

# Photosynthesis

How Cells Acquire Energy

# Carbon and Energy Sources

- Autotrophs
  - Make organic compounds from inorganic compounds
- Heterotrophs
  - Make organic compounds from organic compounds

# Photoautotrophs

- Capture sunlight energy for photosynthesis
  - Plants
  - Some bacteria
  - Many protistans

# Linked Processes

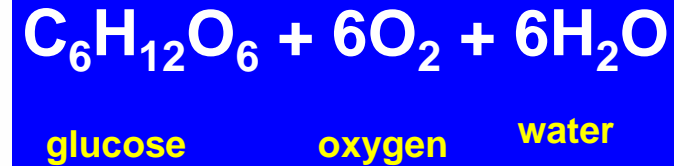
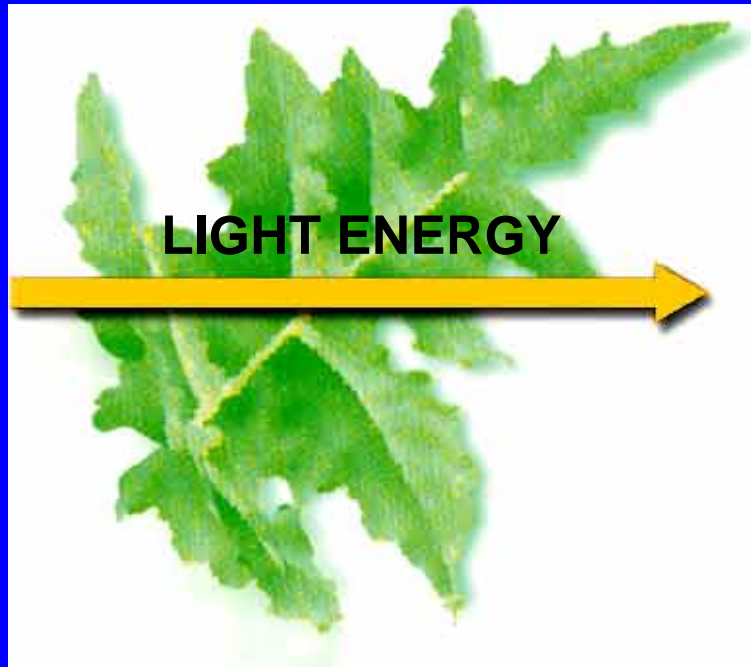
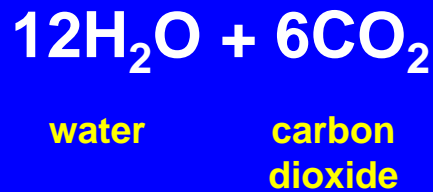
## Photosynthesis

