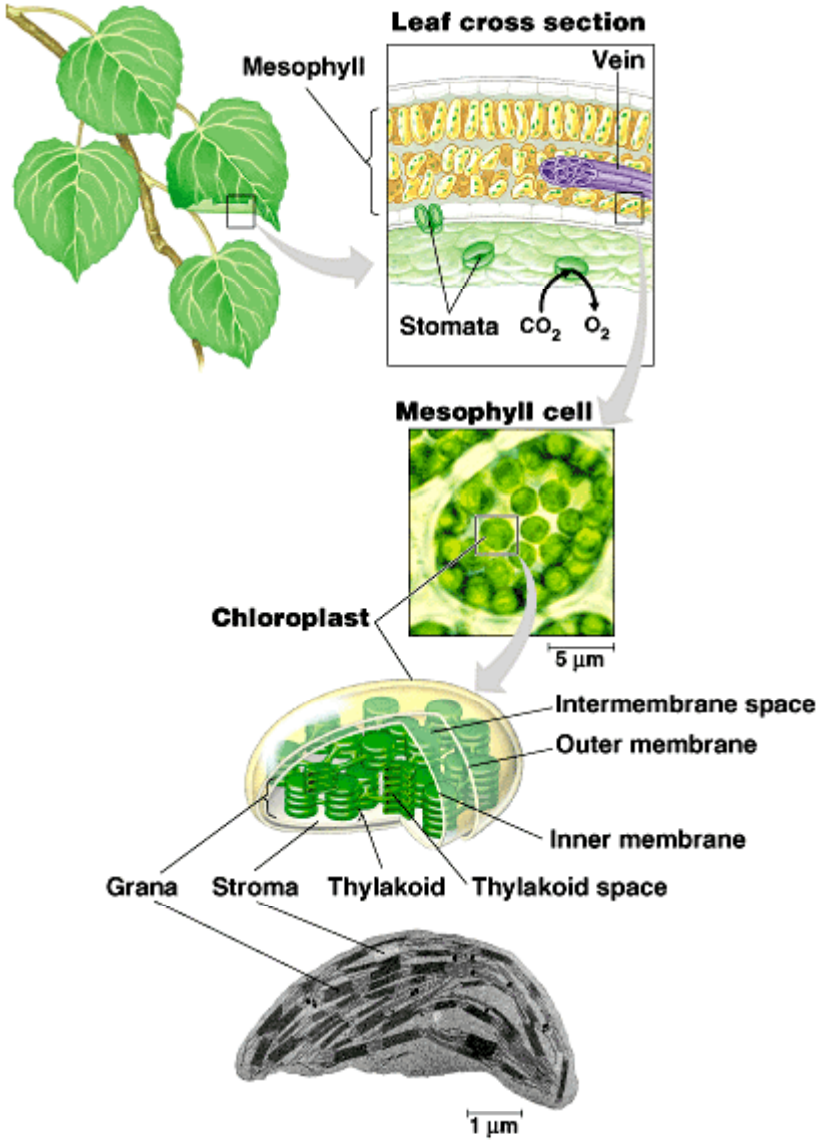
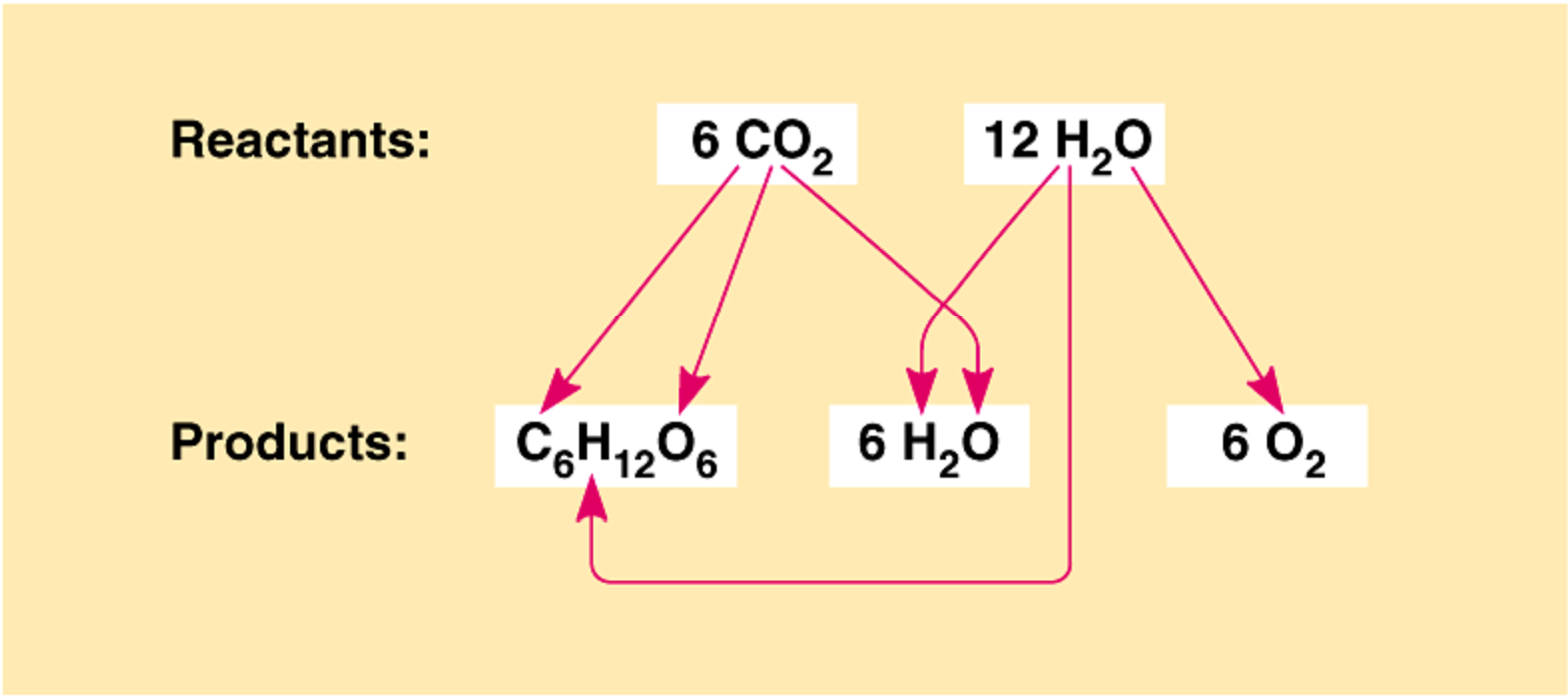
Photosynthesis

