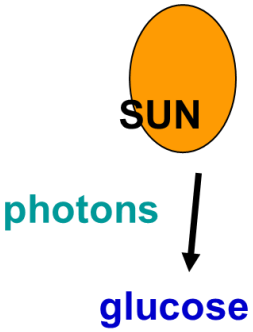
Plant physiology Lec. 8
Photosynthesis



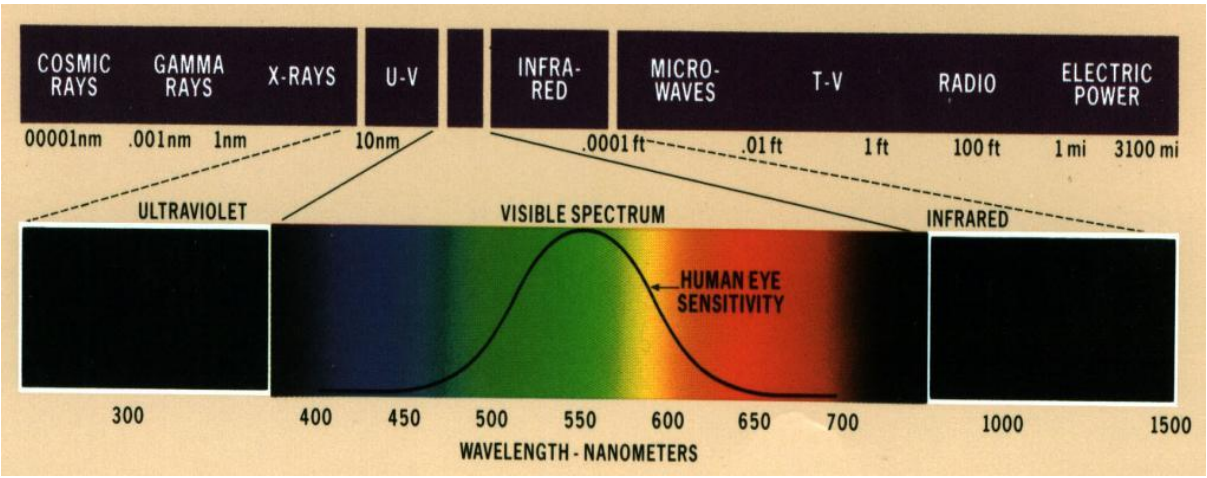
Processes can be:

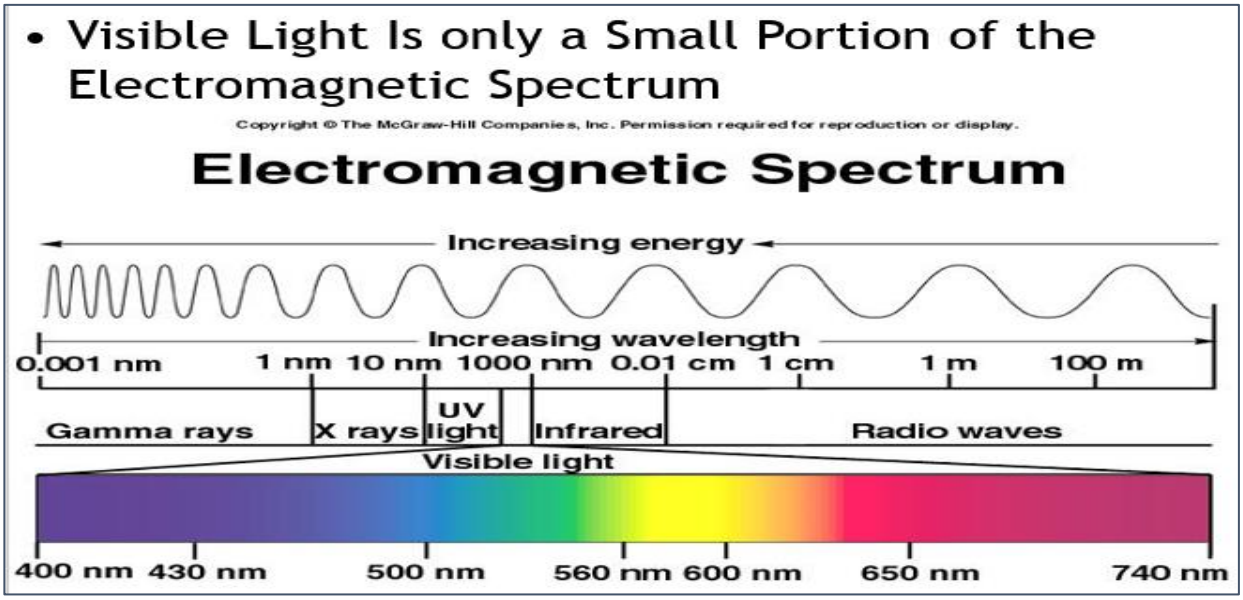
energy consuming (endergonic) or
energy releasing (exergonic) and
catabolic (breakdown) or
anabolic (synthesis)

