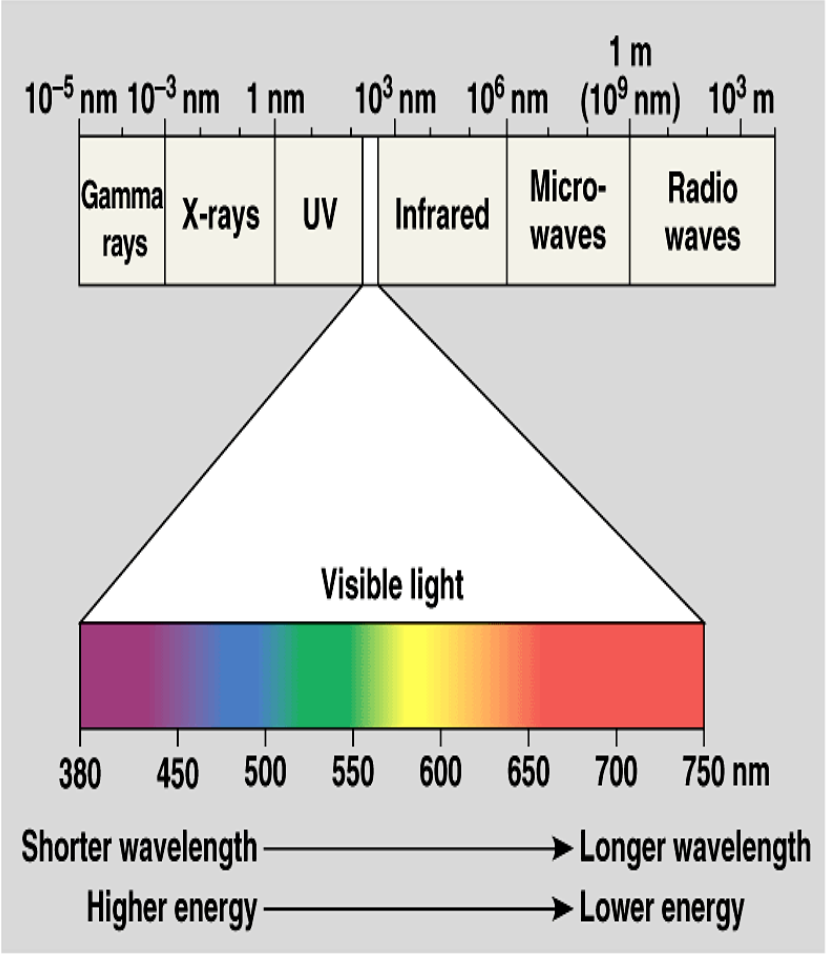
Aim: How is light used during photosynthesis?