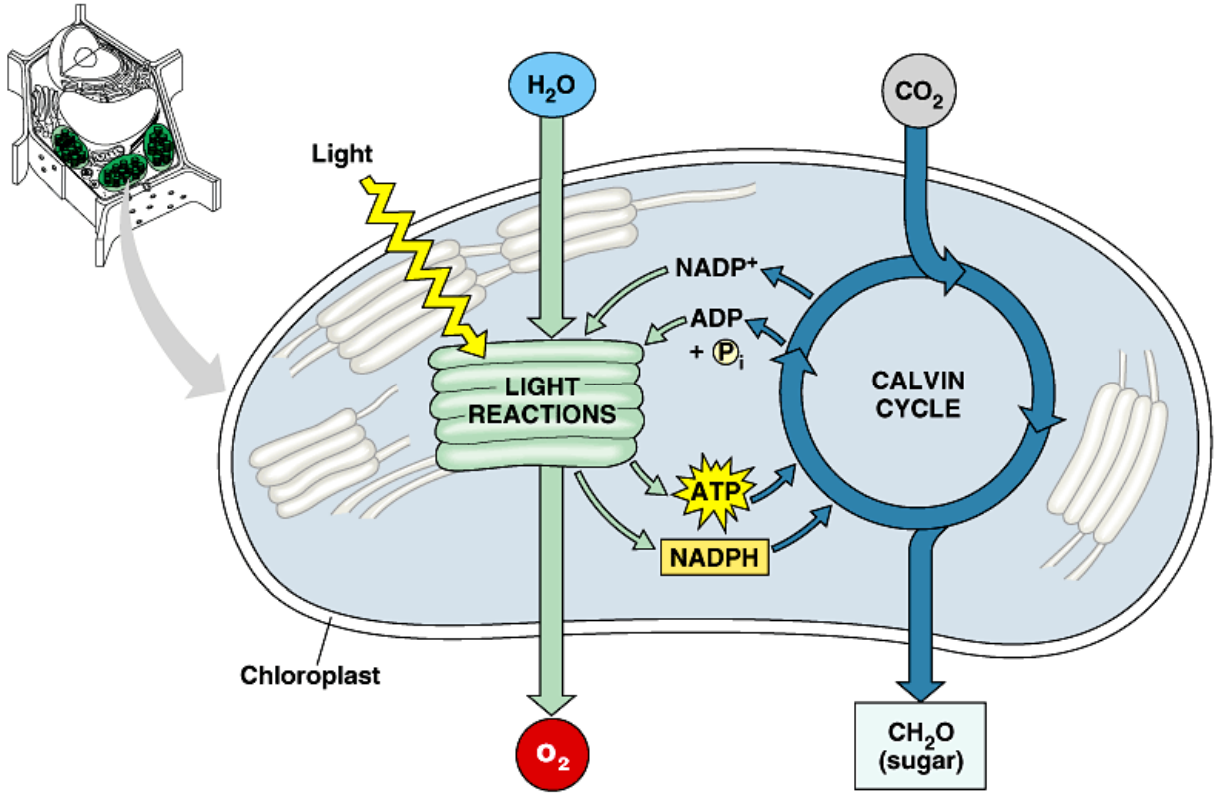
- 6 CO_2 + 12 H_20 + Light → $C_6H_{12}O_6$ + 6 O_2 + 6 H_2O

- Occurs in 2 Stages – both take place in the Chloroplasts
  - <u>Light Reactions</u>
    - Splitting of Water
    - Production of ATP and NADPH for the Calvin Cycle
  - <u>Calvin Cycle</u>
    - Build sugar from the fixation of CO_2





- The oxygen in oxygen gas comes from water



- Light Reactions: Light and Water produce oxygen gas
  - ATP and NADPH at made by electron transport chains
- Calvin Cycle: CO2 is used to build sugar
  - ATP and NADPH are USED to build the sugar
- The Light reactions fuel the Calvin Cycle with ATP and NADPH

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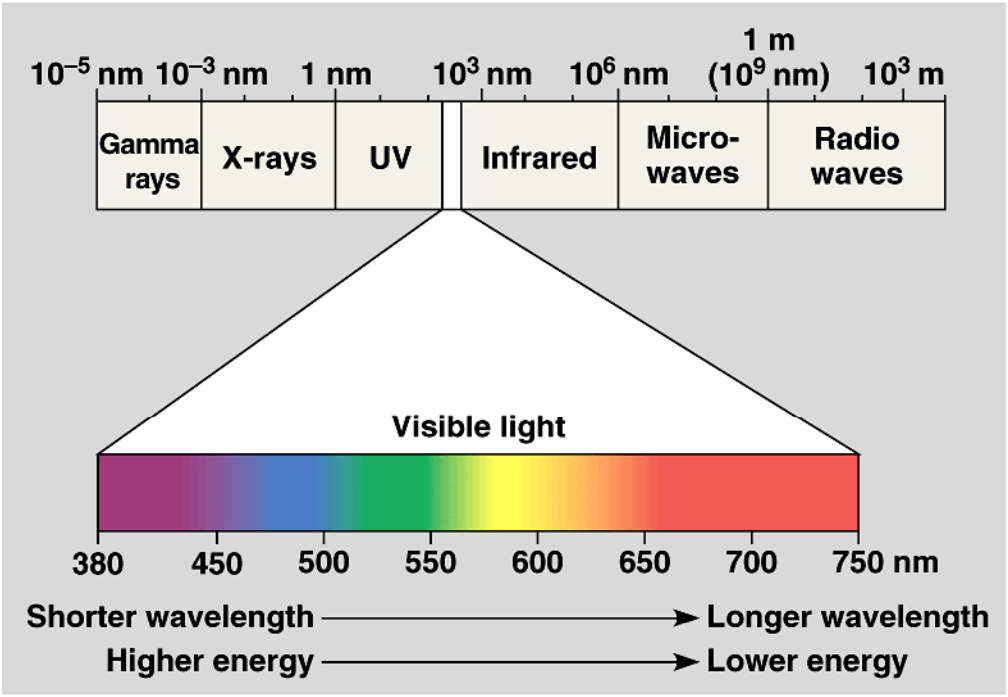
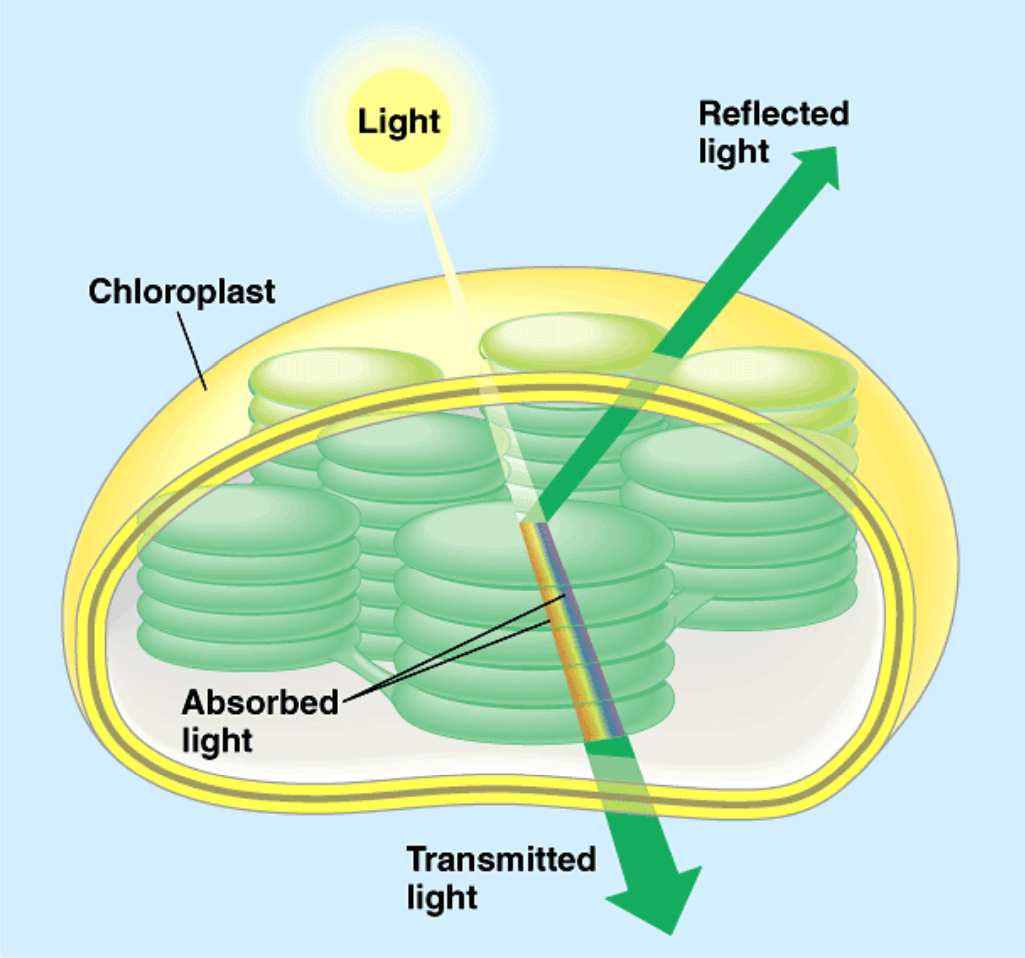
- Do plants use mitochondria for cellular respiration?
  - **A** – Yes
  - **B** - No