- **Photosynthesis is** an **anabolic, endergonic, carbon dioxide (CO_2)** requiring process that uses **light energy (photons)** and **water (H_2O)** to produce **organic macromolecules (glucose).**
  $6CO_2 + 12H_2O \xrightarrow{®} C_6H_{12}O_6 + 6O_2 + 6H_2O$

<u>What is light</u>?

- Photon - a light particle.
- Wavelength – Length of a complete wave of light.
- Frequency – The number of waves per unit length. Sunlight is an electromagnetic radiation coming from the sun. It has a wide spectrum – from cosmic rays to radio waves.

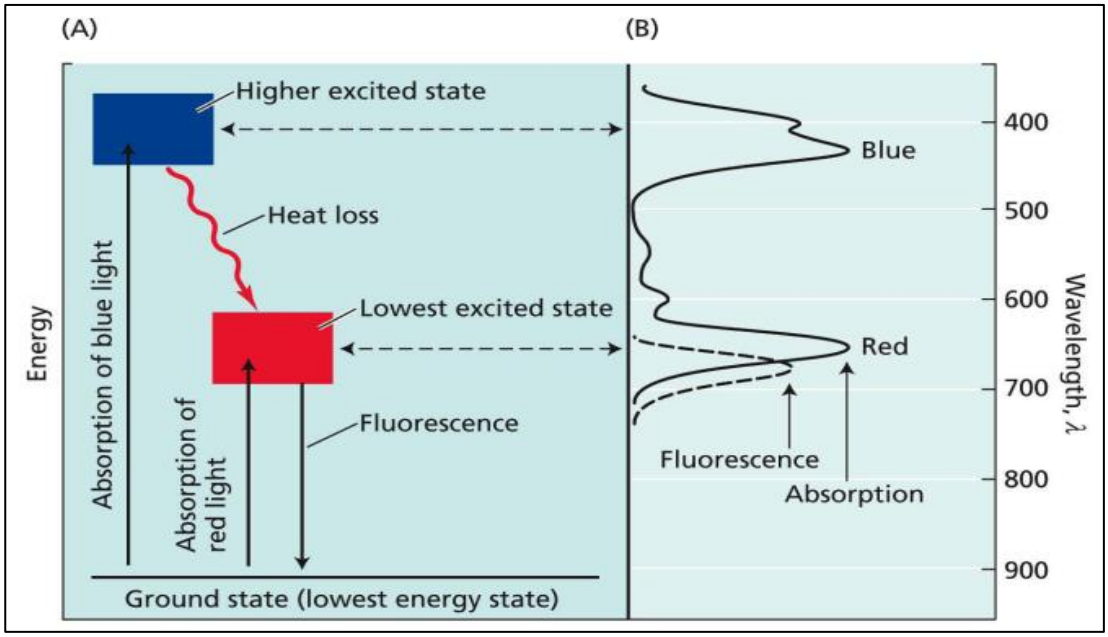




Light absorption and emission by chlorophyll

- Stable for only about several nanoseconds (10^{-9}s), any process that captures its energy must be extremely rapid. In the lowest excited state, the excited chlorophyll has four alternative pathway to dispose energy:
- Fluorescence.
- Heat
- Energy transfer
- Photochemistry (Photosynthesis)