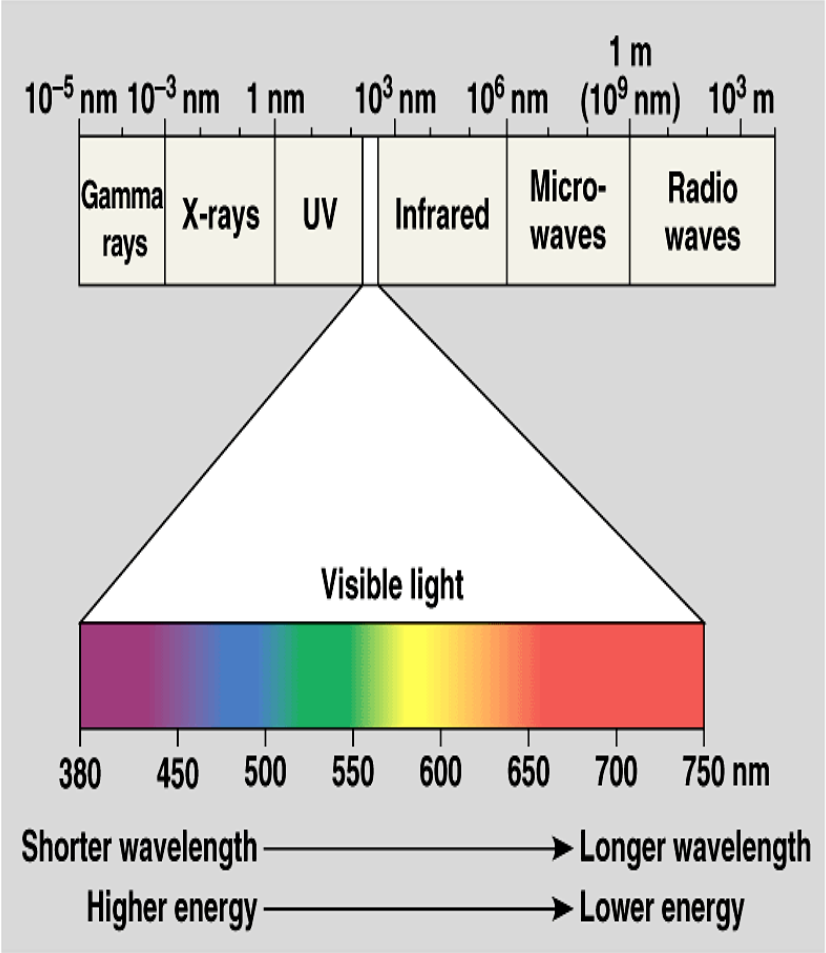
Basic facts about Light

- Light is a form of electromagnetic radiation and travels in rhythmic waves.
- Wavelength = distance between crests
- Electromagnetic wavelength ranges from gamma rays (less than a nanometer) to radio waves (more than a kilometer)



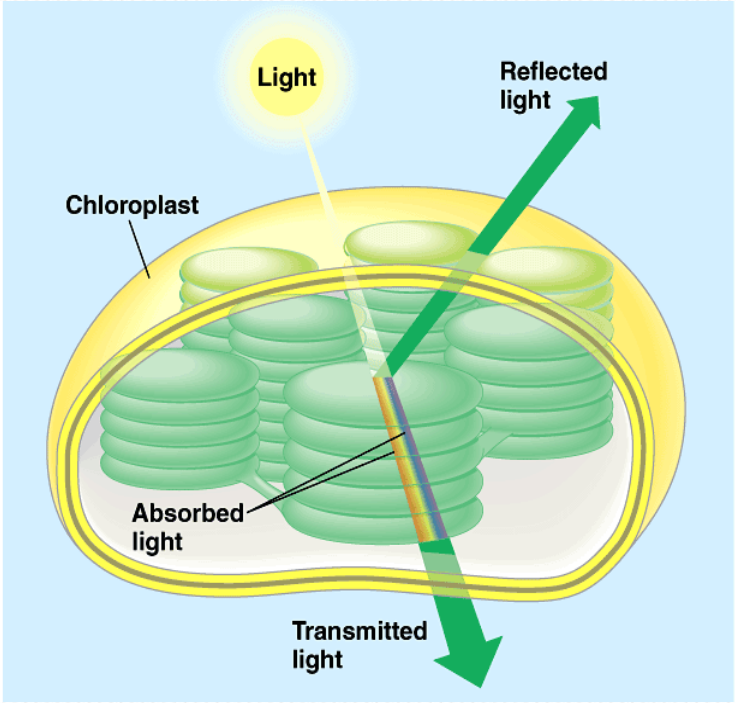
Basic facts about Light (2)

- Light travels as a wave but is also made up of particles called *photons.*
- Photon energy is inversely proportional to wavelength.
- Photons with shorter wavelengths pack more energy.