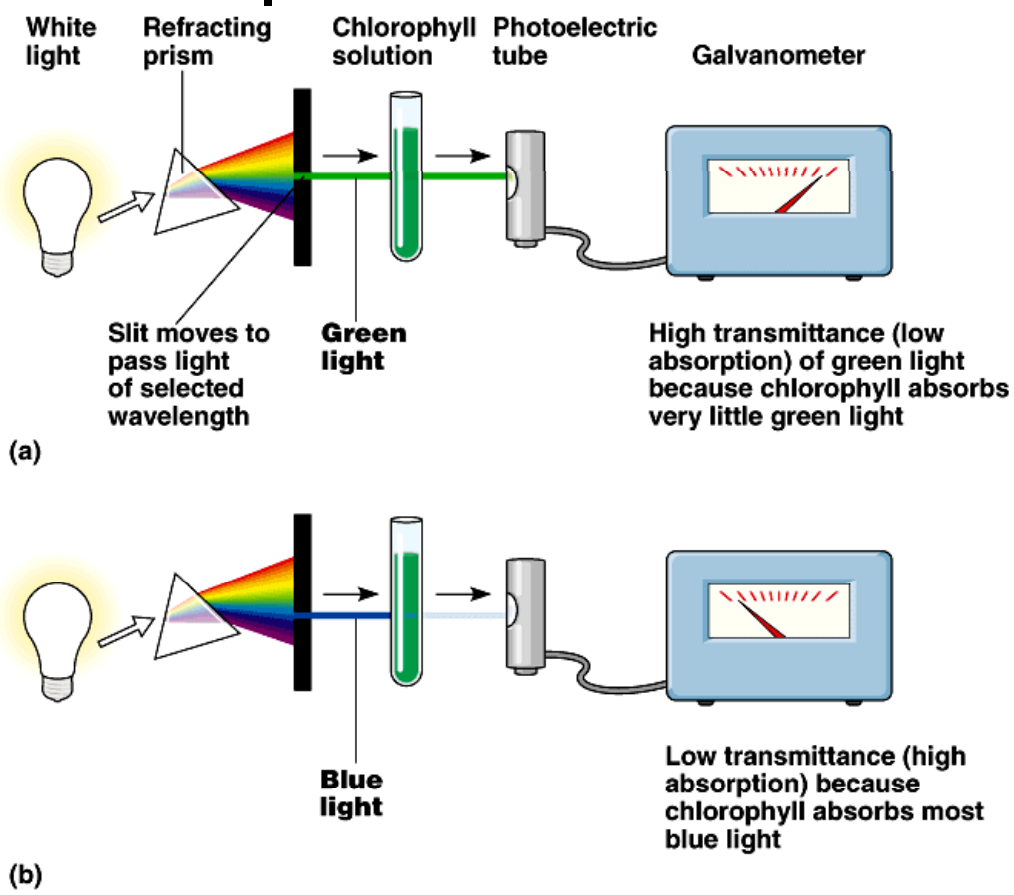
Light



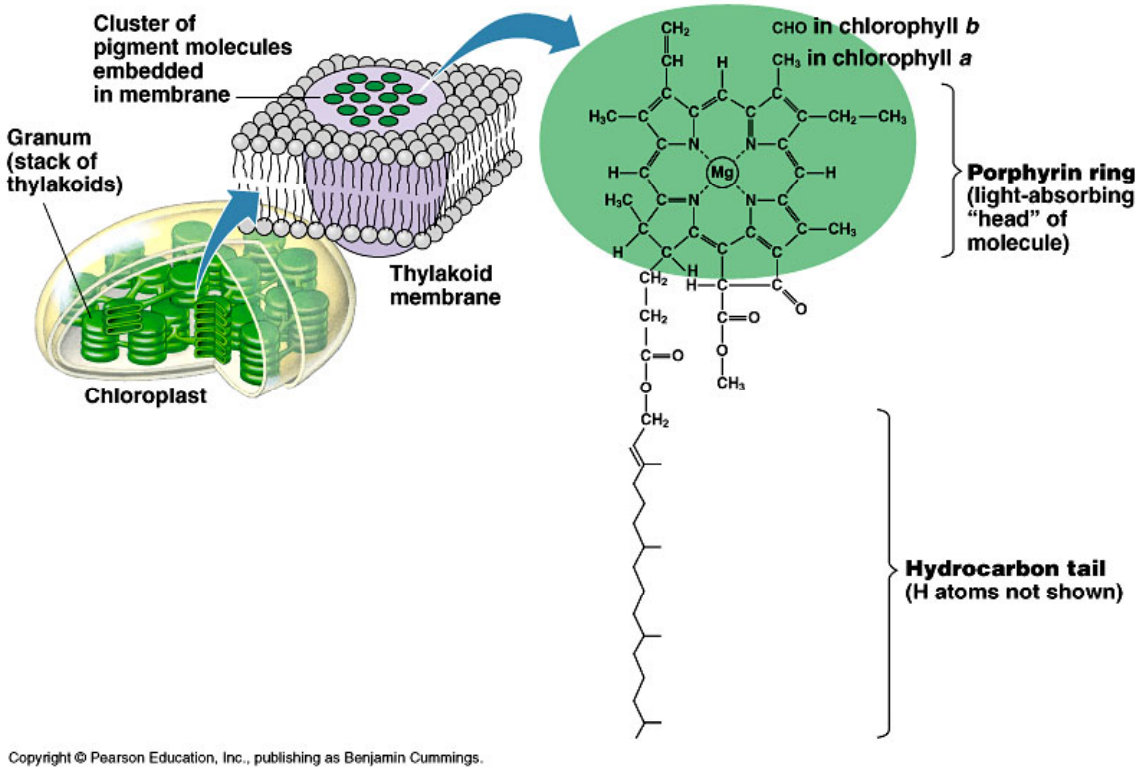
- The electromagnetic spectrum contains EMWs of different wavelengths and energy levels
- Light is composed of energy containing photons
- Photons can be absorbed by molecules altering their energy or conformation
  - Some photon receptors are proteins



