# *Where It Starts: Photosynthesis*

Chapter 5

# *Photosynthesis*

Metabolic Pathways

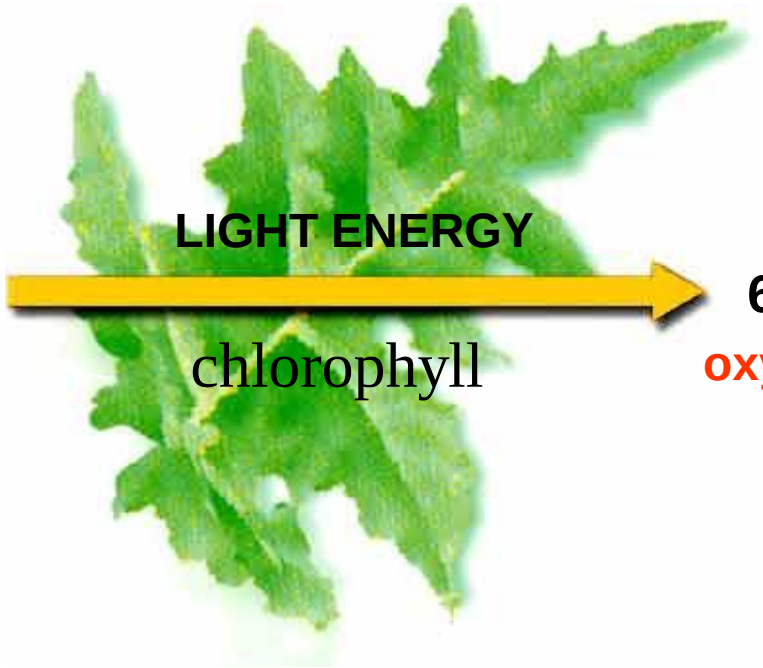
Converts light energy to chemical energy.