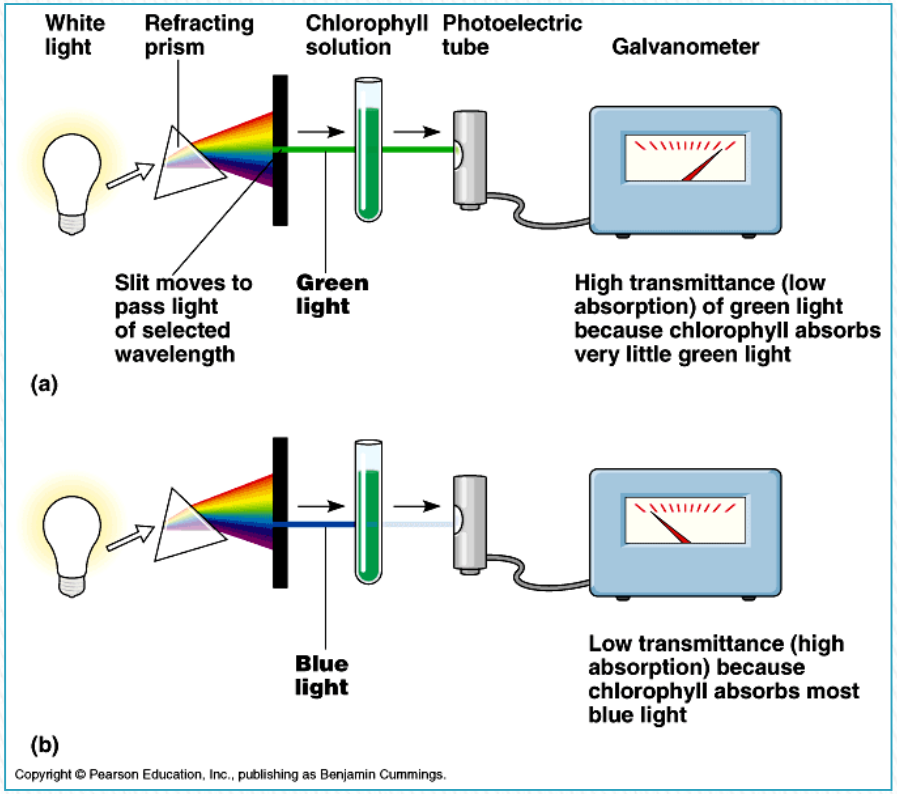
Basic facts about Light (3)

- When light meets matter, it may be reflected, transmitted, or absorbed.
- Different pigments absorb photons of different wavelengths.
- Leaves look green because they absorb red and blue light but reflect green light



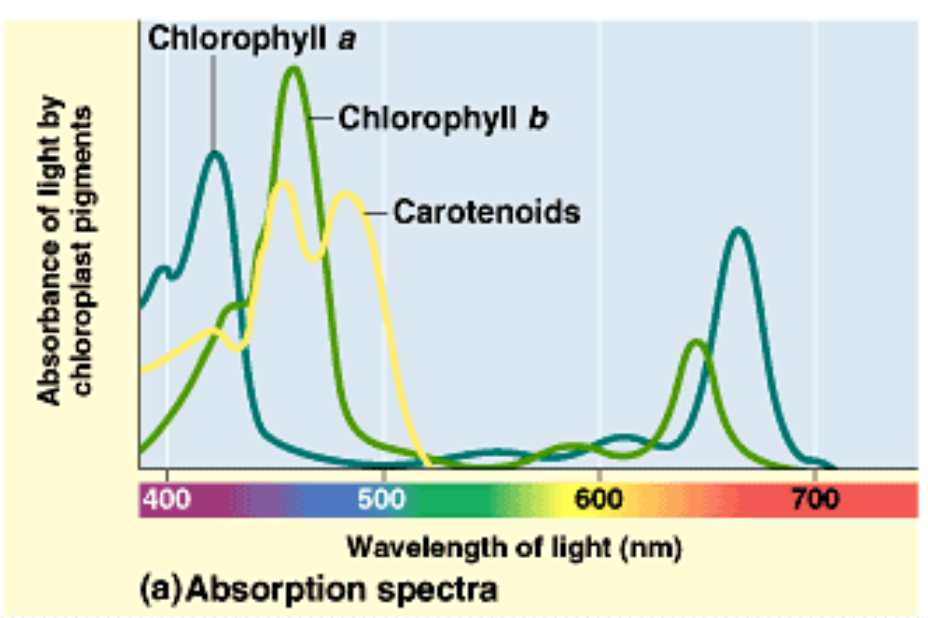
Basic facts about Light (3)

A spectrophotometer measures the ability of a pigment to absorb various wavelengths of light.



