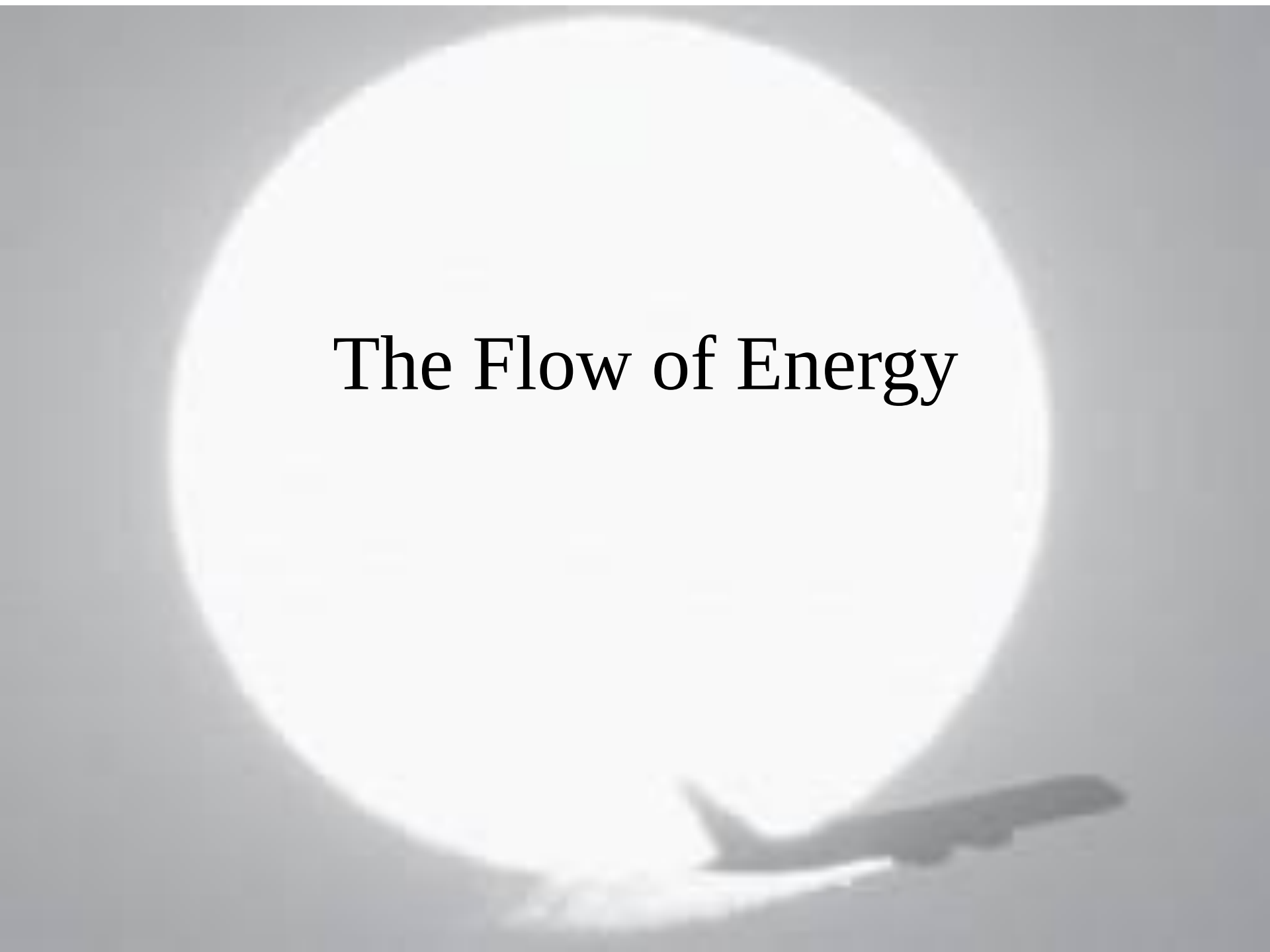
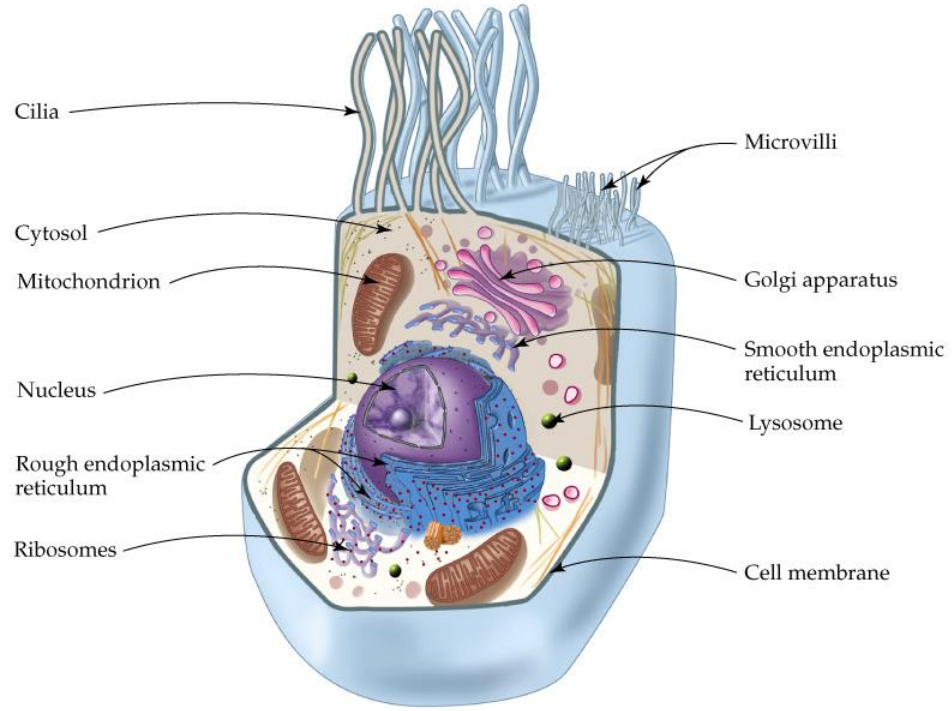