# *Photoautotrophs*

Organisms that can perform photosynthesis

- Cyanobacteria (prokaryotic-no chloroplast)
- Plants
- Algae

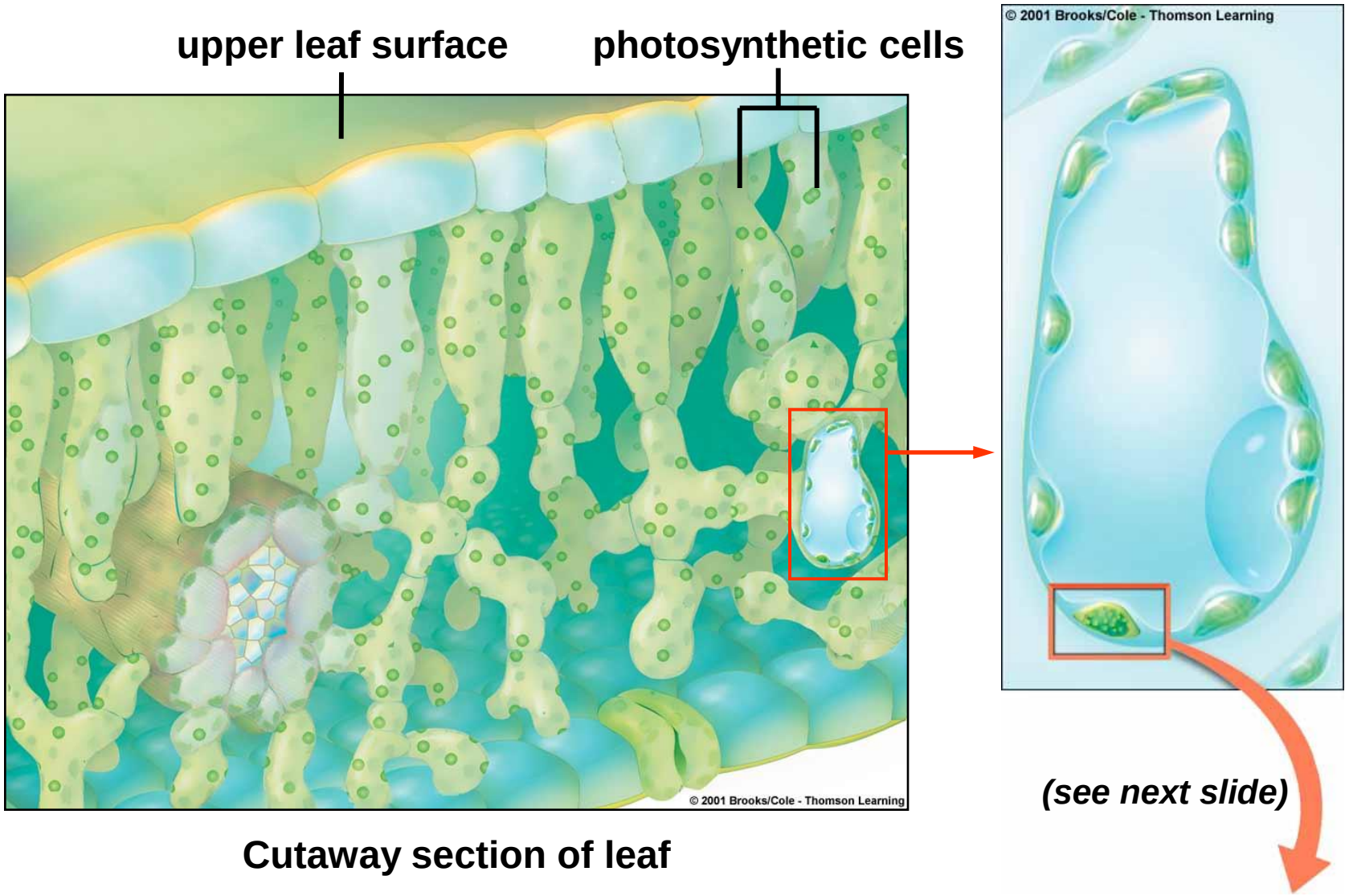
# Photosynthesis Equation




$12H_2O + 6CO_2 \rightarrow 6O_2 + C_6H_{12}O_6 + 6H_2O$

water carbon dioxide

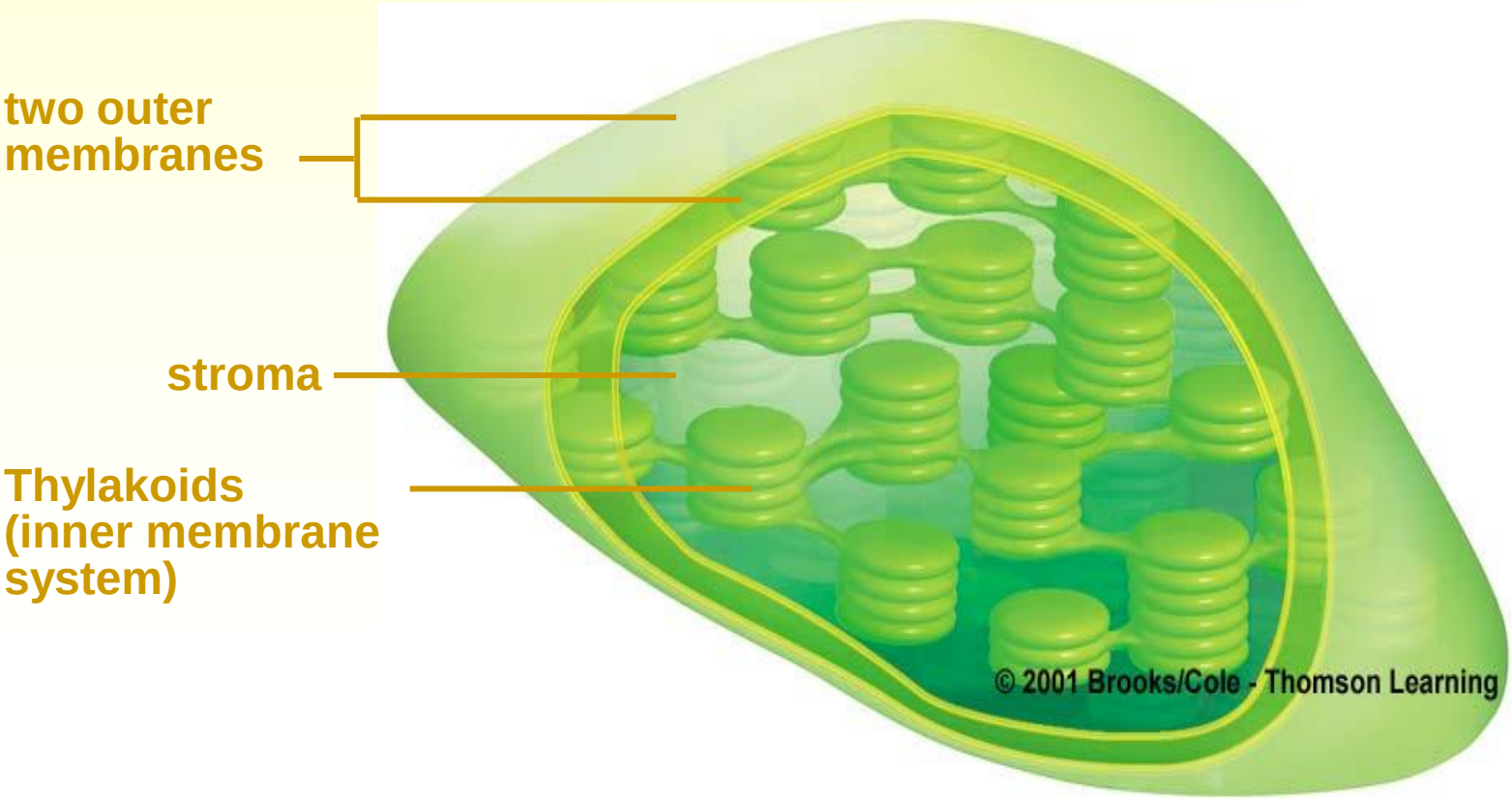
oxygen glucose water



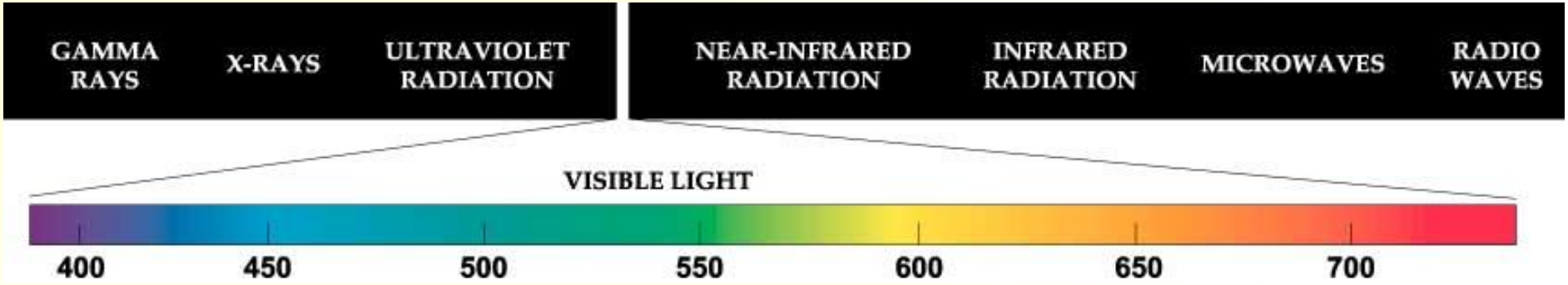

Cutaway section of leaf

# *Chloroplast*

Photosynthetic organelle in plants and algae



# *Different Types of Energy*




**Wavelength of light (nanometers)**

# *Visible Light Spectrum*

- Composed of different colors
- Violet (380 nm) to red (750 nm)
- Longer wavelengths, lower energy

# *Pigments*

- Chemicals that interact with visible light
- Absorbed colors/wavelength (not seen)
- Reflect colors/wavelength (color seen)

# *Variety of Plant Pigment*

- Photosynthetic Pigments

  Chlorophylls

- Accessory Pigments

  Carotenoids

  Anthocyanins

  Phycobilins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# *Photosynthesis…. a Two-Step Process*

1. Light-dependent reactions
2. Light-independent reaction

# *Light Dependant Reactions*

Pigments

Electron transport chain

ATP Production

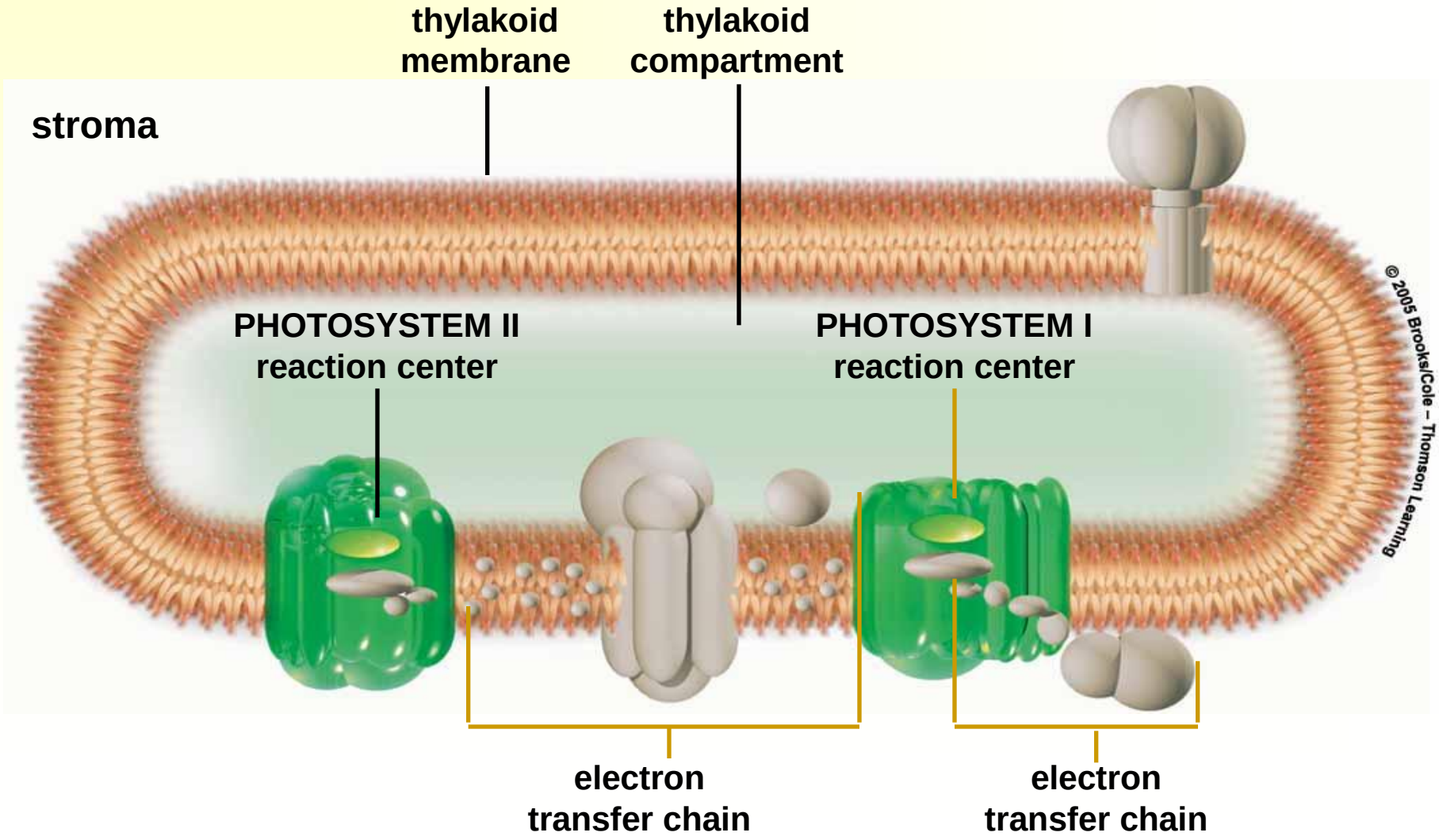
# *Photosystems*

- Capture light energy
- Two types (I and II)
- Composed of….
  - Antenna pigments (accessory pigments)
  - Reaction center (chlorophyll)

# *Electron Transfer Chains*

- Next to photosystems
- Accepts electrons from reaction center
- Electrons pass along chain
- ATP generated.