Light absorption and emission by chlorophyll



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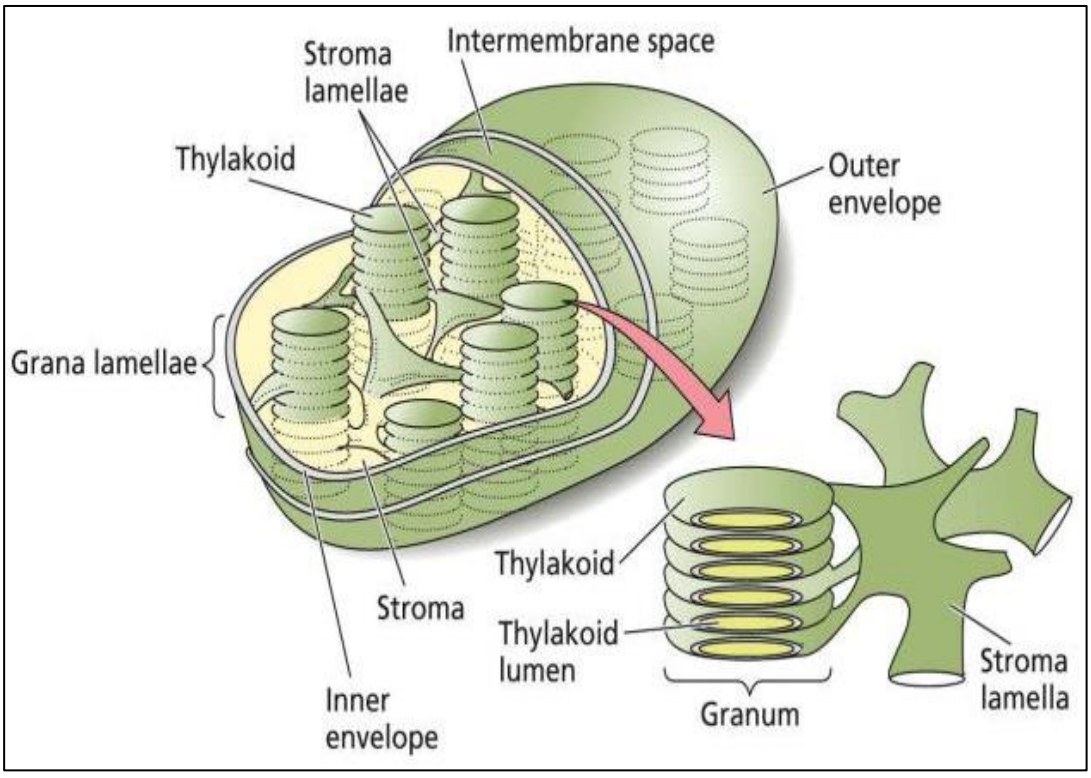
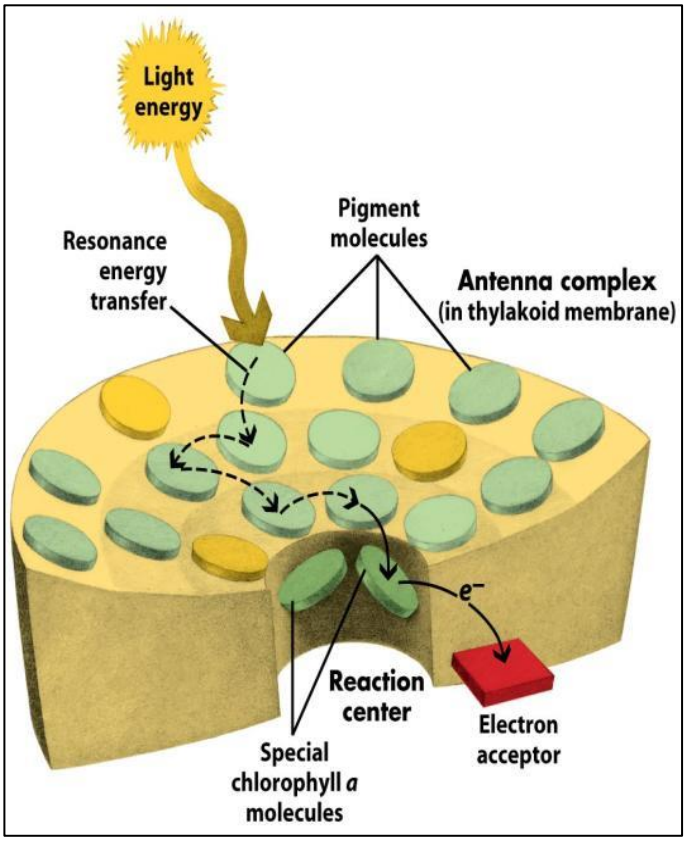
Chloroplasts