- Energy-storing pathway
- Releases oxygen
- Requires carbon dioxide

## Aerobic Respiration

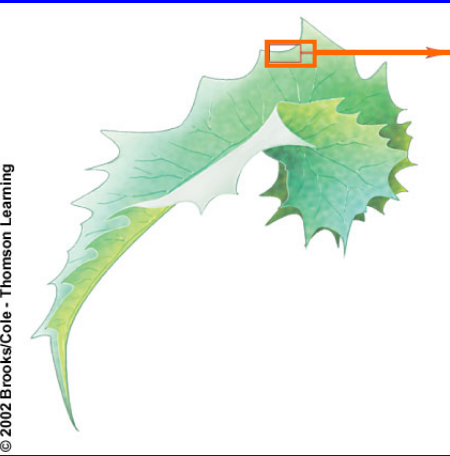
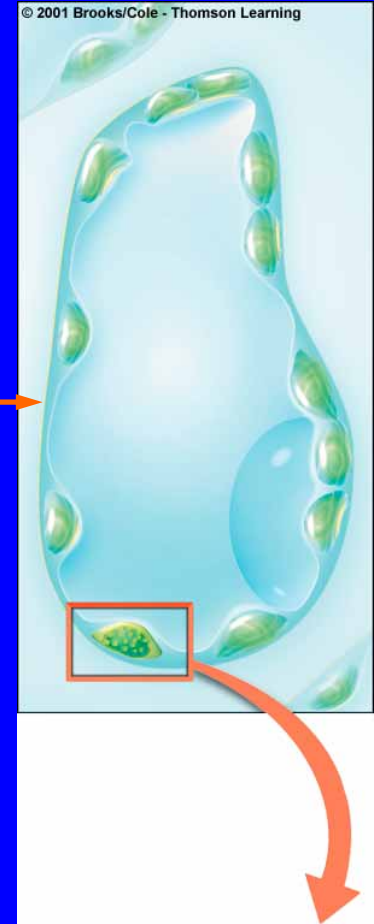
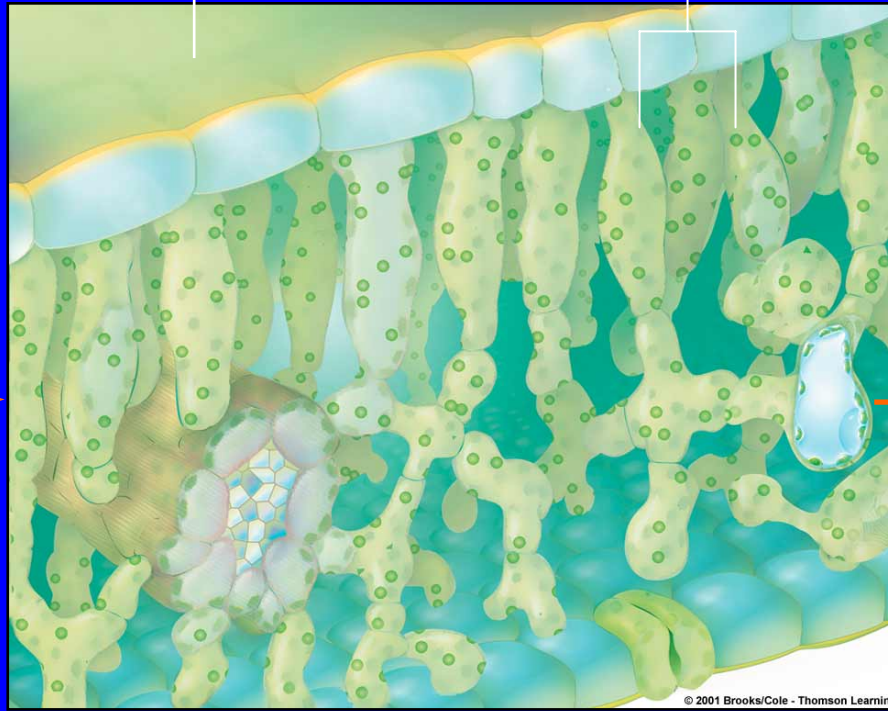
- Energy-releasing pathway
- Requires oxygen
- Releases carbon dioxide

# Photosynthesis Equation



leaf's upper surface

photosynthetic cells



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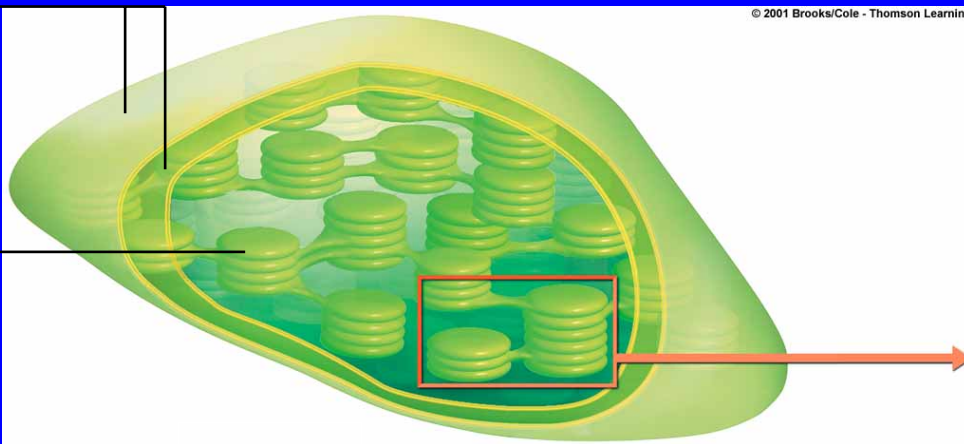
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two outer layers of membrane