# *Thylakoid Membrane Section*



# *Light-Dependent Reactions*

Two variants

1. Noncyclic pathway
2. Cyclic pathway

# *Noncyclic Electron Flow*

- Two-step pathway
- Uses both  photosystems (I and II)
- Produces ATP and NADPH
- Split water
- Release oxygen

# Non Cyclic Electron Flow

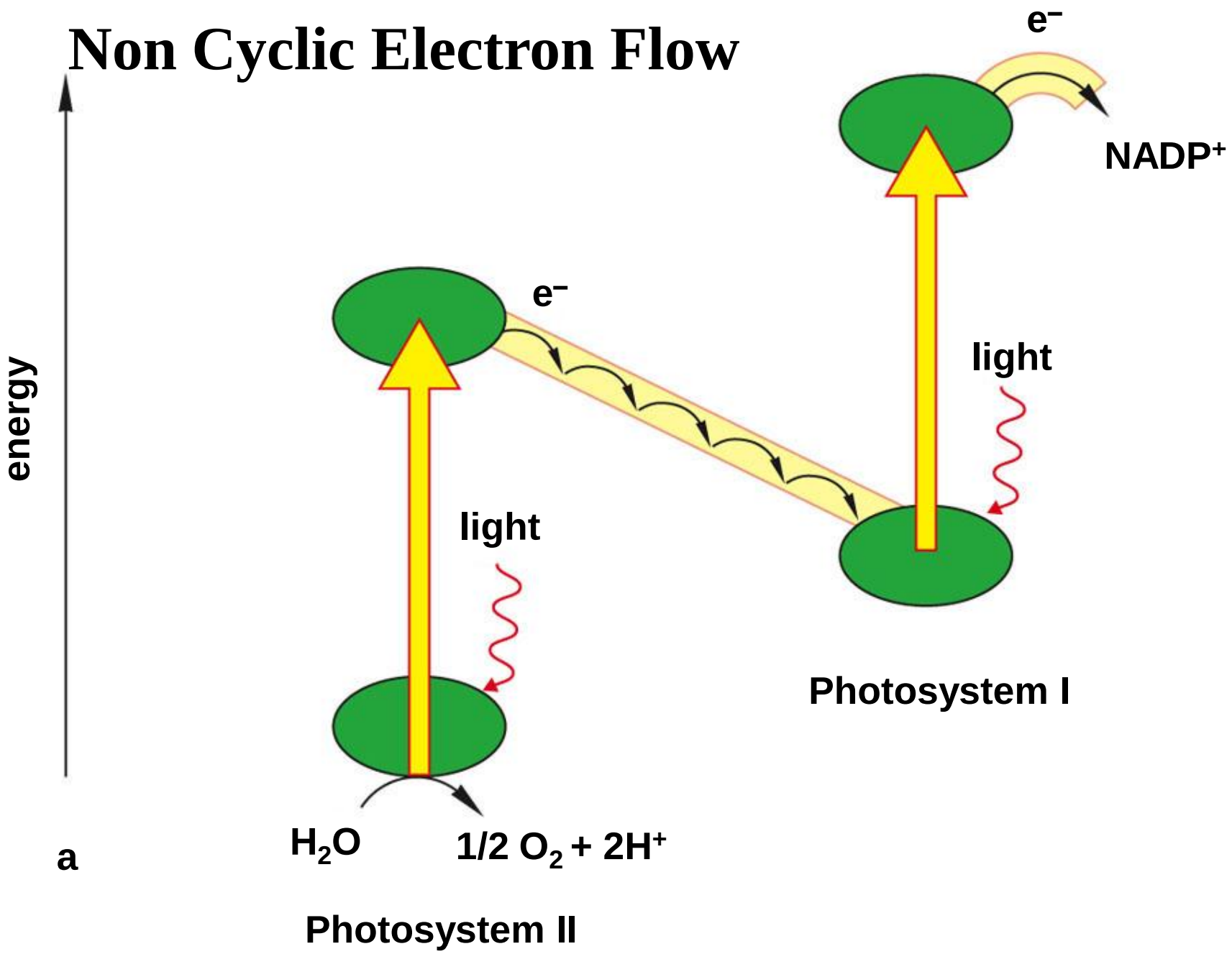





Fig. 5-6a, p.76

# *ATP Synthesis*
# *Noncyclic Pathway*

- $H^+$ concentrated in thylakoid
- $H^+$ Passive transport through ATP synthase
- ATP produced
- Chemiosmosis

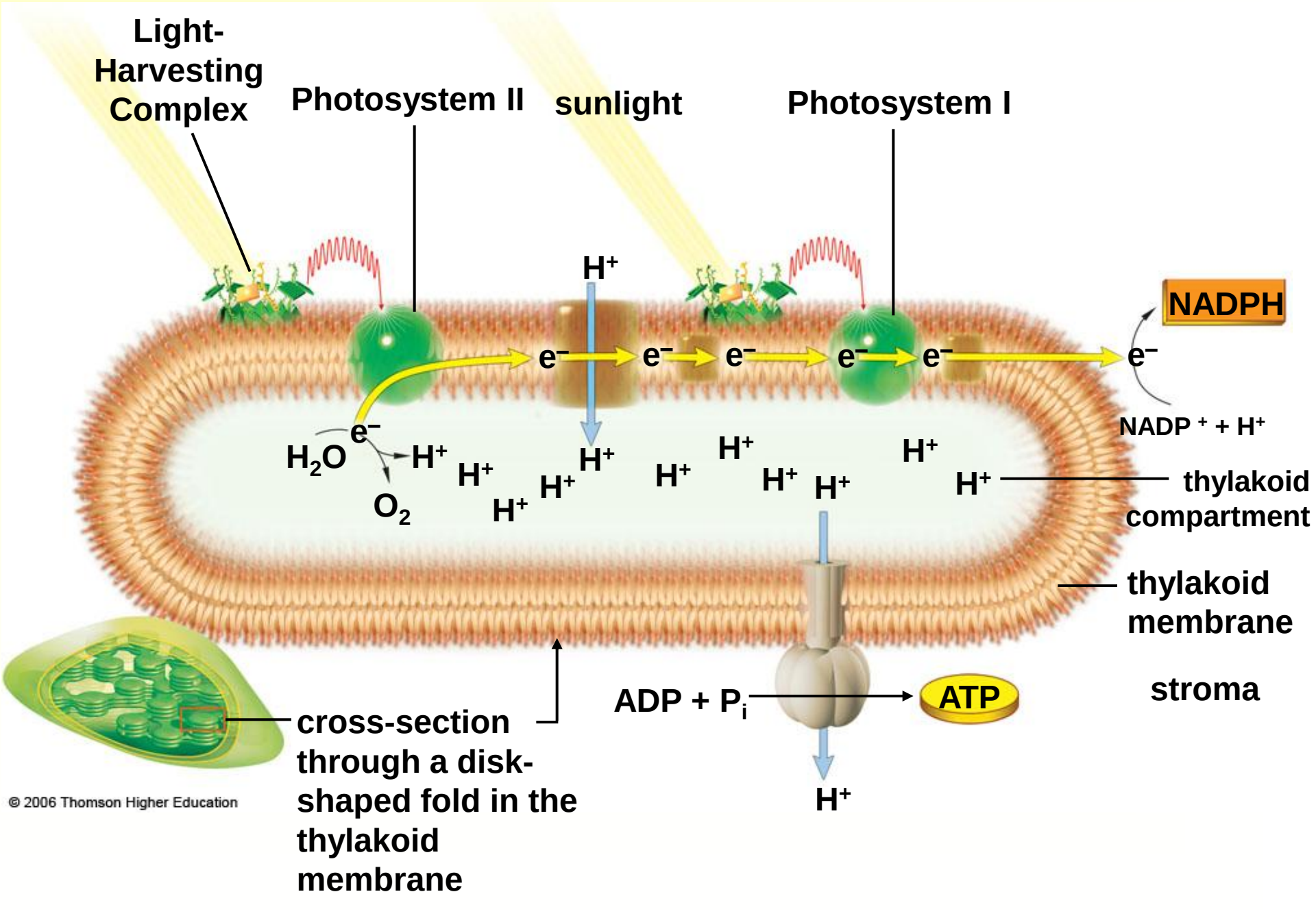

Light-Harvesting Complex
Photosystem II
sunlight
Photosystem I
NADPH
NADP + + H+
e–
H2O
O2
H+
thylakoid compartment
thylakoid membrane
stroma
ADP + Pi
ATP
cross-section through a disk-shaped fold in the thylakoid membrane
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Fig. 5-7, p.77

# *Non Cyclic Electron Flow: Summary*

## Reactants

- Location: Thylakoid Membranes
- Light
- Photosystem I and II with Chlorophyll
- Water
- Electron Transport Chains
- ADP
- $NADP^+$

## Products

- Oxygen
- ATP
- NADPH

# *Cyclic Electron Flow*

- Photosystem I only
- Electrons
  - Donated by chlorophyll *a*
  - Passed to electron transfer chain
  - Passed back to photosystem I
- Electron flow drives ATP formation
- No NADPH is formed