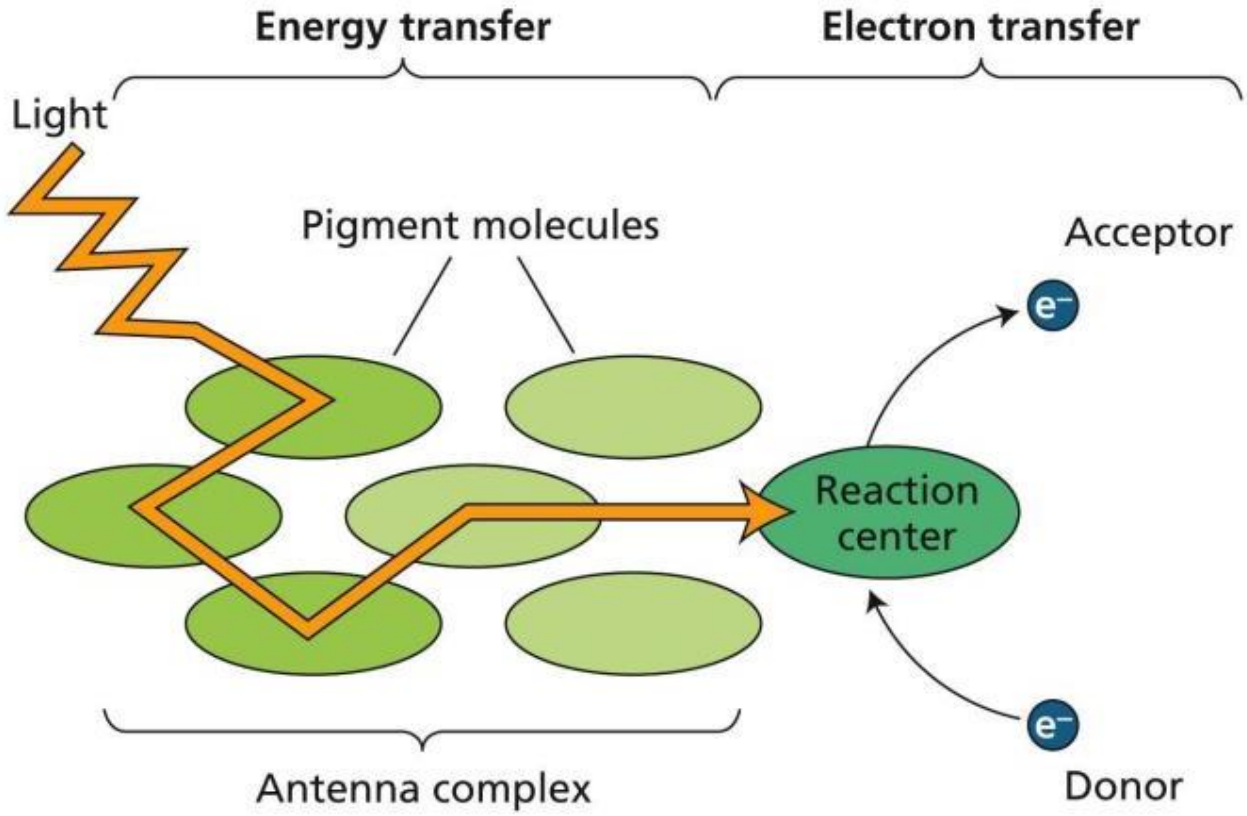
A pigment is any substance that absorbs light, the color of the pigment comes from the wavelengths of light reflected.