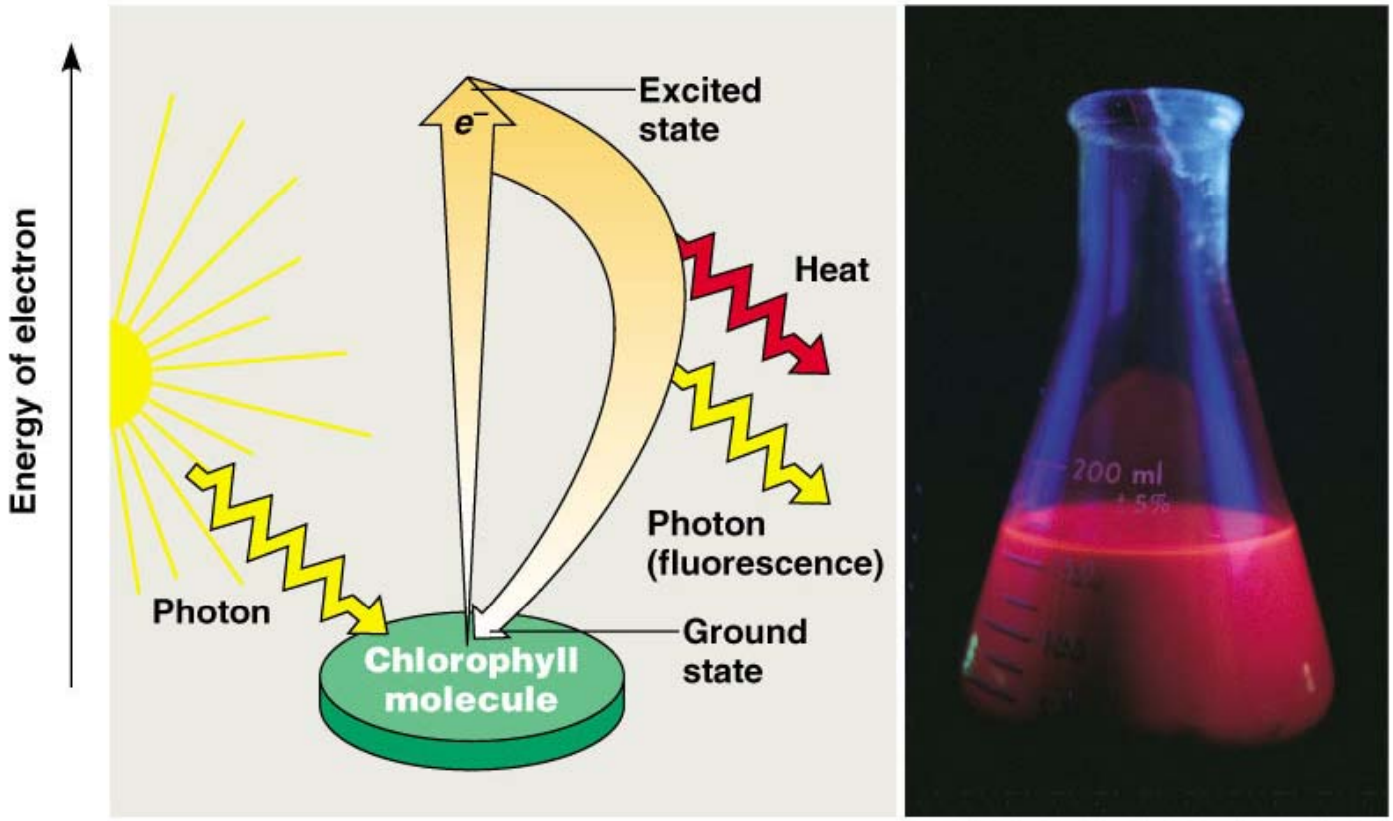
- Leaves are green because Chloroplasts REFLECT the green light.
- Pigments in chloroplasts absorb the photons from specific wavelengths
  - Chlorophyll a
    - Violet/blue and red
  - Chlorophyll b
    - Blue and orange/red
  - Carotenoids
    - Violet and blue/green



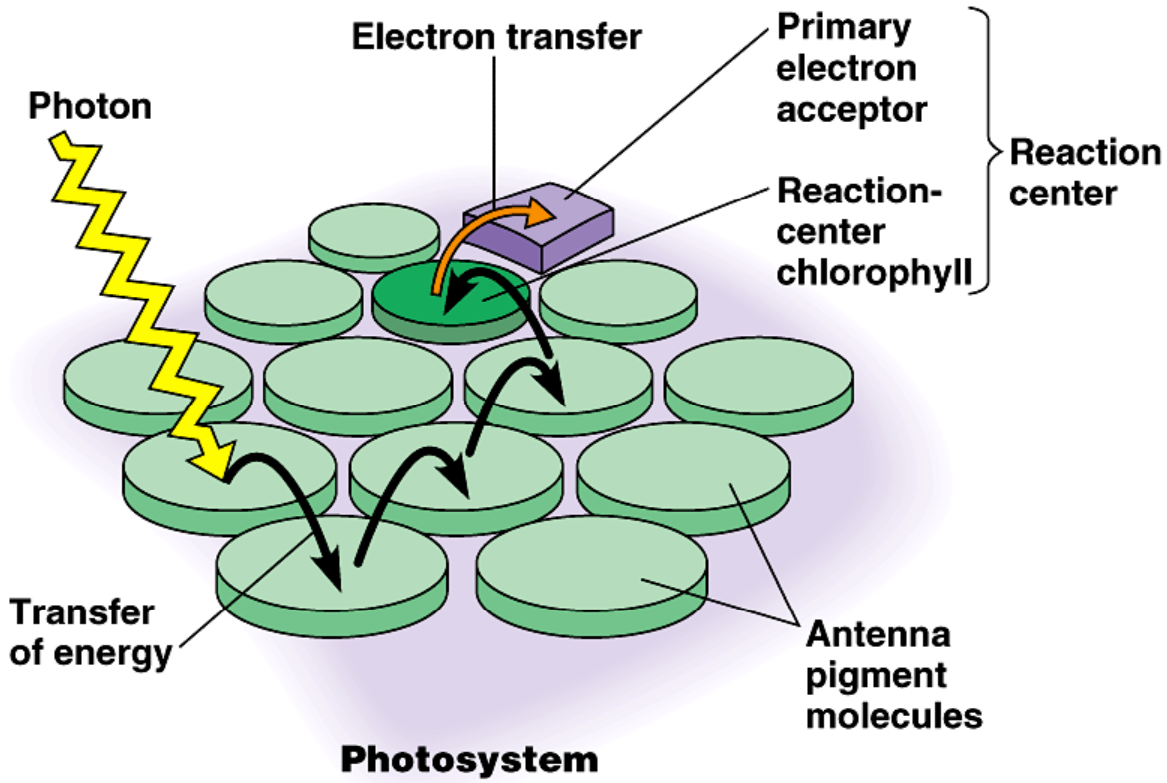
- Experimental evidence demonstrating that green light is NOT absorbed by chloroplasts
- Blue light IS absorbed
- Spectrophotometer measures beams of light of a given wavelength through a solution.