# Cyclic Electrton Flow

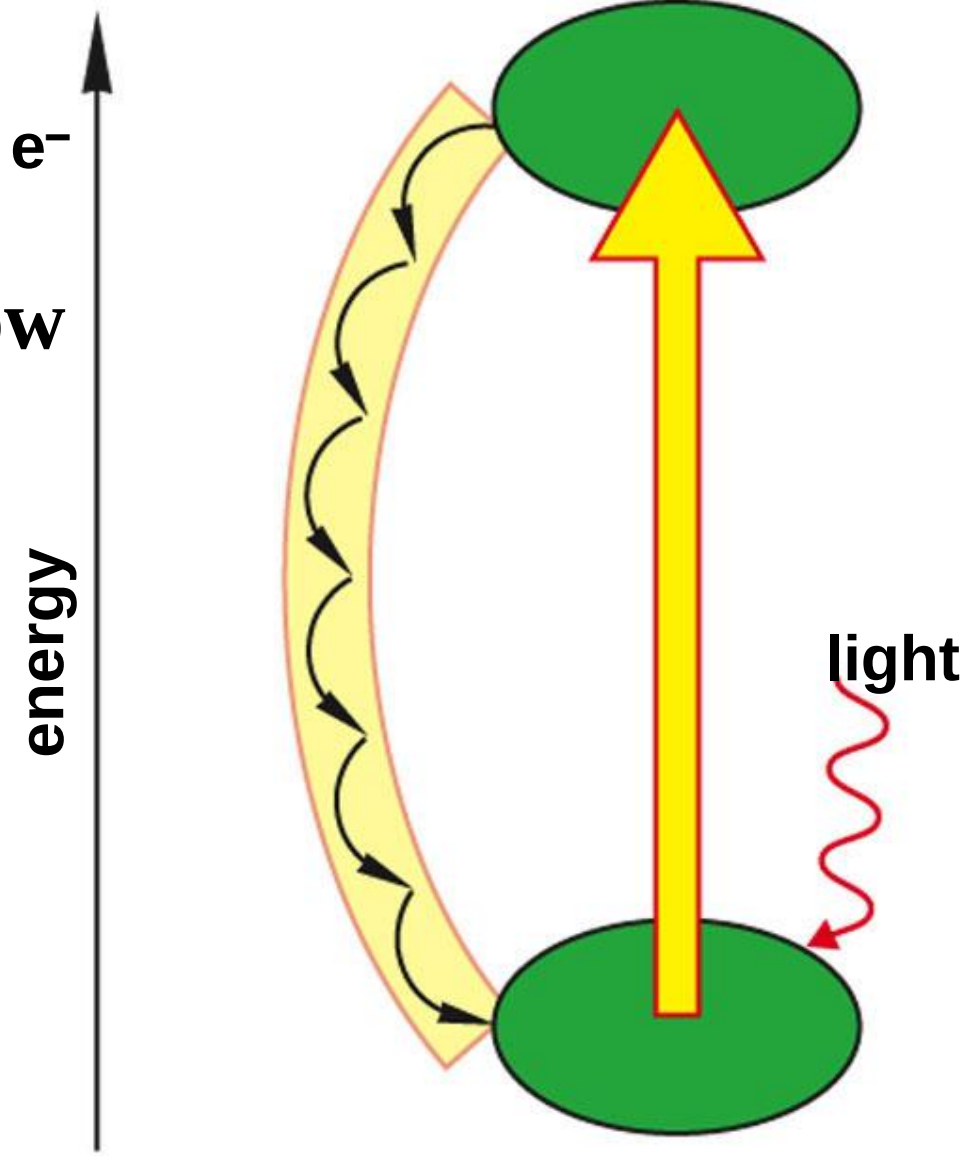





Fig. 5-6b, p.76

# *Cyclic Electron Flow: Summary*

## Reactants

- Location: Thylakoid Membranes
- Light
- Photosystem I with Chlorophyll
- Electron Transport Chain
- ADP

## Products

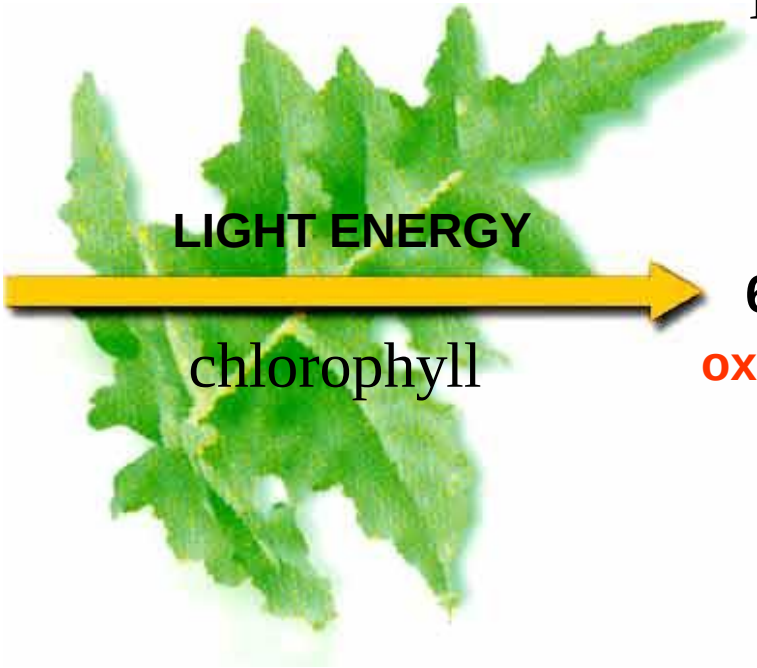
- ATP

# Photosynthesis Equation

LR

$12H_2O + 6CO_2$

water carbon dioxide




LR

$6O_2 + C_6H_{12}O_6 + 6H_2O$

oxygen glucose water

LR

# *Light Independent reaction*

Synthesis of glucose

# *Light-Independent reaction*

- Fixes carbon dioxide
- Synthesizes sugar
- Independent of light
- Take place in the stroma
- Calvin-Benson cycle

THESE REACTIONS PROCEED IN THE CHLOROPLAST'S STROMA

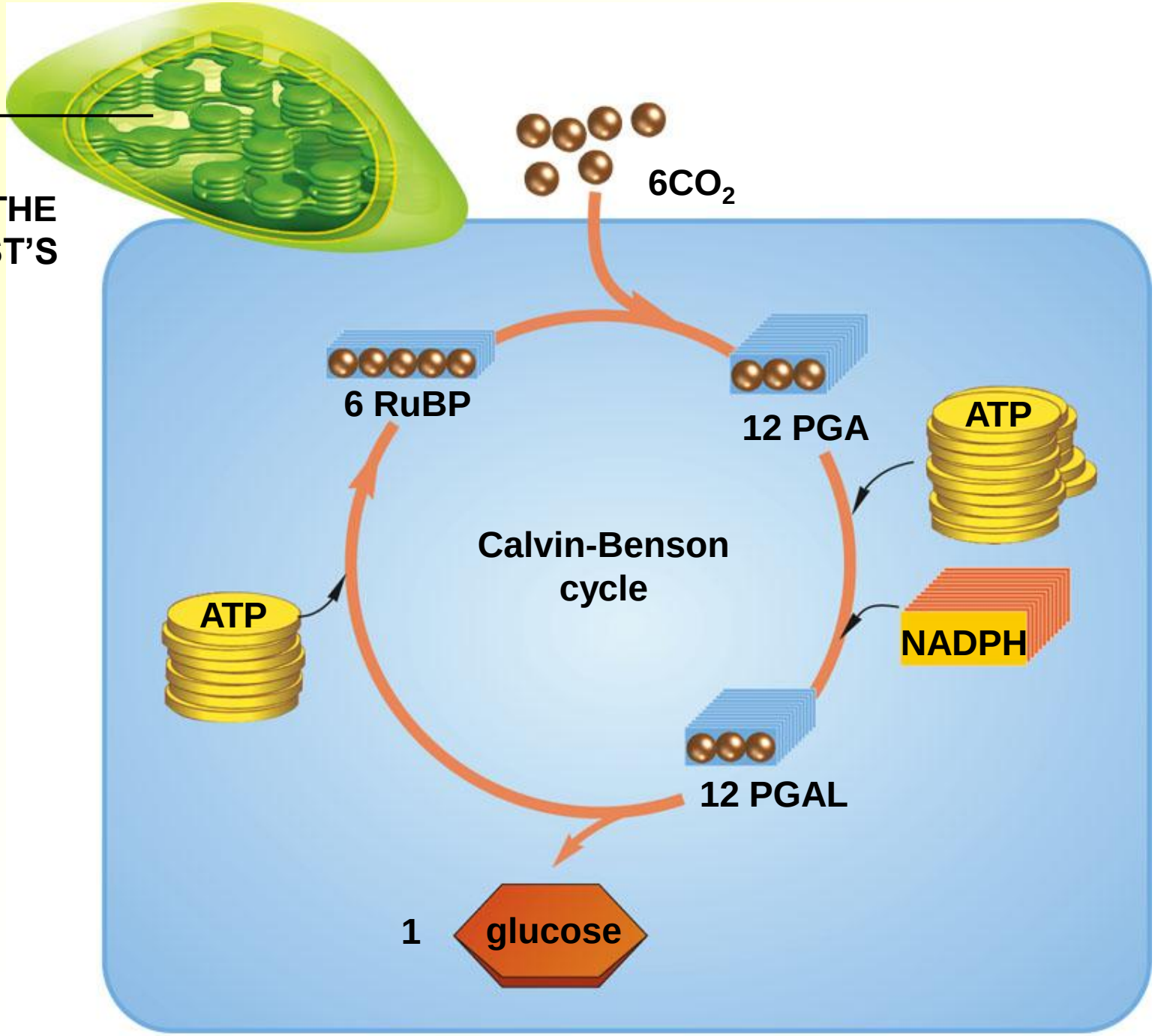





Fig. 5-8, p.78

# *Light Independent reaction*

- Reactants
  - Carbon dioxide
  - ATP
  - NADPH
  - RuBP
- Products
  - Glucose
  - ADP
  - $NADP^+$
  - RuBP