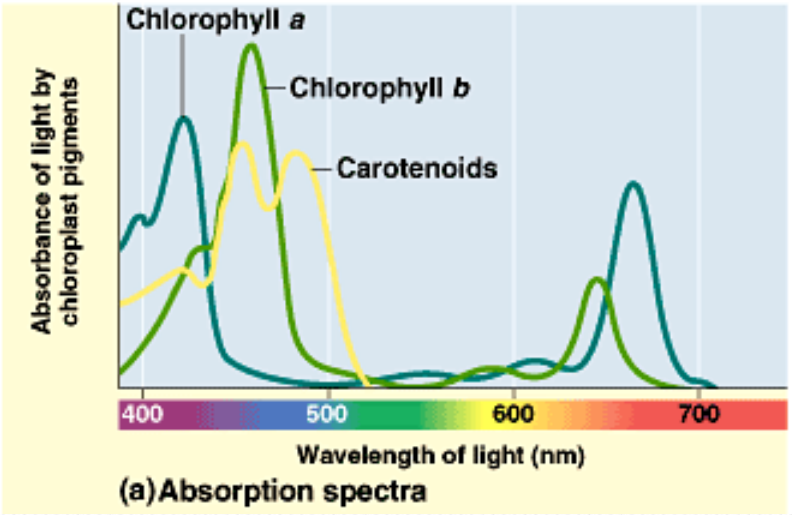
Absorption and Action Spectra

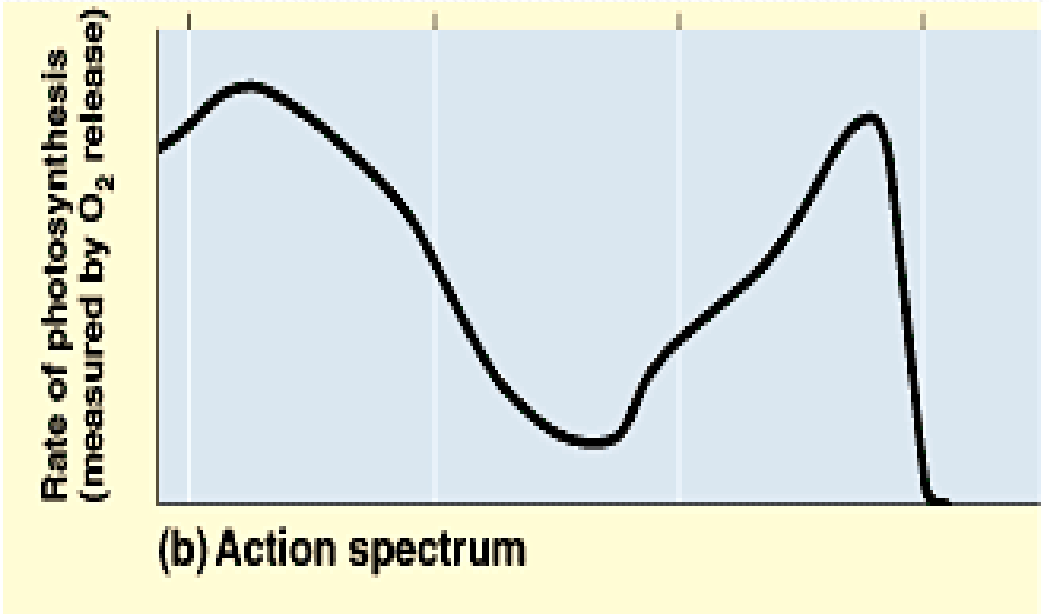
- Absorbed light can perform photosynthetic work.
- In the thylakoid are several pigments that differ in their absorption spectrum.
- **Chlorophyll *a*,** the dominant pigment, absorbs best in the red and blue wavelengths, and least in the green



Absorption and Action Spectra (2)