Chlorophyll is the green pigment common to all photosynthetic cells, absorbs all wavelengths of visible light except green, which it reflects to be detected by our eyes. All photosynthetic organisms have chlorophyll a. accessory pigments absorb energy that chlorophyll a does not absorb,

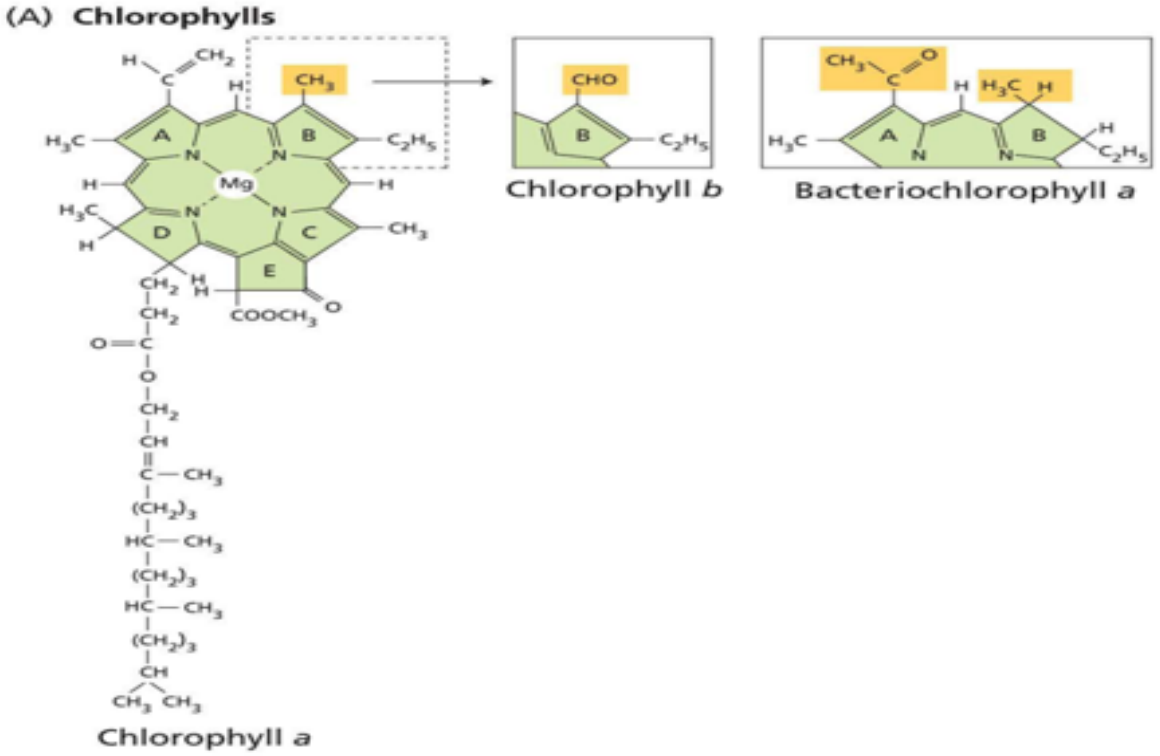
chlorophyll b, xanthophylls and carotenoids (Beta-Carotene).