- Chlorophyll is a pigment
- Chlorophyll is NOT a protein
- It is a molecule of the class: Porphyrin



- The light energy absorbed by a chlorophyll molecule can be released in the form of photons
- OR
- Utilized by a neighboring molecule



- Chloroplasts use Photosystems to harness the energy from light
- Photons (a form of energy) are absorbed and that energy is used to transfer electrons and to split a molecule of water
- Water –(light and an enzyme)→ oxygen atom + 2 electrons + 2 protons

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- 5) What does the chemiosmotic process in chloroplasts involve?
  - A) formation of glucose, using carbon dioxide, NADPH, and ATP
  - B) diffusion of electrons through the thylakoid membrane
  - C) establishment of a proton gradient
  - D) reduction of water to produce ATP energy
  - E) movement of water by osmosis into the thylakoid space from the stroma

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- 6) Which of the following are products of the light reactions of photosynthesis that are utilized in the Calvin cycle?
  - A) H_2O and O_2
  - B) ADP, Pi, and $NADP^+$
  - C) ATP and NADPH
  - D) electrons and H^+
  - E) CO_2 and glucose

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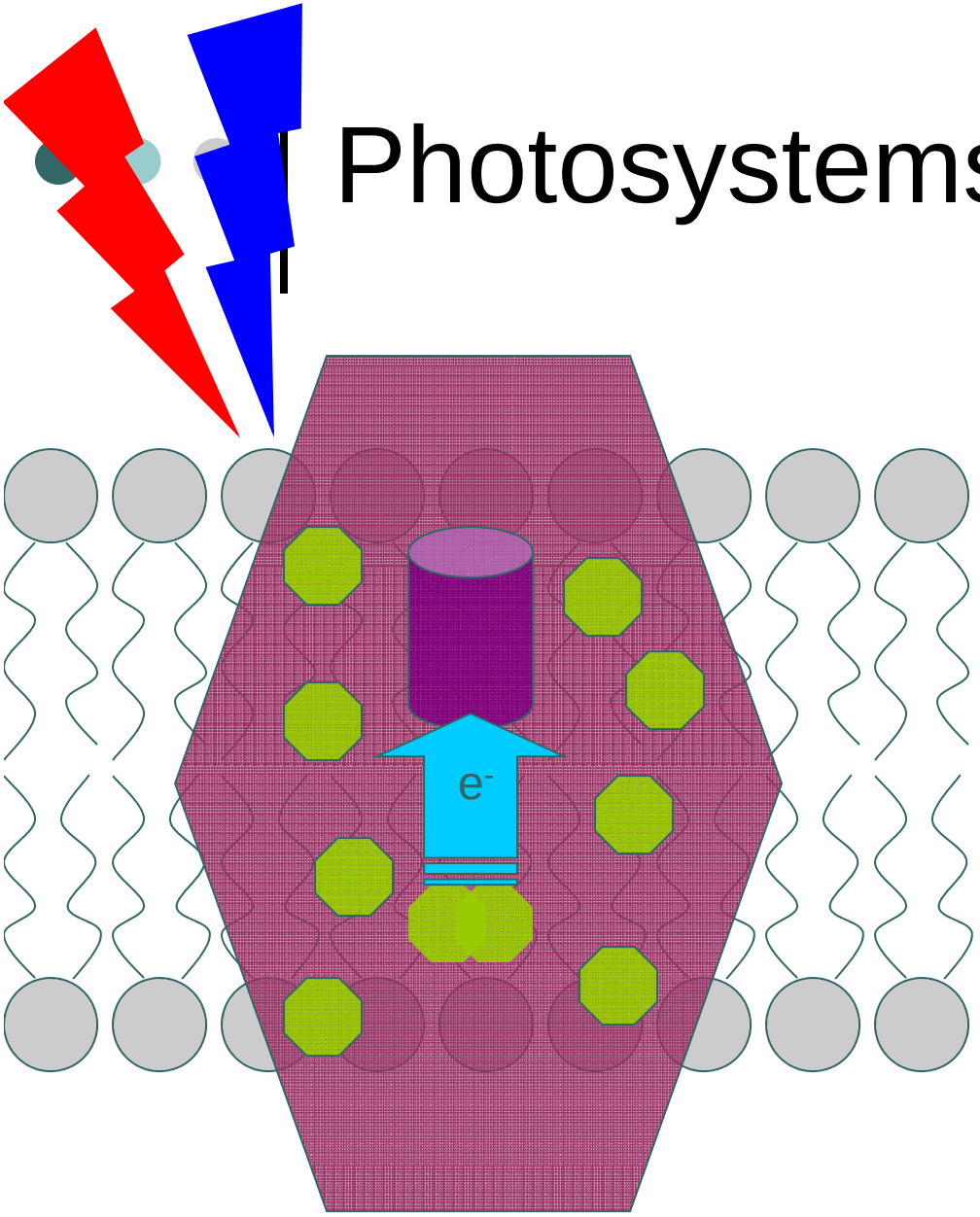
- A plant has a unique photosynthetic pigment. The leaves of this plant appear to be blue and purple. What wavelengths of visible light are *not being absorbed by this pigment?*
  - A) blue and purple
  - B) green, blue, and violet
  - C) blue, green, and red
  - D) green and yellow
  - E) red and yellow

Photosystems



- Complexes of Proteins and Pigments embedded through membrane within the chloroplast