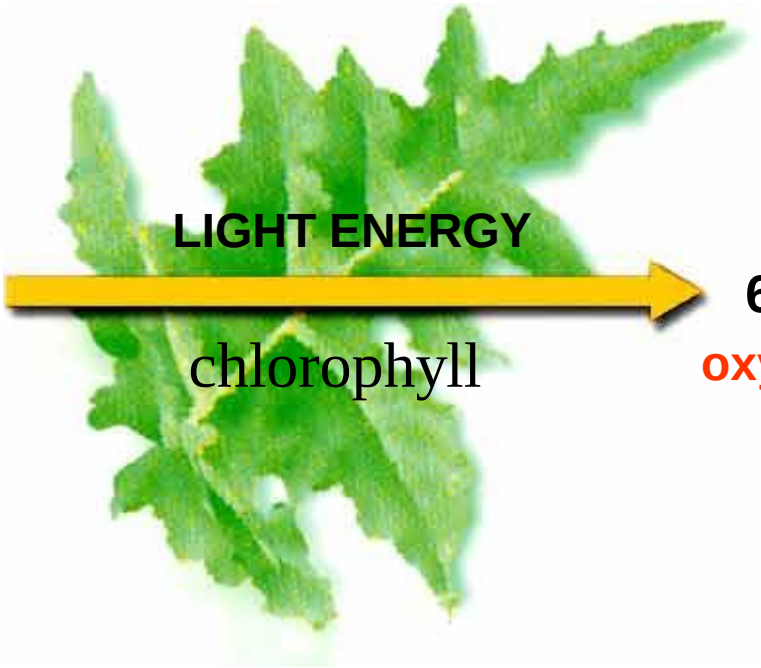
Reaction pathway is cyclic and RuBP (ribulose bisphosphate) is used and produced

# Photosynthesis Equation

LIR

$12H_2O + 6CO_2$

water carbon dioxide

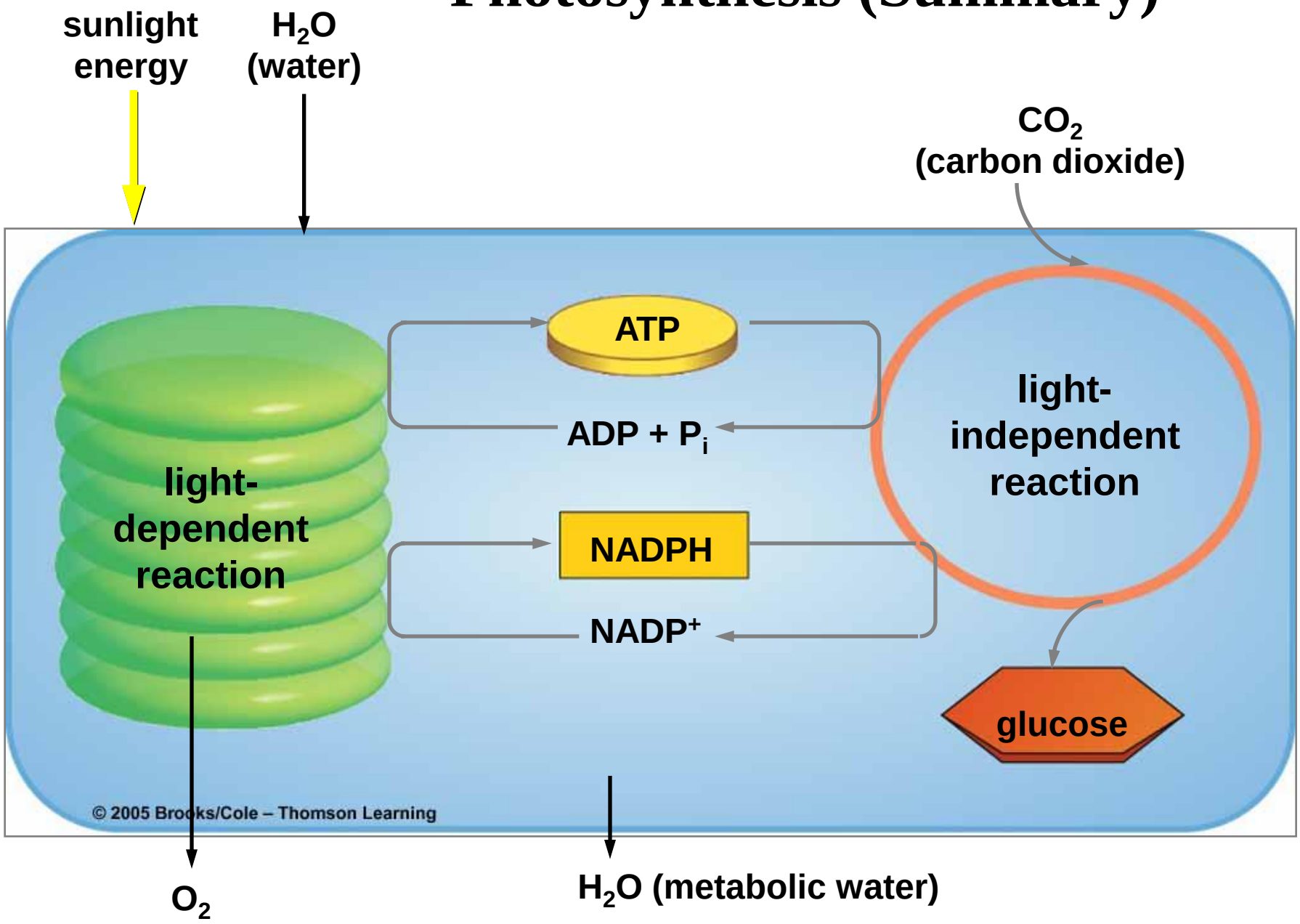



LIR

$6O_2 + C_6H_{12}O_6 + 6H_2O$

oxygen glucose water

# Photosynthesis (Summary)



# *The C3 Pathway*

- The standard photysynthesis pathway
- The first stable intermediate is a three-carbon PGA
- Because the first intermediate has three carbons, the pathway is called the C3 pathway