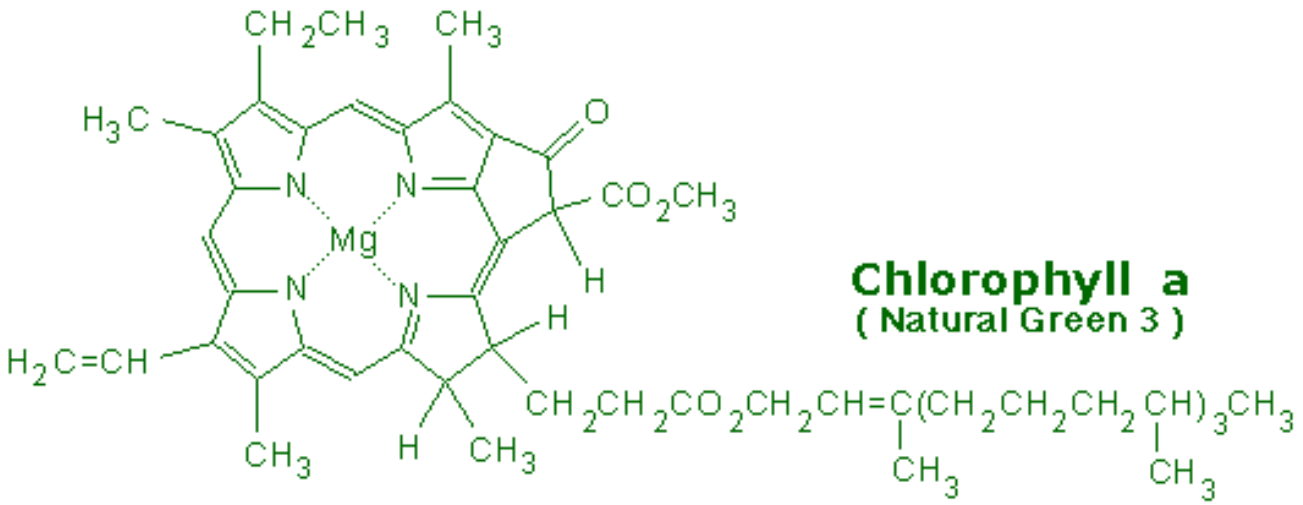
- Collectively, these photosynthetic pigments determine an overall **action spectrum** for photosynthesis.
- The action spectrum of photosynthesis does not match exactly the absorption spectrum of any one photosynthetic pigment, including chlorophyll *a*.



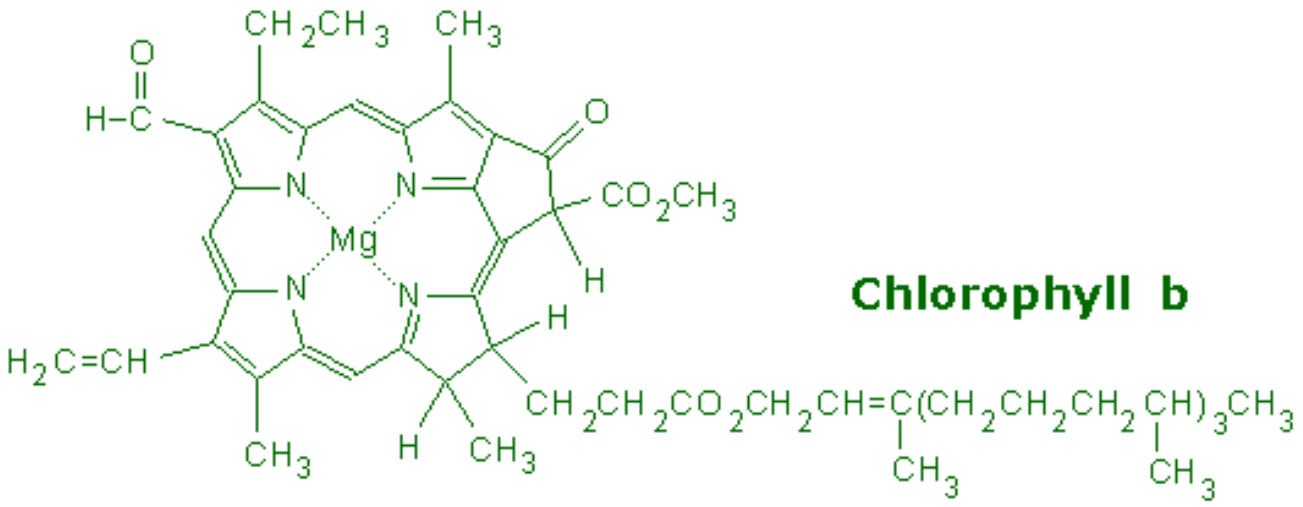


Chlorophyll pigments

- Only chlorophyll *a* participates directly in the light reactions
- **Chlorophyll *b*,** with a slightly different structure than chlorophyll *a*, has a slightly different absorption spectrum and funnels the energy from these wavelengths to chlorophyll *a*.
- **Carotenoids** can funnel the energy from other wavelengths to chlorophyll *a* and also participate in *photoprotection* against excessive light.