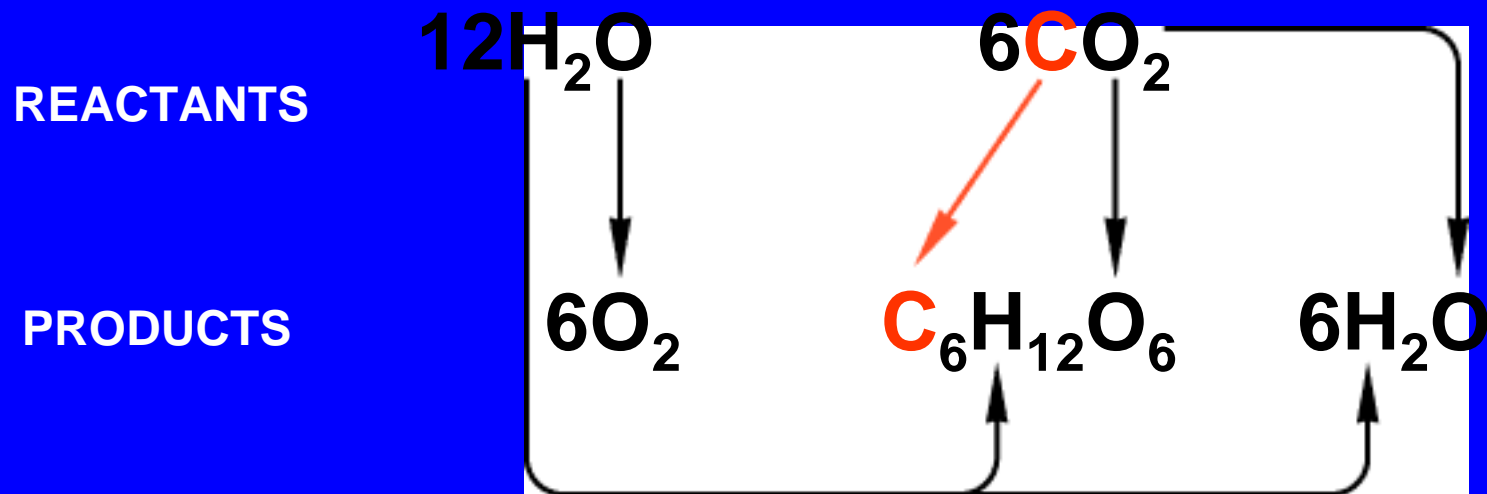
Thylakoid membranes

stroma



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# Chloroplasts



# Two stages

- Light dependent reactions
  - absorb solar energy
- Calvin cycle
  - make sugar

# Sunlight Energy

- Almost 1/3 is reflected back into space
- Of the energy that reaches Earth's surface, about 1% is intercepted by photoautotrophs