**Leaves of basswood, a typical C3 plant. Far right, basswood leaf cross section.**

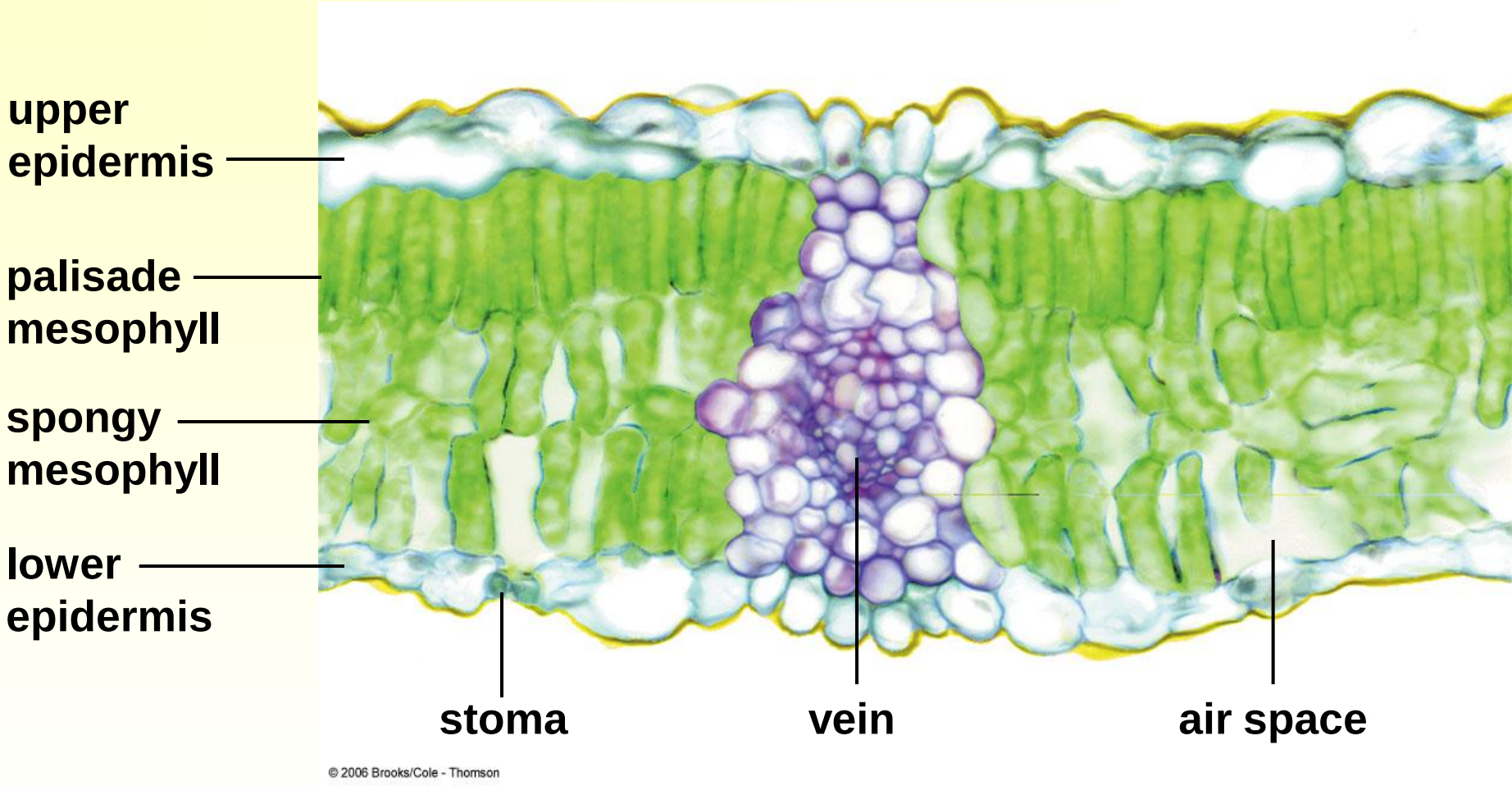
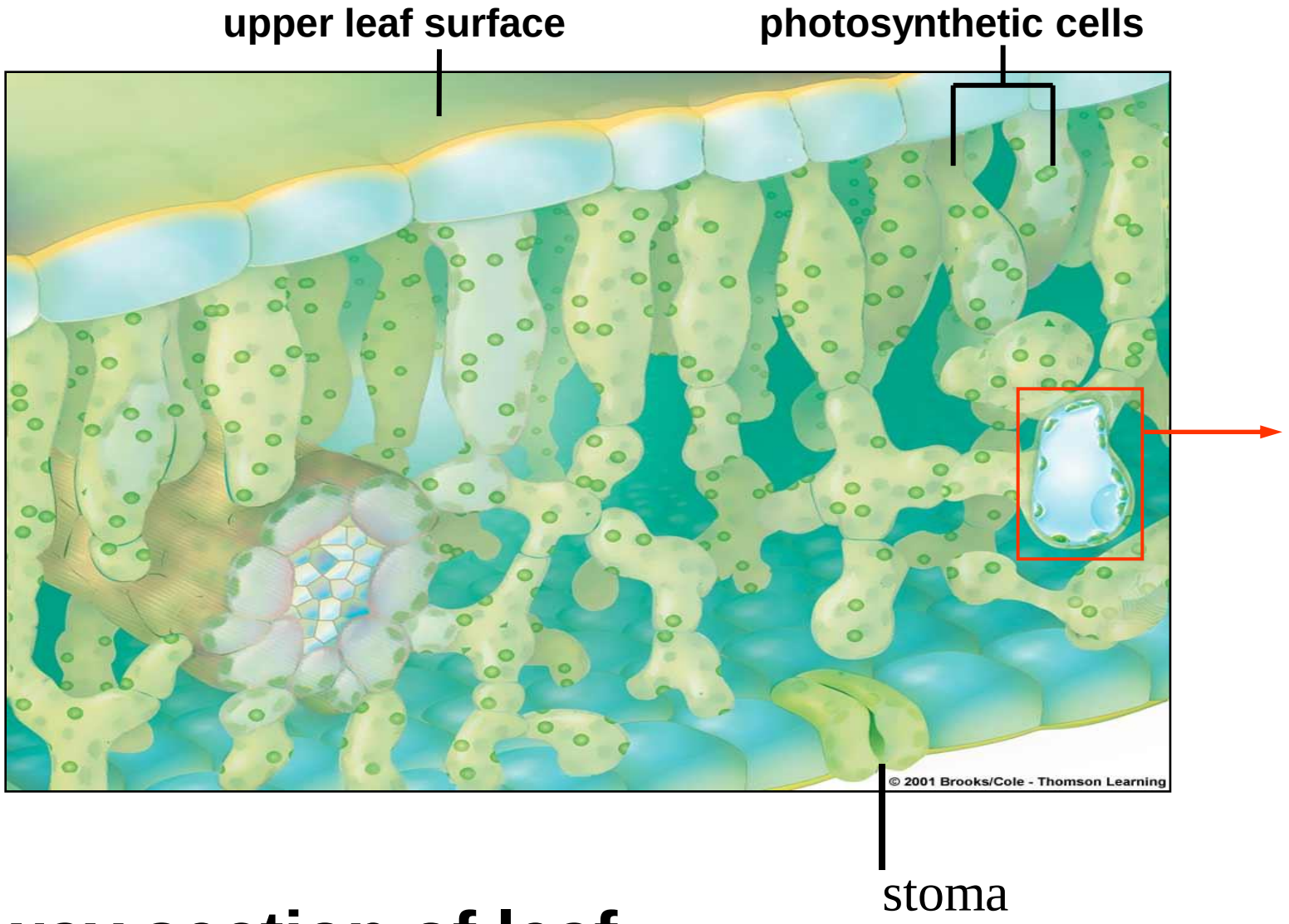

upper epidermis
palisade mesophyll
spongy mesophyll
lower epidermis
stoma
vein
air space
© 2006 Brooks/Cole - Thomson

Fig. 5-8, p.78

# *Photorespiration in C3 Plants*

- On hot, dry days stomata close
- Inside leaf
  - Oxygen levels rise
  - Carbon dioxide levels drop
- RuBP bonds to oxygen instead of carbon dioxide
- Only one PGAL forms instead of two glucose