Chlorophyll a
(Natural Green 3)



Chlorophyll b

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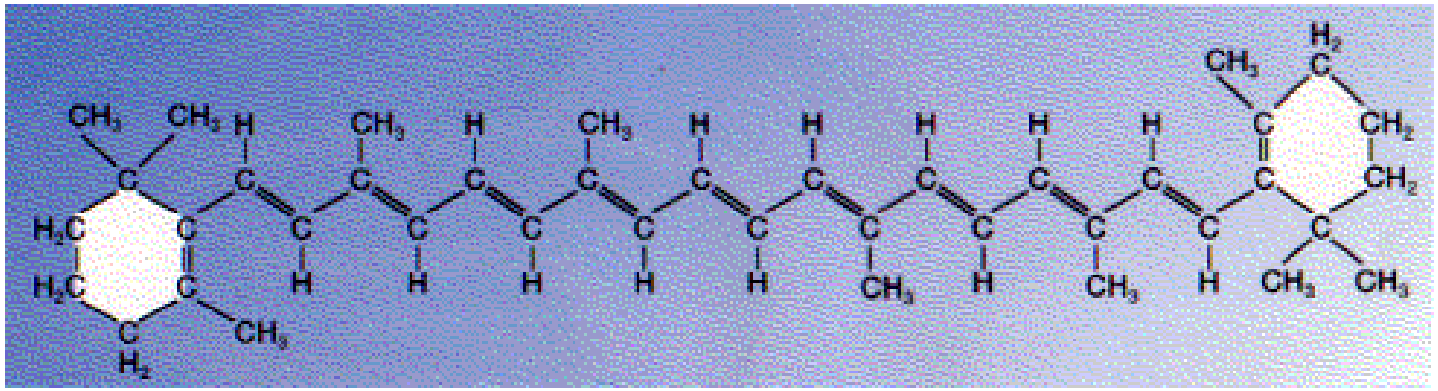
Caratenoids