# Electromagnetic Spectrum

Shortest  
wavelength



Longest  
wavelength

Gamma rays

X-rays

UV radiation

Visible light

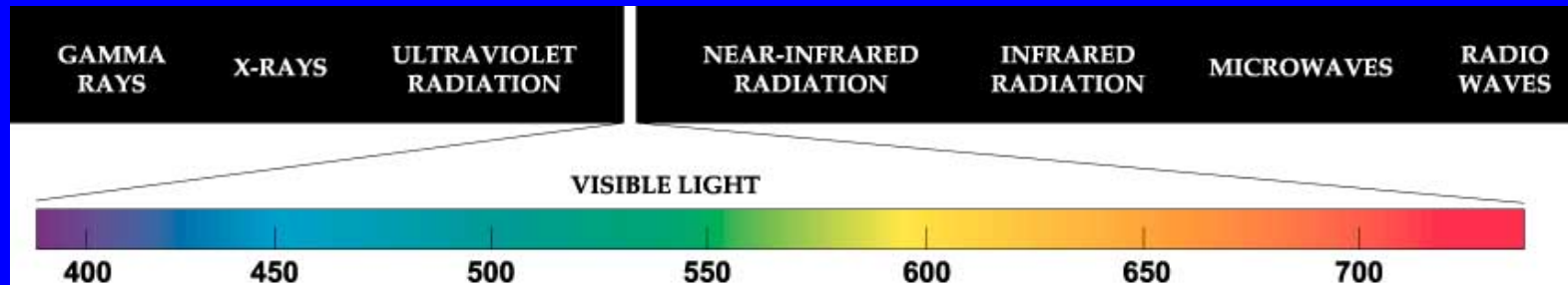
Infrared radiation

Microwaves

Radio waves

# Visible Light

- We perceive wavelengths as different colors
- Violet (380 nm) to red (750 nm)
- Longer wavelengths, lower energy

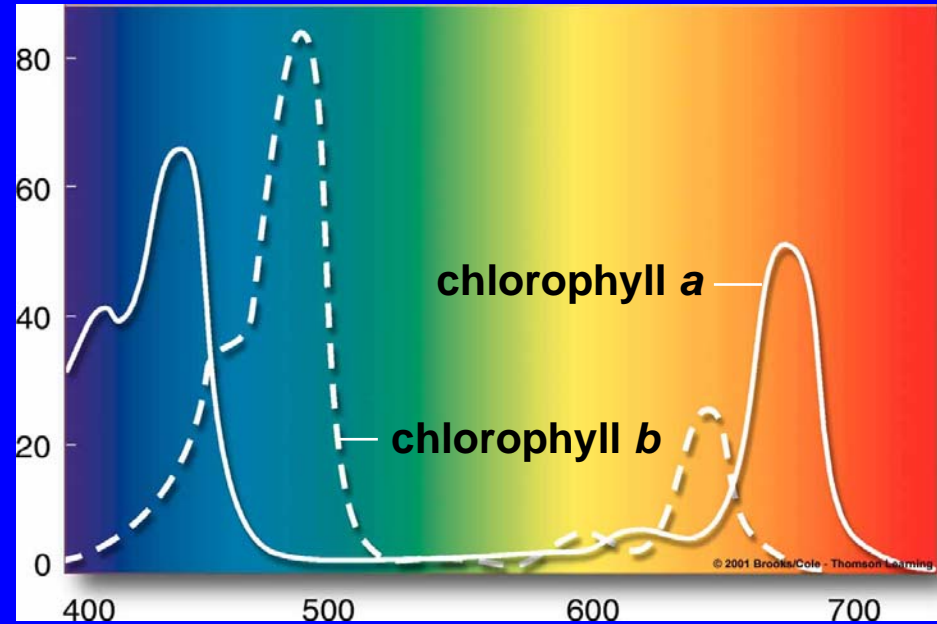


# Photons

- Packets of light energy
- Each type of photon has fixed amount of energy
- Photons having most energy travel as shortest wavelength (blue-green light)

# Pigments

- Light-absorbing molecules
- Absorb some wavelengths and transmit others



Wavelength (nanometers)