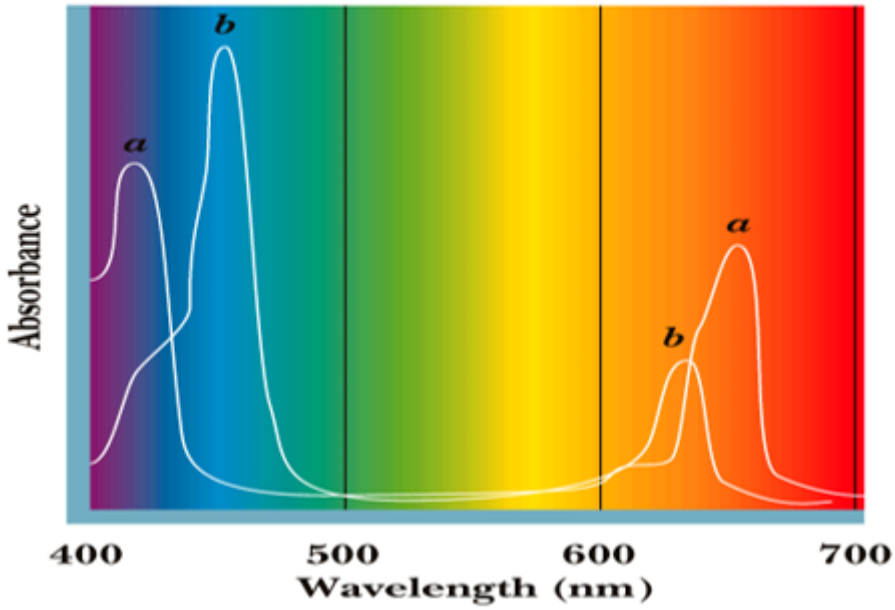
Basic concept of energy transfer during photosynthesis



Molecular structure of some photosynthetic pigments



Absorption spectrum of Chlorophyll a and b



Photosynthesis Stages

- **2 Stage Process**
  - **Light Dependent Reactions**
    - Require Light to Occur
    - Involves the Actual Harvesting of Light Energy
    - Occur in\on the Grana
  - **Dark or Light Independent Reactions, Chemical Reactions**
    - Do not Need Light to Occur
    - Involve the Creation of the Carbohydrates
  - **Occur in the Stroma**
  - **Products of the Light Reaction Are Used to Form C-C Covalent Bonds of Carbohydrates**

- ## Light Reactions

When Light Strikes Magnesium (Mg) Atom in Center of Chlorophyll Molecule, the Light Energy Excites a Mg Electron and It Leaves Orbit from the Mg Atom.

- The Electron Can Be Converted to Useful Chemical Energy. The Excited Electron (plus Additional Light Energy) eventually Provides Energy so a Phosphate Group Can Be Added to a Compound Called Adenosine Diphosphate (ADP), Yielding Adenosine Triphosphate (ATP)
- ATP Is an Important Stored Energy Molecule.