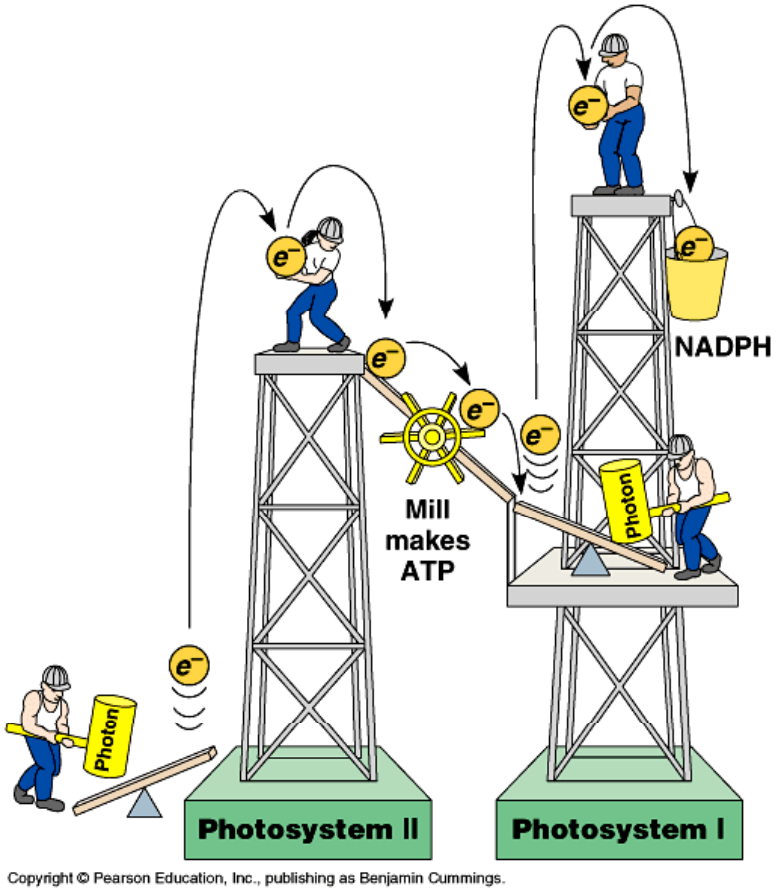
pigments

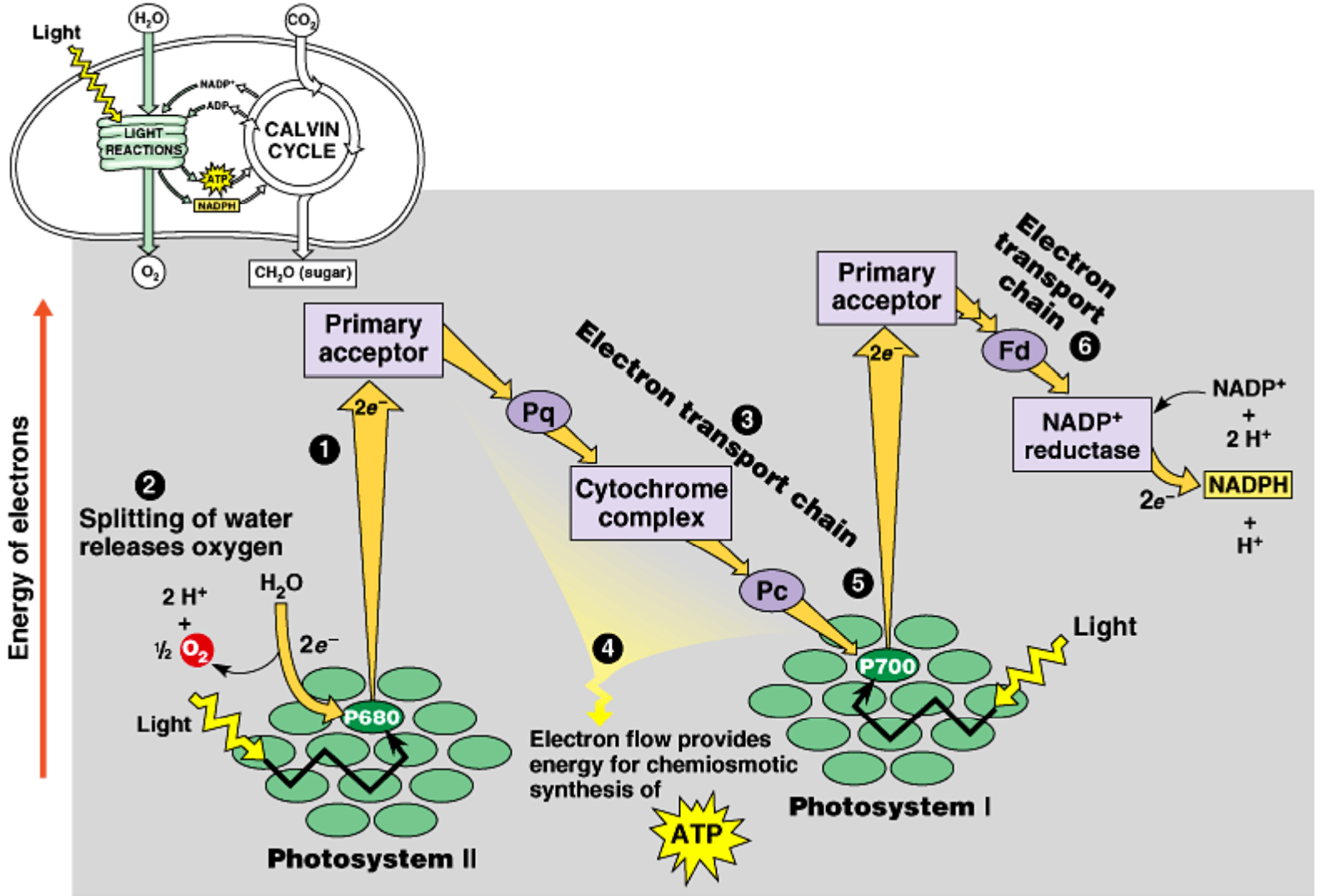
protein

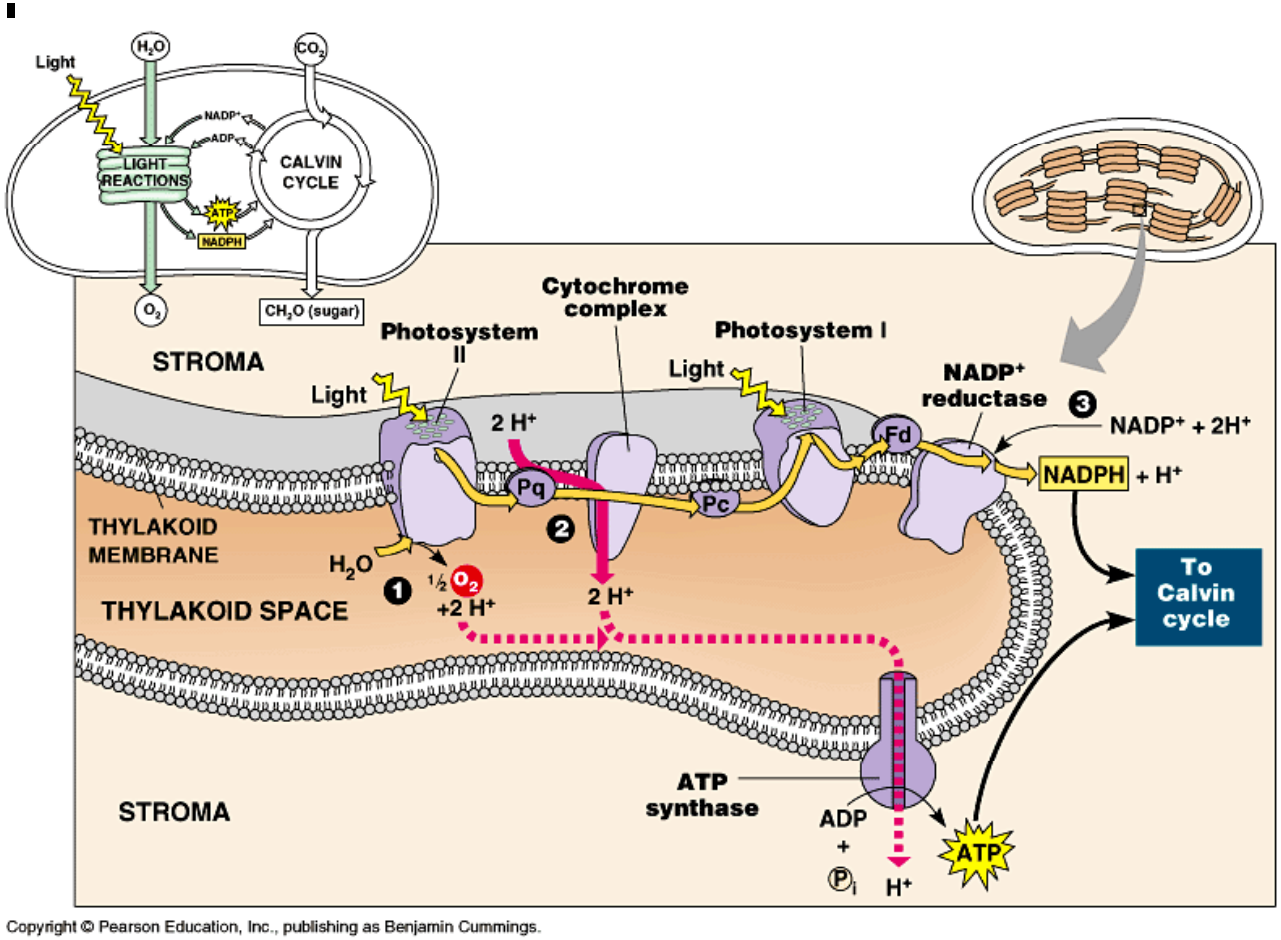
protein: Primary electron acceptor

Light Reactions – 2 photosystems

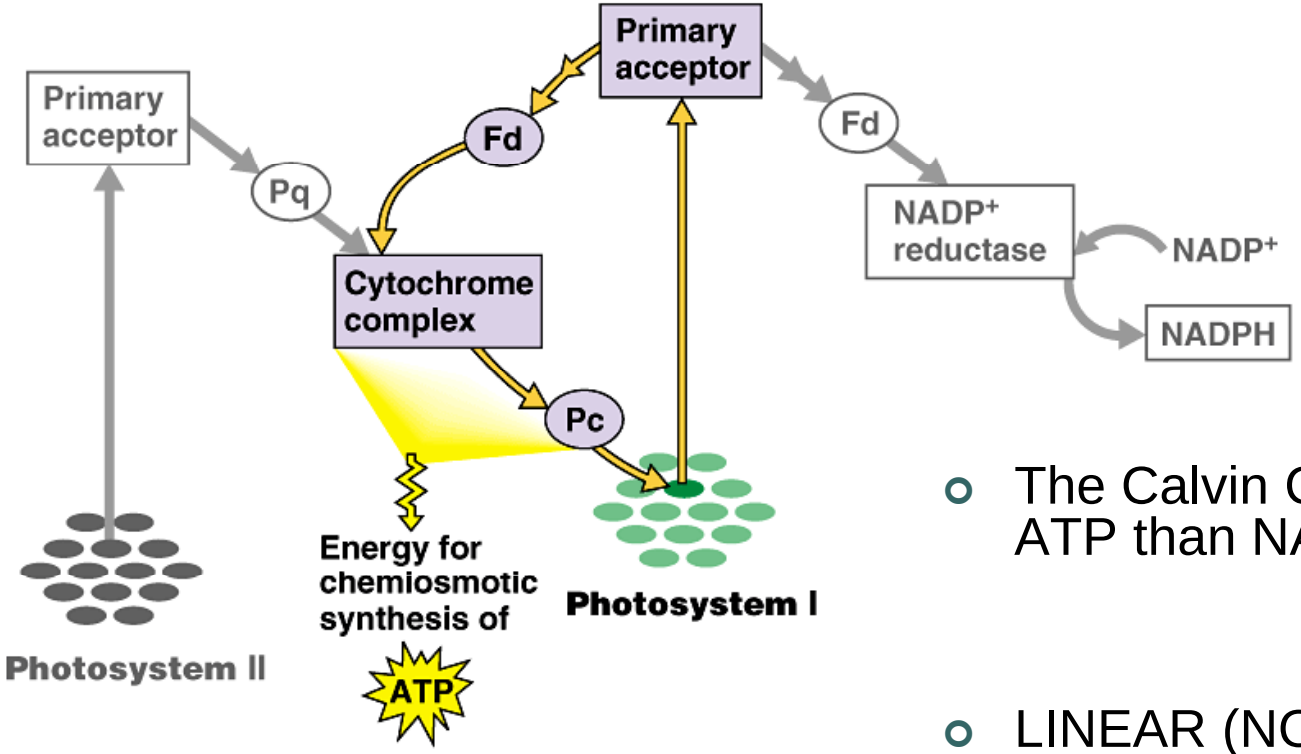
- Photosystem II (P680)
  - Primarily uses light of wavelength 680
  - Transfers electrons to an Electron Transport Chain that converts ADP to ATP
- Photosystem I (P700)
  - Primarily uses light of wavelength 700
  - Transfers electrons to an Electron Transport Chain that converts NADP+ to NADPH







- The mechanism of ATP production is analogous to the mechanism in Mitochondria - CHEMIOSMOSIS

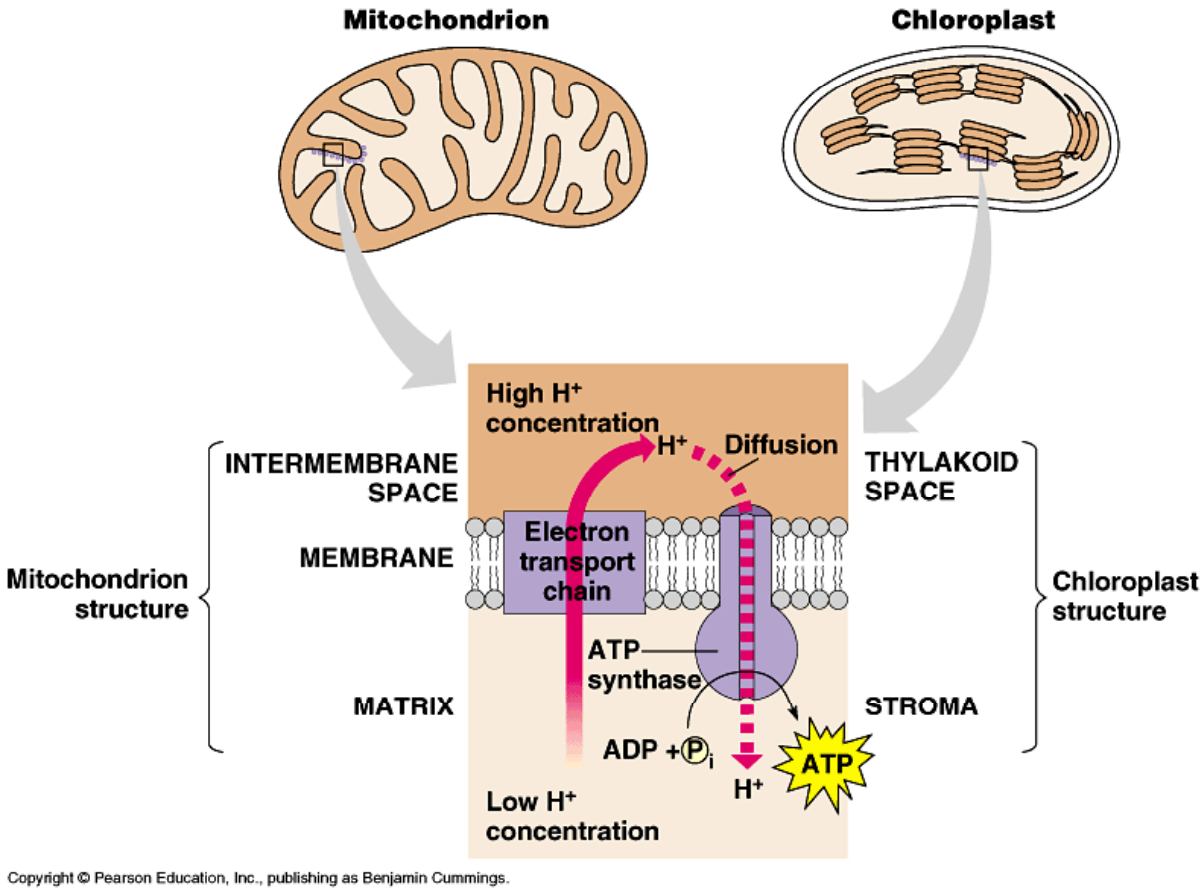


- The Calvin Cycle uses **MORE** ATP than NADPH

- LINEAR (NON cyclic) electron flow
  - Uses PS II and I
  - Uses 2 electron transport chains to produce
    - ATP
    - NADPH

- CYCLIC electron flow
  - Only uses PS I (P700)
  - Uses 1 electron transport chain to produce
    - Additional ATP

Chemiosmosis



- Mechanism of production of ATP relies on a concentration gradient of Hydrogen ions (H^+)
- Diffusion through ATP synthase catalyzes the reaction of ADP with Pi to form ATP

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- 4) What does cyclic electron flow in the chloroplast produce?
  - A) glucose
  - B) NADPH
  - C) ATP
  - D) A and B
  - E) A, B, and C