# Variety of Pigments

Chlorophylls *a* and *b*

Carotenoids

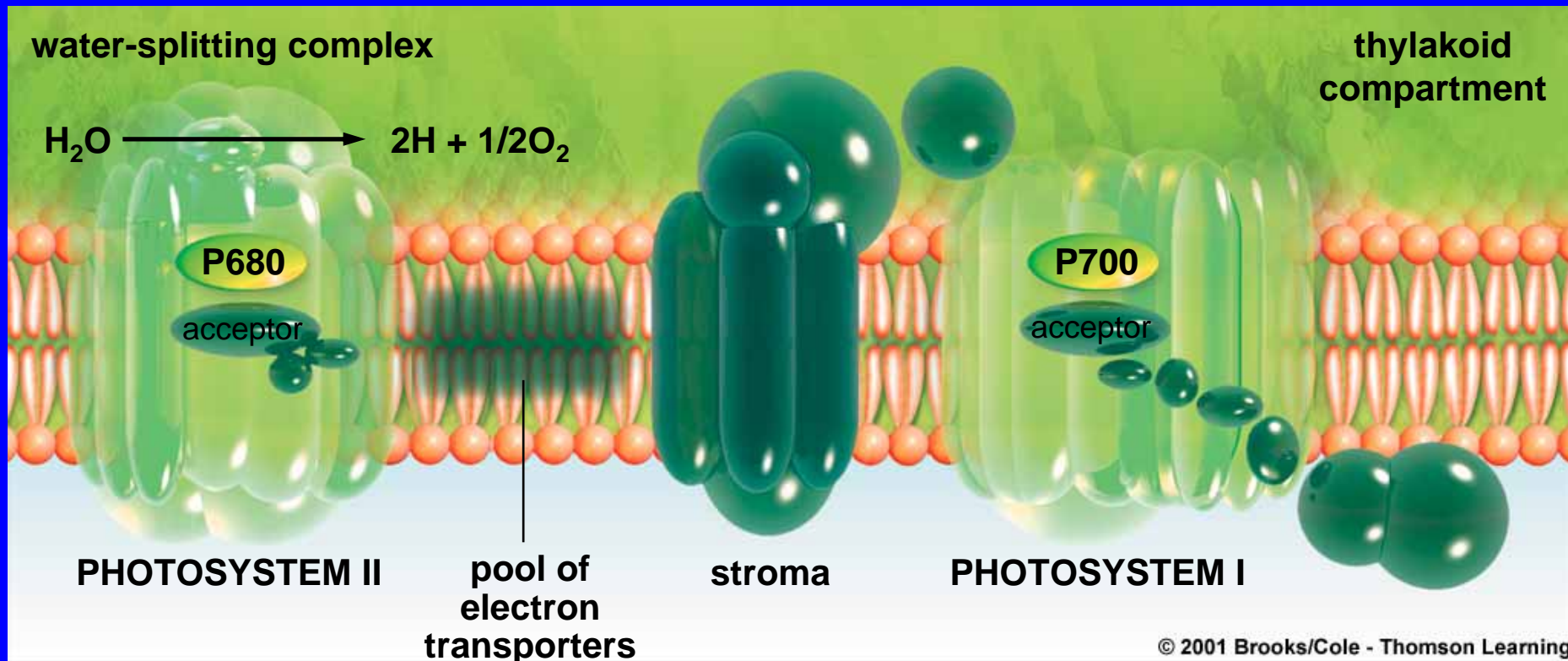
Anthocyanins

Phycobilins

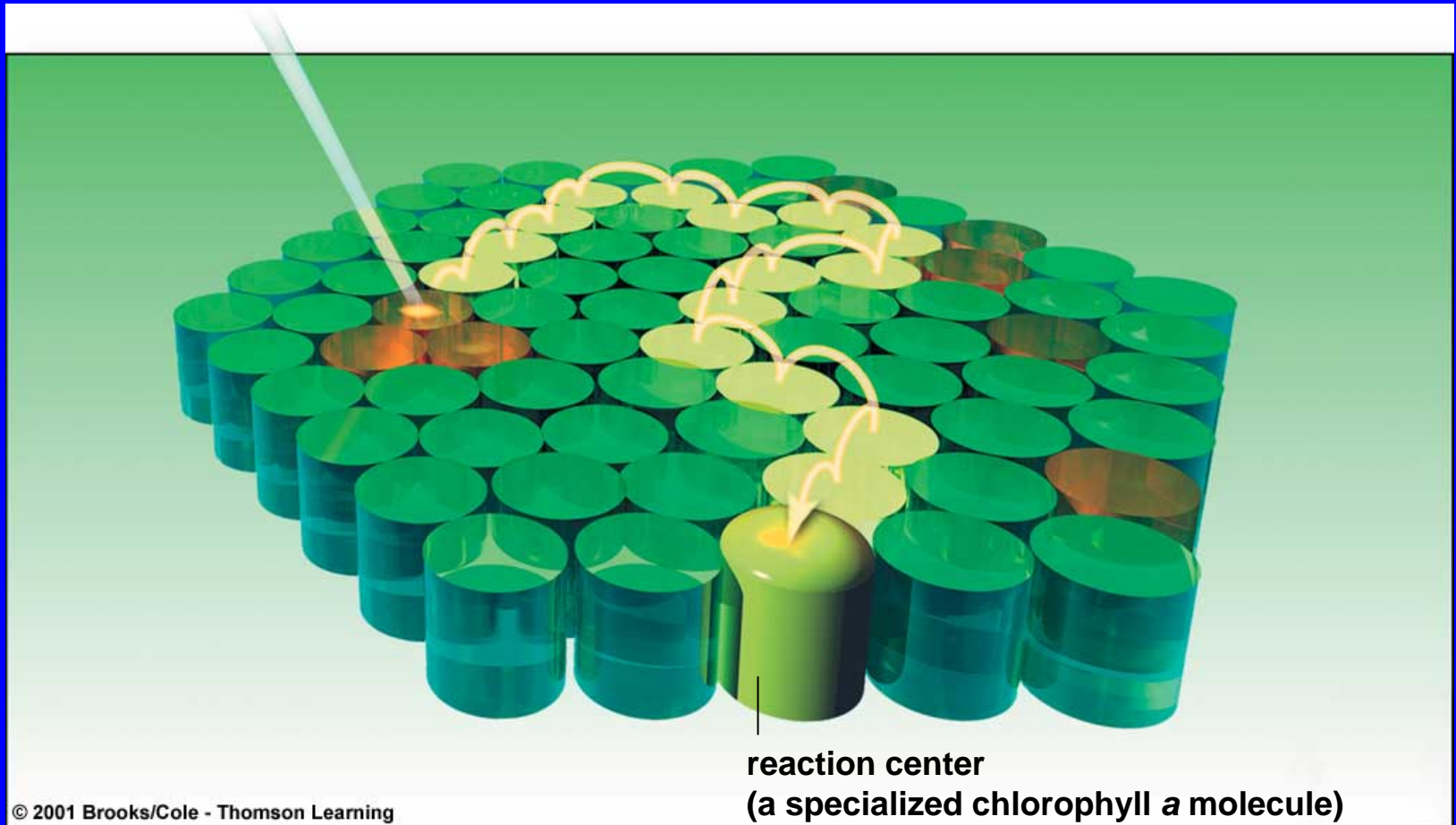
# Pigments in Photosynthesis

- Embedded in thylakoid membrane
- Pigments and proteins organized into photosystems
- Photosystems located next to electron transport systems