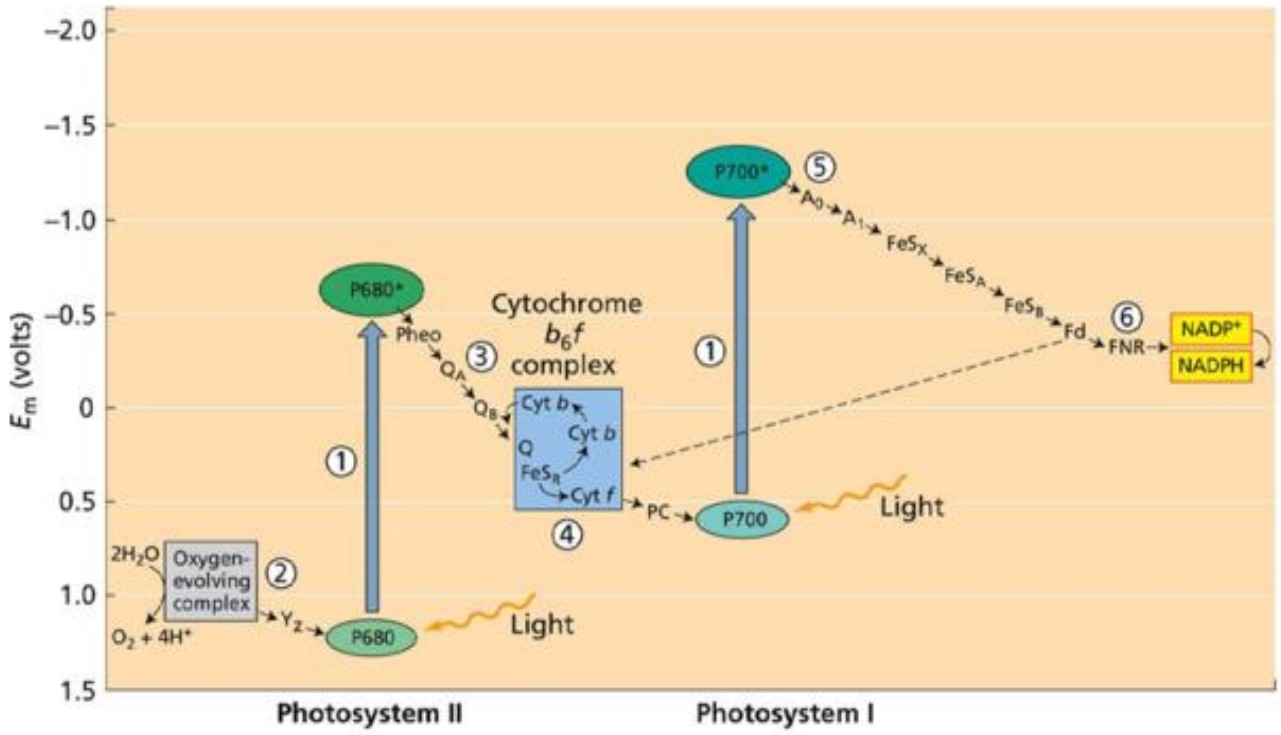
- ## Photolysis (Hill Reaction)
  - The 2 Water Molecules Are Split into Hydrogen and Oxygen
  - The Hydrogen Is Attached to a Molecule Called Nicotinamide Adenine Dinucleotide Phosphate (NADP)
    - Produces $NADPH_2$
  - The Oxygen Is Given off as Oxygen Gas
  - $2\ H_20 + NADP + light$ à $NADPH_2 + O_2$