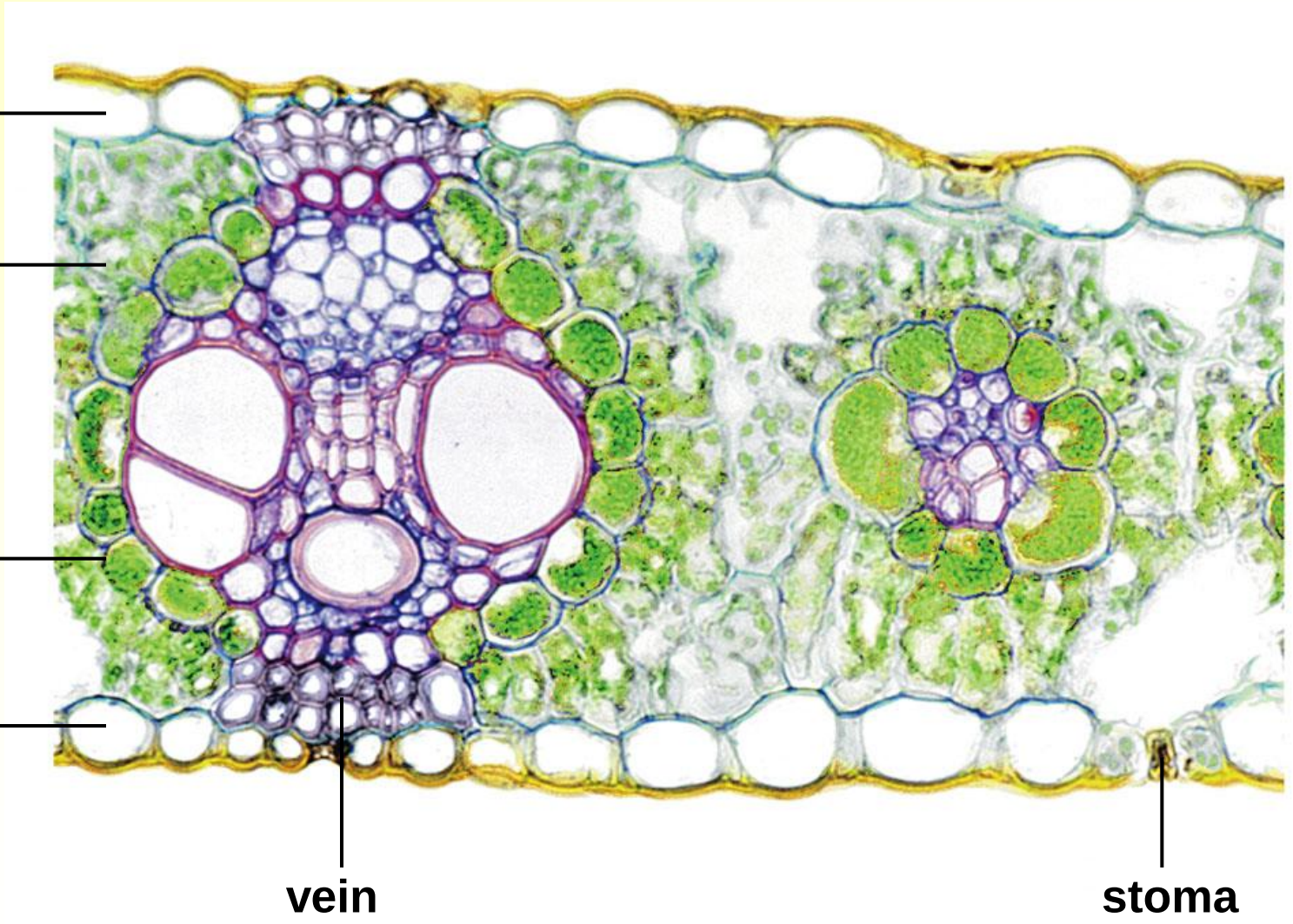

# Cutaway section of leaf

# *C4 Plants*

- Carbon dioxide is fixed twice
  - Carbon dioxide is stored as a four carbon compound
  - Carbon dioxide is released from the compound for use in Calvin-Benson cycle
- Evolutionary defense against photorespiration
- Corn and Crabgrass are examples



Fig. 5-9, p.79




**Corn leaf, cross-section**

Fig. 5-9a, p.79

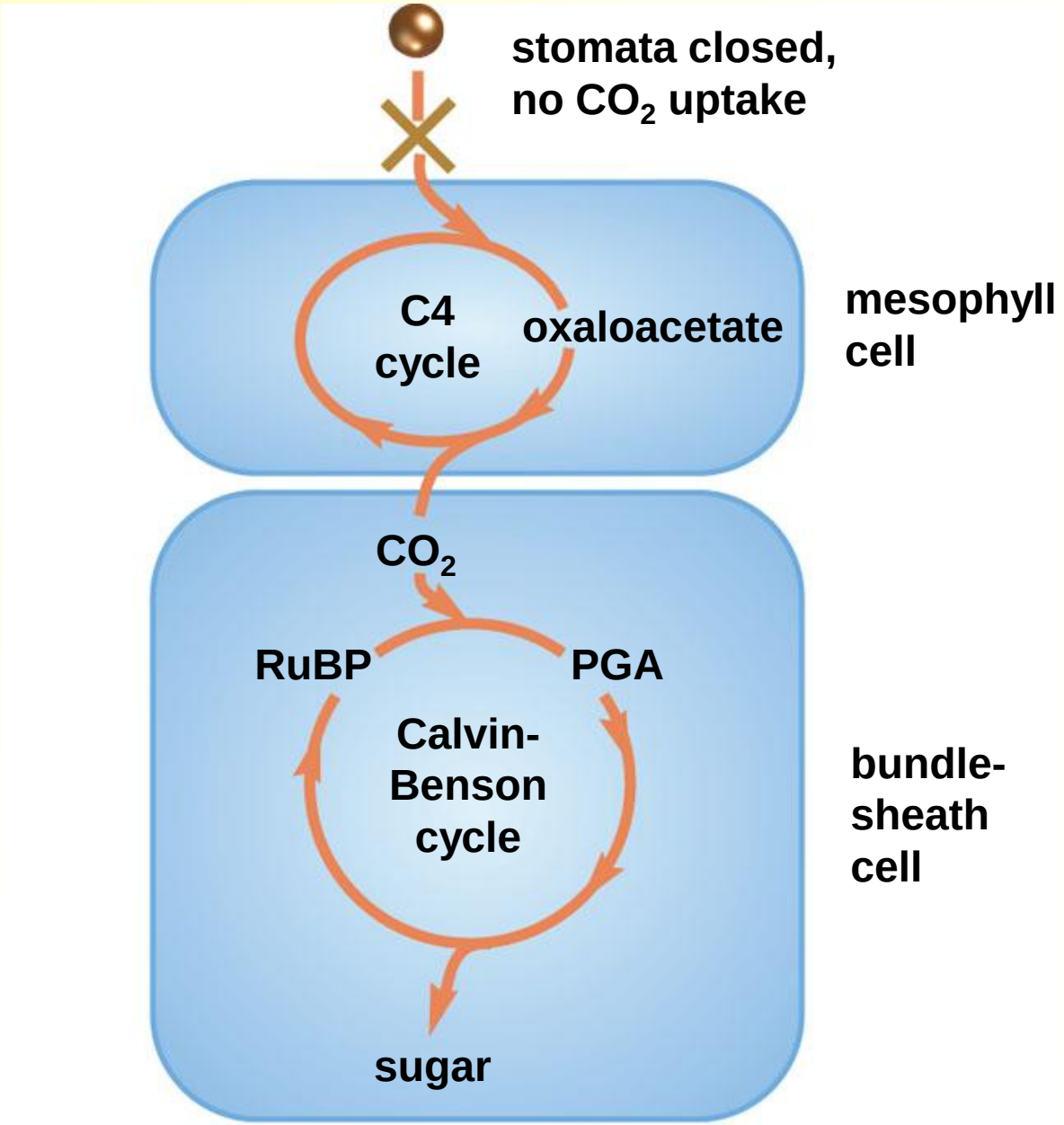





Fig. 5-9b, p.79

# *CAM Plants*

- Carbon is fixed twice (in same cells)
- Night
  - Stomates open for gas exchange.
  - Carbon dioxide is fixed by repeated turns of a type of C4 cycle
- Day
  - Carbon dioxide is released and fixed in Calvin-Benson cycle
- Cacti and other fleshy plants