# Photosystems and Electron Transporters



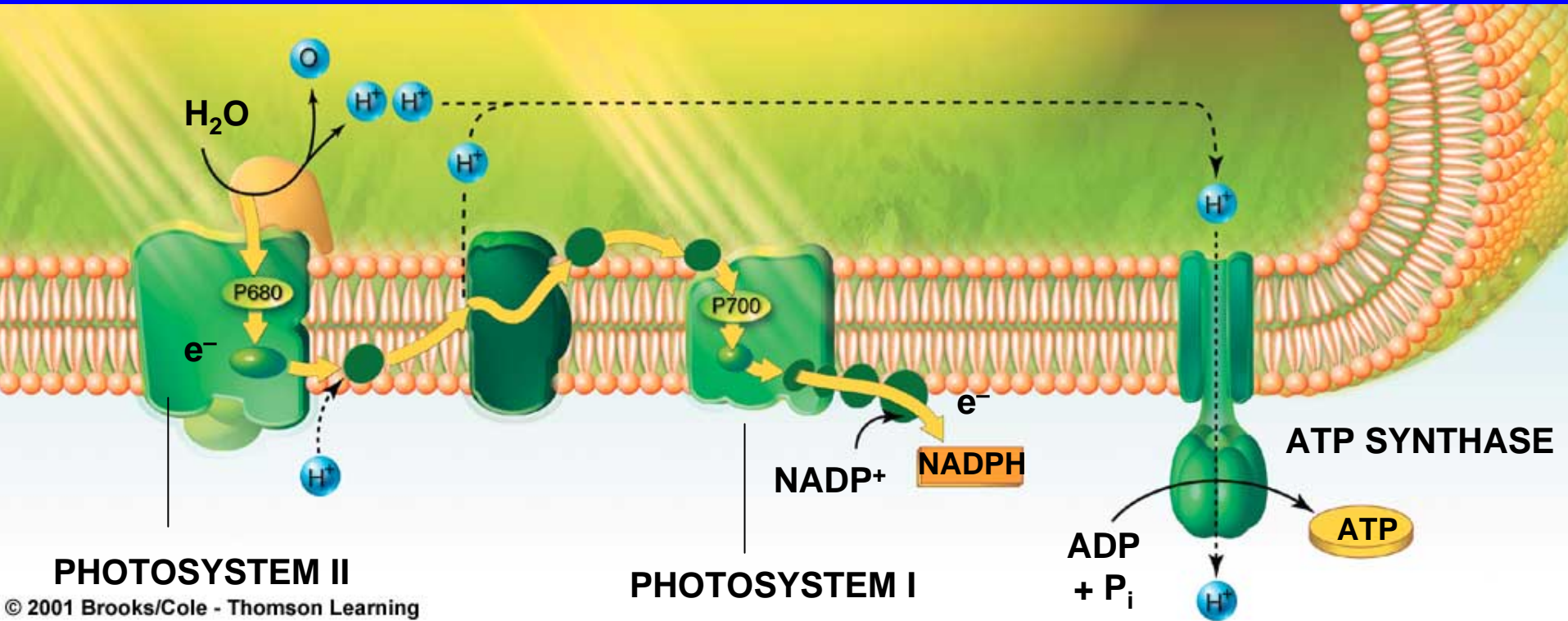
# Pigments in a Photosystem



# Electron Transport System

- Adjacent to photosystem
- Acceptor molecule donates electrons from reaction center
- Flow of electrons produces ATP and NADPH