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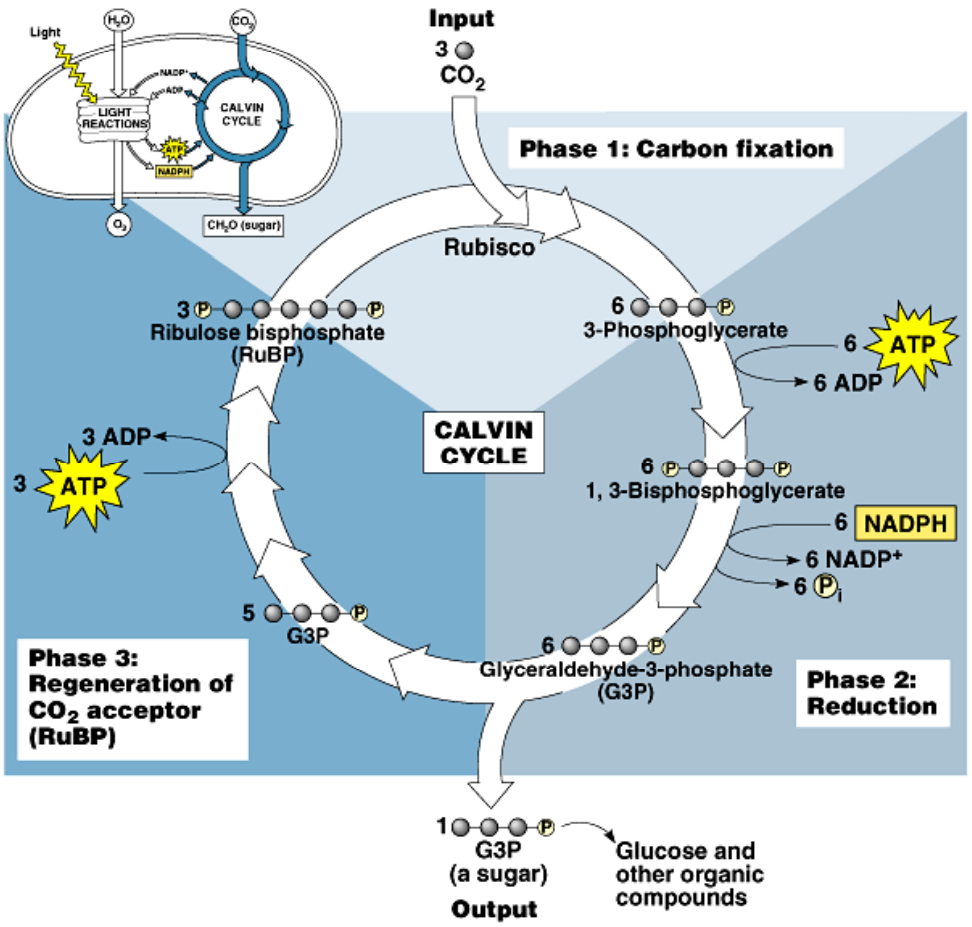
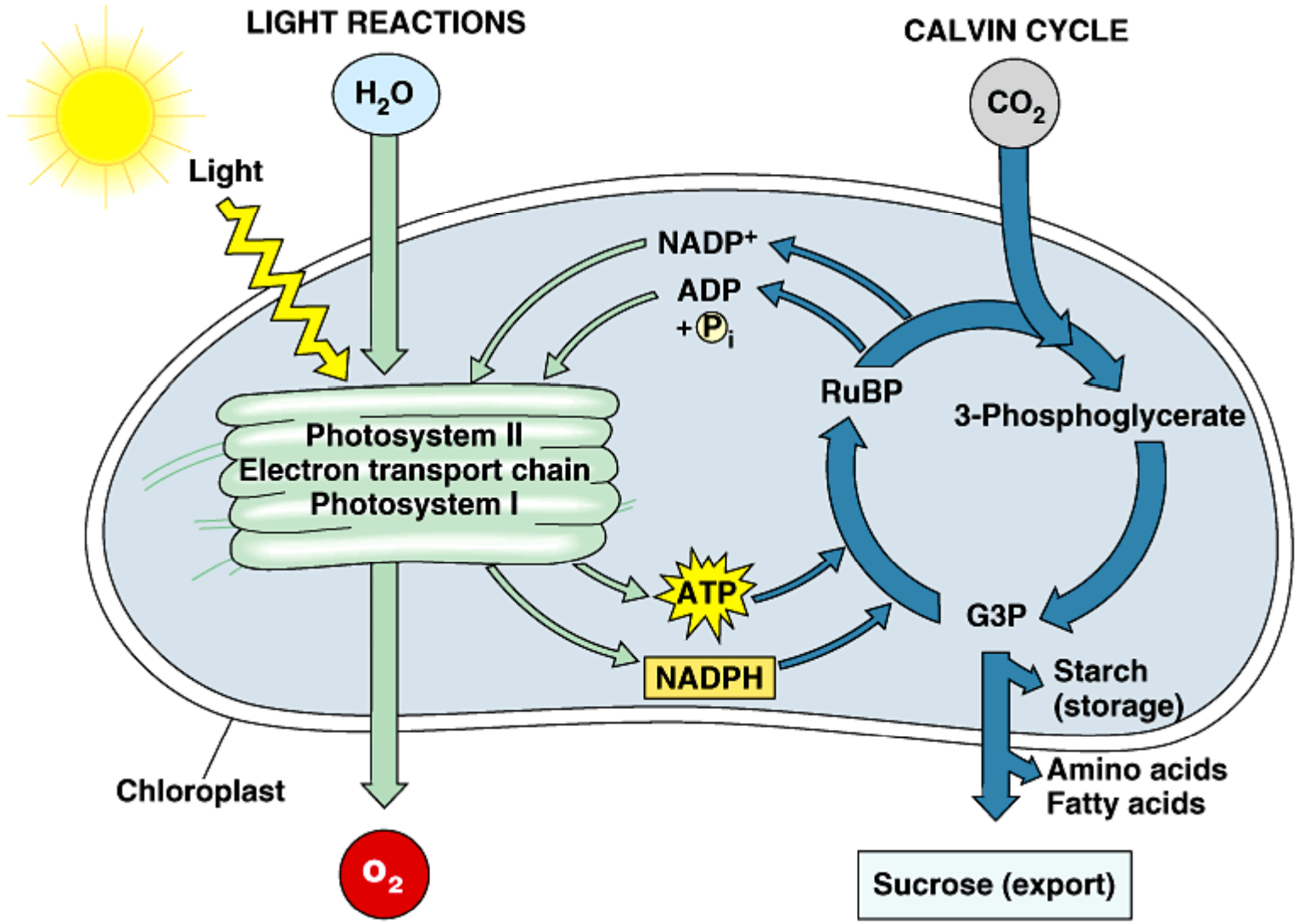
- 3) What are the products of noncyclic photophosphorylation?
  - A) ATP and P700
  - B) ATP and NADPH
  - C) P700 and P680
  - D) ADP and NADP
  - E) heat and fluorescence

Calvin Cycle



- Cyclic series of biochemical reactions
- Rubisco is the enzyme that catalyzes the fixation of Carbon Dioxide to RuBP
- RuBP is **regenerated**
- A 3 carbon sugar results from the calvin cycle which is used to build glucose for cellular respiration



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- All of the events listed below occur in the light reactions of photosynthesis except
  - A – oxygen is produced
  - B – NADP+ is reduced to NADPH
  - C – carbon dioxide is incorporated by Rubisco
  - D – ADP is phosphorylated to yield ATP
  - E – light is absorbed and funneled to reaction centers

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Which of the following statements best represents the relationships between the light reactions and the Calvin Cycle?

- **A** - The light reactions provide ATP and NADPH to the Calvin cycle, and the cycle returns ADP, Pi, and NADP+ to the light reactions.
- **B** - The light reactions provide ATP and NADPH to the carbon fixation step of the Calvin cycle, and the cycle provides water and electrons to the light reactions.
- **C** - The light reactions supply the Calvin cycle with CO2 to produce sugars, and the Calvin cycle supplies the light reactions with sugars to produce ATP.
- **D** - The light reactions provide the Calvin cycle with oxygen for electron flow, and the Calvin cycle provides the light reactions with water to split.
- **E** - There is no relationship between the light reactions and the Calvin cycle.