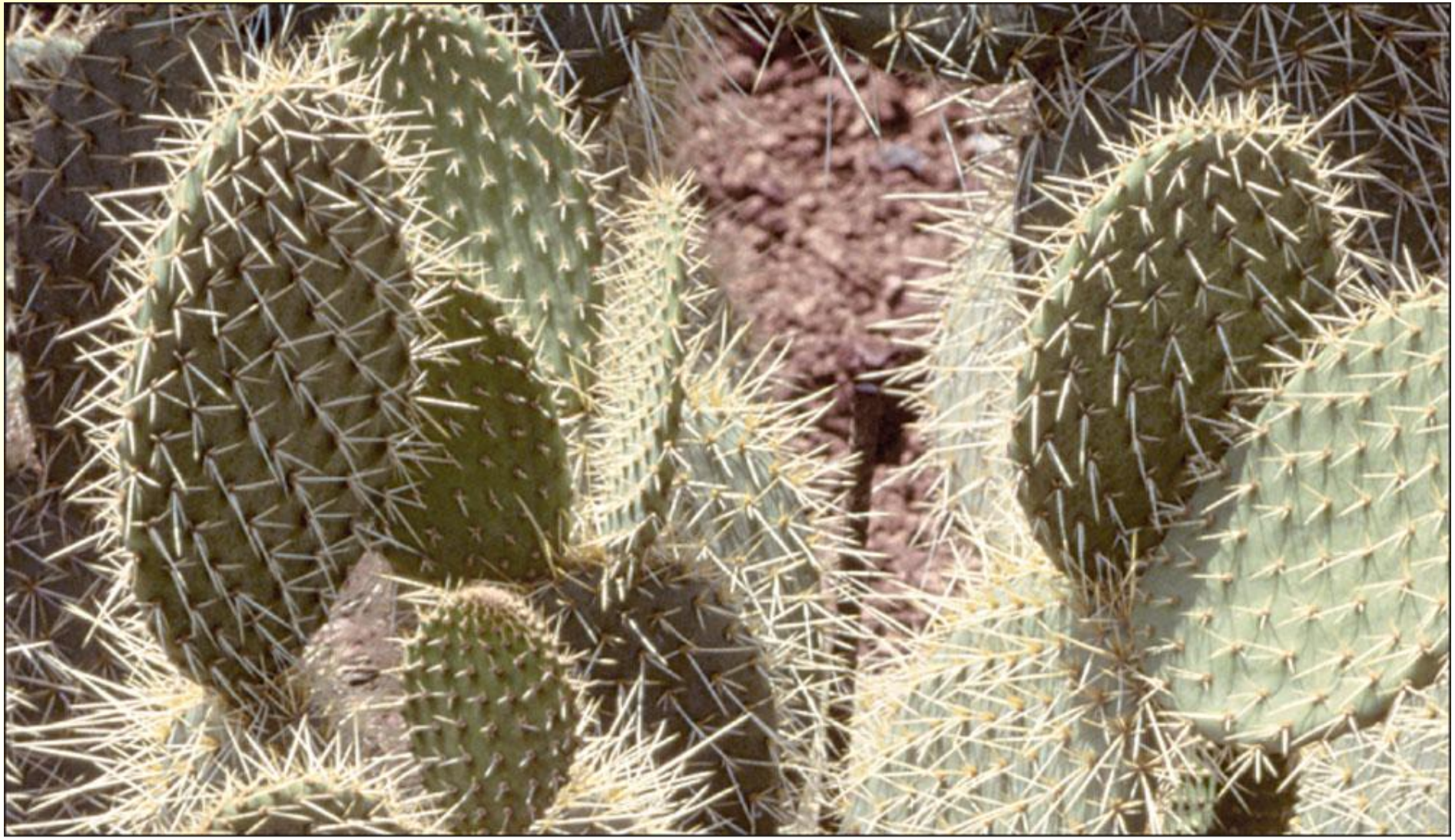




Fig. 5-10, p.79

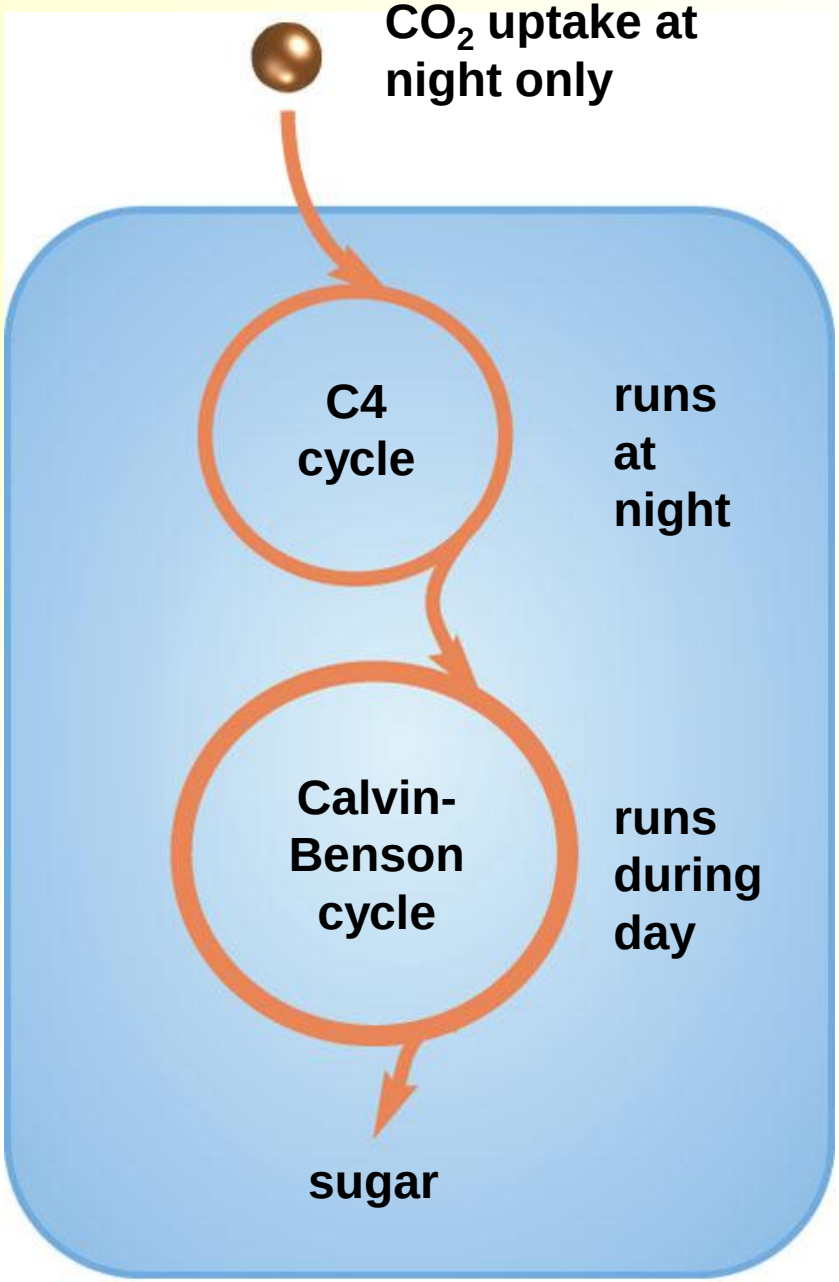
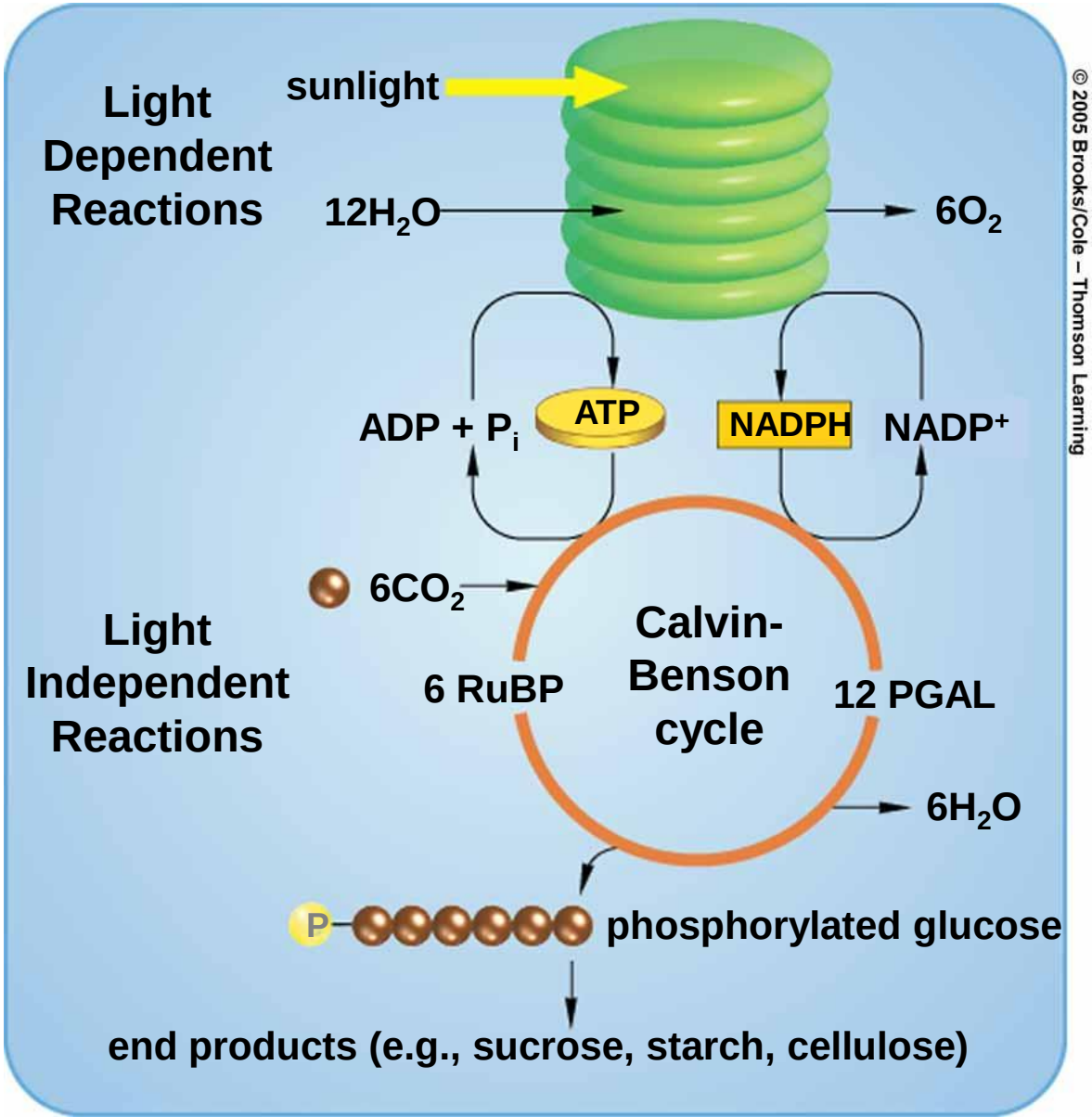





Fig. 5-10, p.79

# Summary of Photosynthesis



# *Carbon and Energy Sources*

- Photoautotrophs
  - Carbon source is carbon dioxide
  - Energy source is sunlight
- Heterotrophs
  - Get carbon and energy by eating autotrophs or one another

# *Linked Processes*

## Photosynthesis

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

## Aerobic Respiration

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