# Light reactions



# Light-Independent Reactions

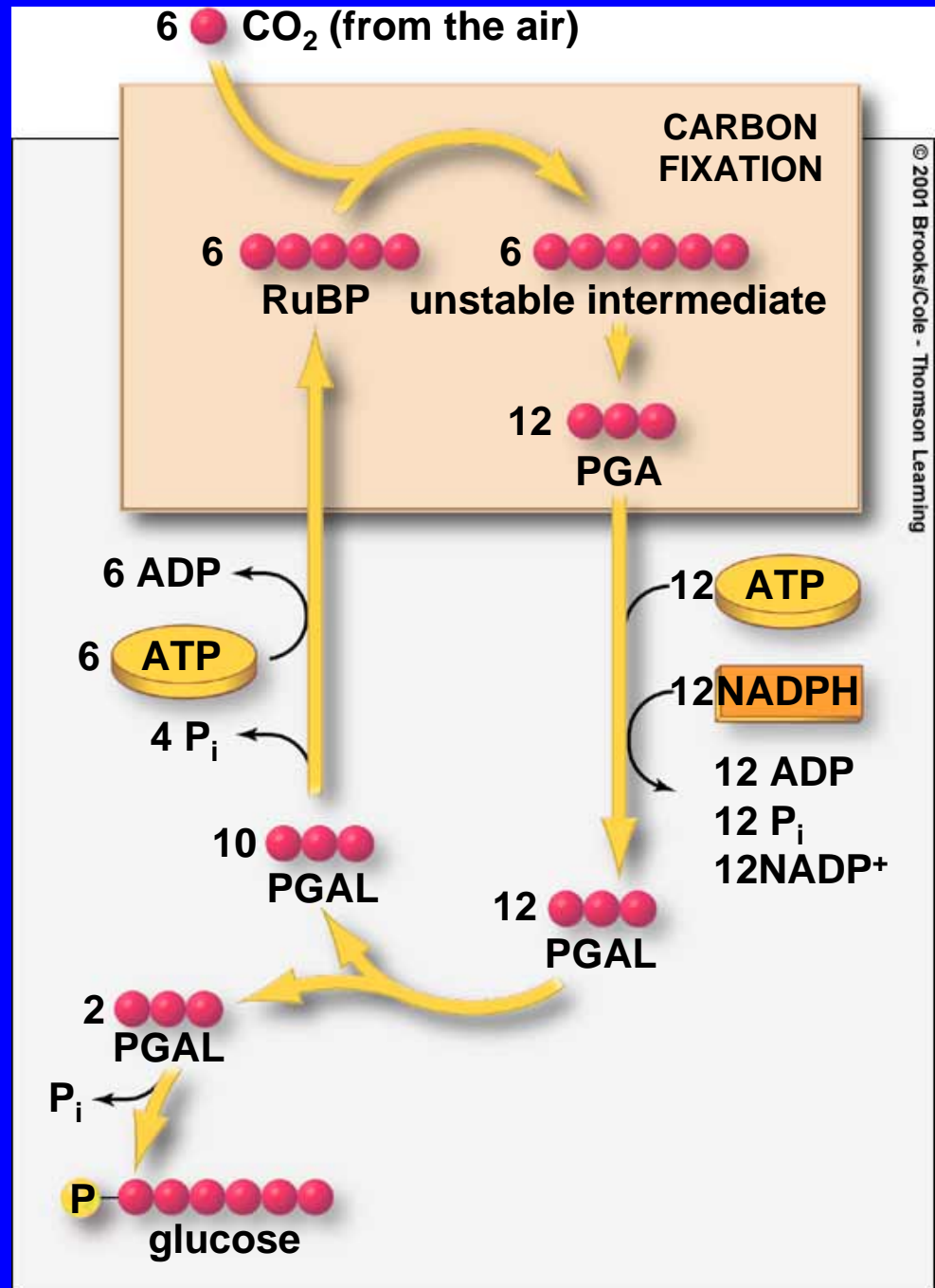
- Synthesis part of photosynthesis
- Can proceed in the dark
- Stroma
- Calvin-Benson cycle

# Calvin-Benson Cycle

- Overall reactants
  - Carbon dioxide
  - ATP
  - NADPH
- Overall products
  - Glucose
  - ADP
  - NADP<sup>+</sup>

# Calvin-Benson Cycle

- CO<sub>2</sub> attached to sugar: fixation
- Sugar energized by ATP and NADPH



# Using the Products of Photosynthesis

- Glucose is the building block for:
  - sucrose
    - Most easily transported plant carbohydrate
  - starch
    - Most common storage form

# Hydrothermal Vents

- Fissures in sea-floor where seawater mixes with molten rock
- Complex ecosystem is based on energy from these vents
- Bacteria are producers in this system

# Light and Life at the Vents

- Vents release faint radiation at low end of visible spectrum
- These photons could be used to carry out photosynthesis
- Nisbet and Van Dover hypothesize that the first cells may have arisen at hydrothermal vent systems

# Supporting Evidence

- Absorption spectra for ancient photosynthetic bacteria correspond to wavelengths measured at the vents
- Photosynthetic machinery contains iron, sulfur, manganese, and other minerals that are abundant at the vents