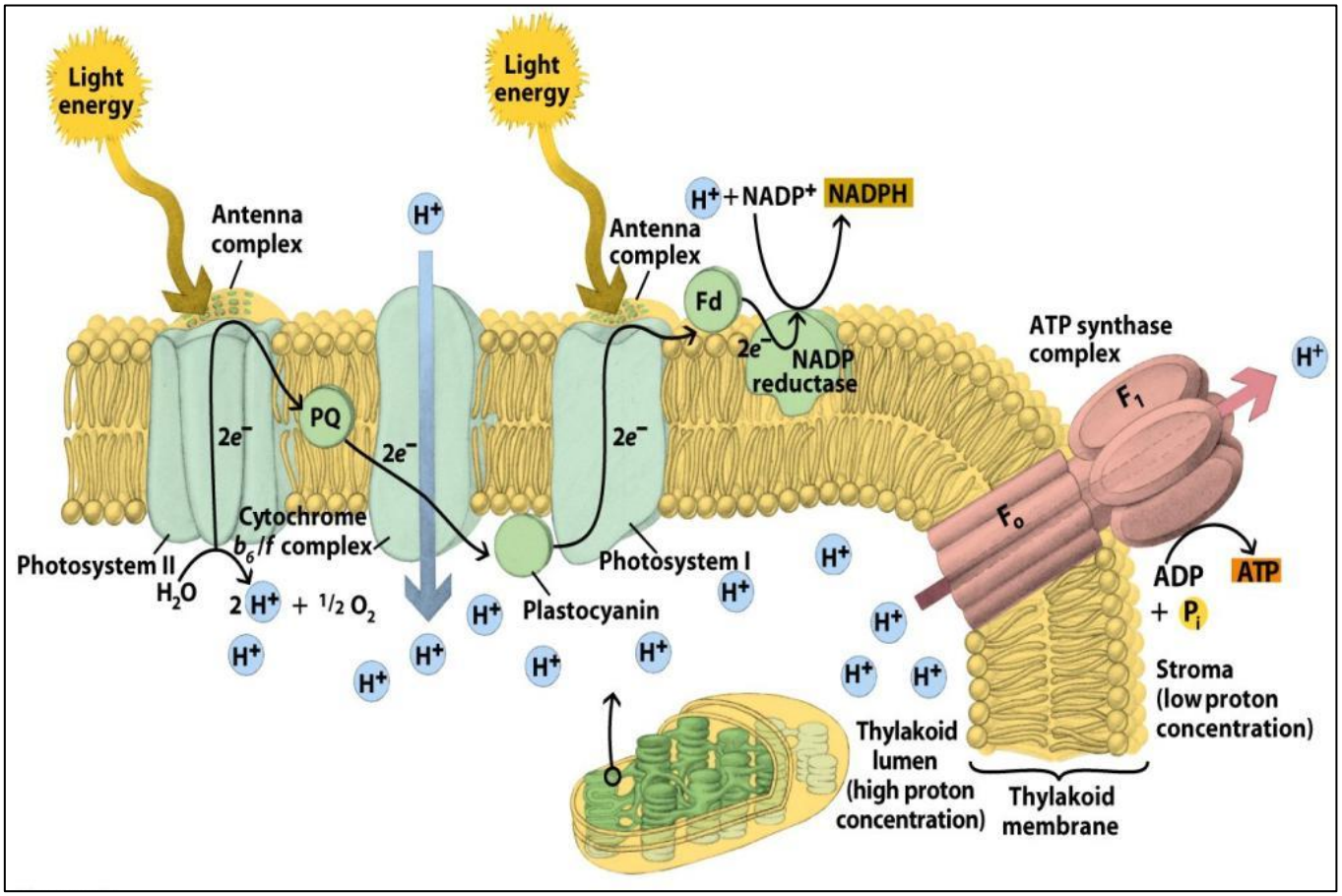
During the light reaction, there are two possible routes for electron flow:

A. **Cyclic Electron Flow:**
   Occurs in the thylakoid membrane. Uses Photosystem I only. P700 reaction center- chlorophyll a.Uses Electron Transport Chain (ETC). Generates ATP only.

B. **Noncyclic Electron Flow:** Occurs in the thylakoid membrane. Uses PS II and PS I. P680 center (PSII) - chlorophyll a. P700 center (PS I) - chlorophyll a. Uses Electron Transport Chain (ETC). Generates O2, ATP and NADPH.

Z scheme for photosynthetic organisms





Photophosphorylation

Light-Driven ATP Synthesis: Electron transfer through the proteins of the Z scheme drives the generation of a proton gradient across the thylakoid membrane.

- Protons pumped into the lumen of the thylakoids flow back out, driving the synthesis of ATP
- ATP Synthase complex is composed CF0 and CF1, CF0 is a channel for H+ CF1 has several protein subunits for the reaction:
- ADP + Pi + H+ ⟶ ATP+ H2O
- ATP is the energy molecule of life.

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ADP + Pi + H+ → ATP+ H2O

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