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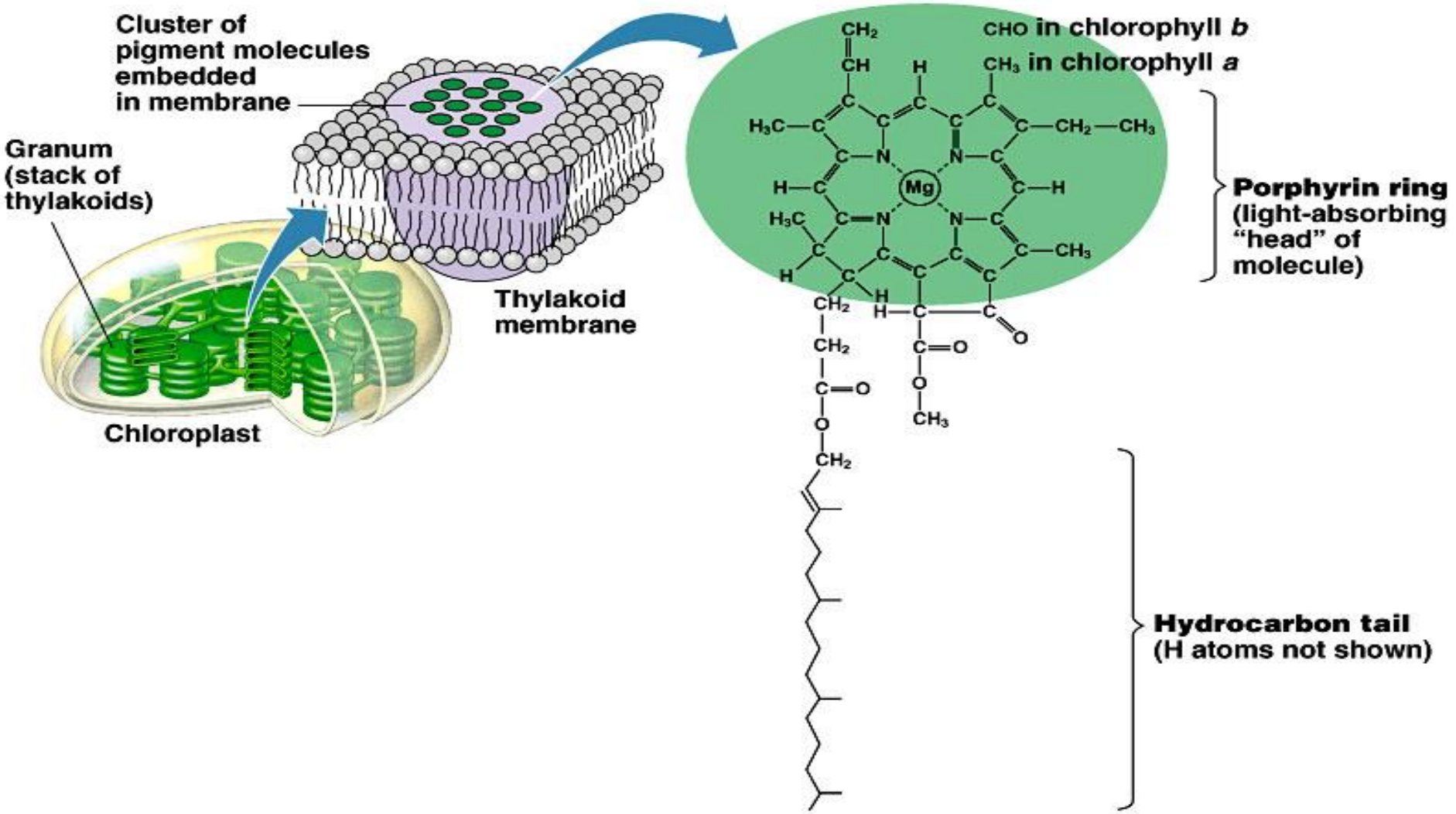
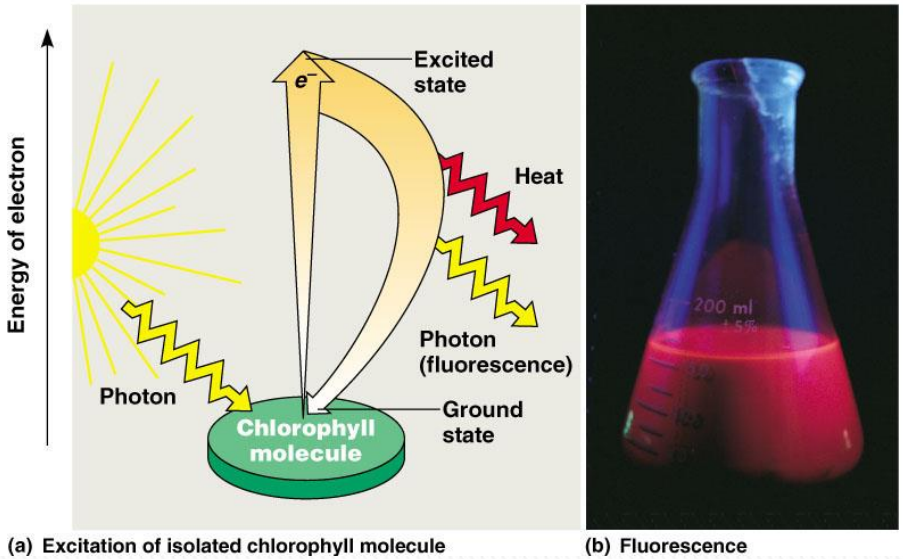
How do chlorophyll molecules trap sunlight energy?

- Photons are absorbed by clusters of pigment molecules in the thylakoid membranes.
- The energy of the photon is converted to the potential energy of an electron raised from its ground state to an excited state.
  - In chlorophyll *a* and *b*, it is an electron from magnesium in the porphyrin ring that is excited.


Cluster of pigment molecules embedded in membrane
Granum (stack of thylakoids)
Thylakoid membrane
Chloroplast
CHO in chlorophyll b
CH3 in chlorophyll a
Porphyrin ring (light-absorbing "head" of molecule)
Hydrocarbon tail (H atoms not shown)

How do chlorophyll molecules trap sunlight energy? (2)

- Excited electrons are unstable.
- Generally, they drop to their ground state in a billionth of a second, releasing heat energy.
- Some pigments, including chlorophyll, release a photon of light, in a process called fluorescence, as well as heat.

