$ or acetic acid, that is,

$$6\,CO_2 + 12\,H_2 \rightarrow C_6H_{12}O_6 + 6H_20$$

and



hydroxybutyric
acid