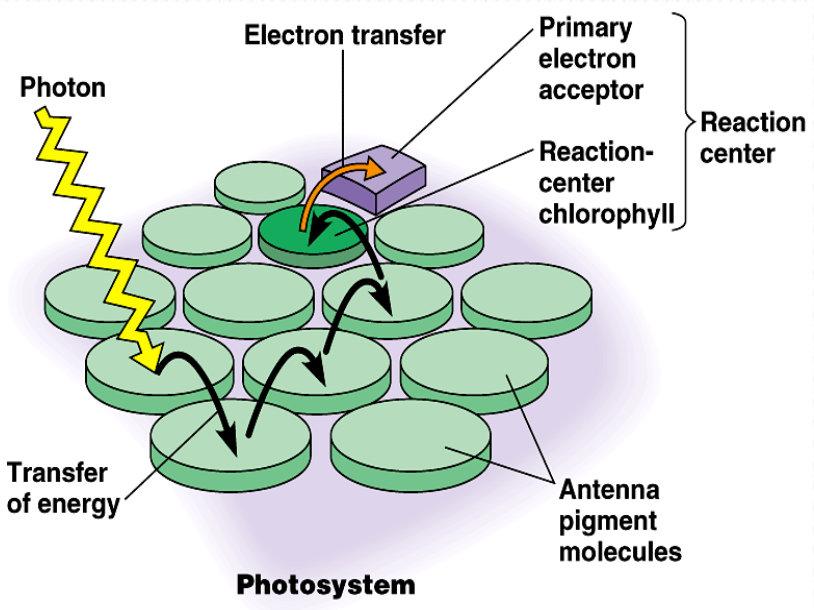


(a) Excitation of isolated chlorophyll molecule

(b) Fluorescence

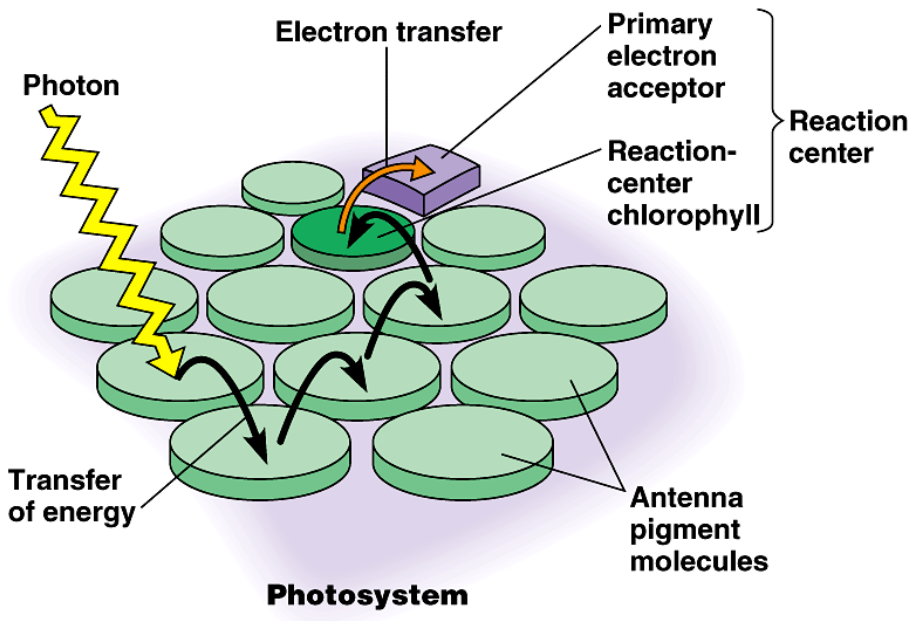
How do chlorophyll molecules trap sunlight energy? (3)

- In the thylakoid membrane, chlorophyll is organized along with proteins and smaller organic molecules into **photosystems**.
- A photosystem acts like a light-gathering "antenna complex" consisting of a few hundred chlorophyll *a*, chlorophyll *b*, and carotenoid molecules.



Photosystem Function (2)

- When any antenna molecule absorbs a photon, it is transmitted from molecule to molecule until it reaches a particular chlorophyll *a* molecule, the **reaction center**. This process is called *inductive resonance*.
- At the reaction center is a **primary electron acceptor** which removes an excited electron from the reaction center chlorophyll a.
  - This starts the light reactions.



Photosystem Function (3)

- There are two types of photosystems.
- **Photosystem I** has a reaction center chlorophyll, the P700 center, that has an absorption peak at 700nm.
- **Photosystem II** has a reaction center with a peak at 680nm.
- These two photosystems work together to use light energy to generate ATP and NADPH.