The Flow of Energy



Energy for Cells

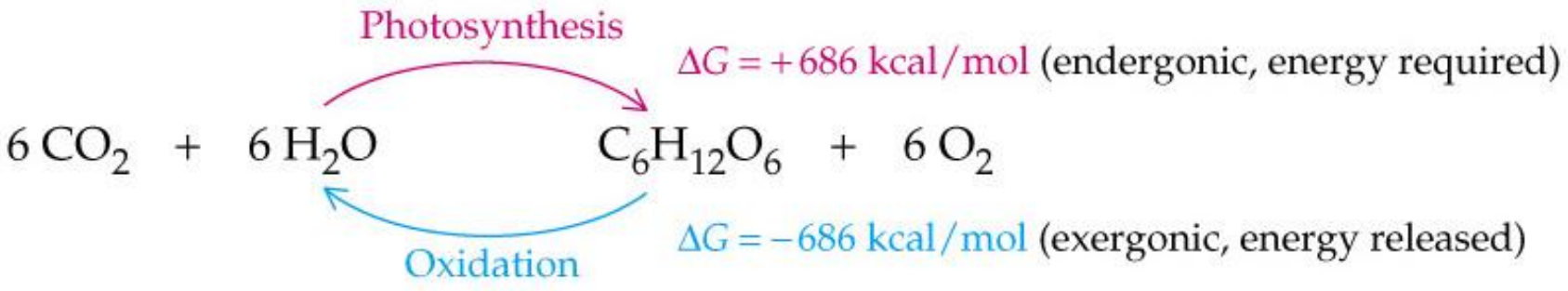
- ***<u>ATP (Adenosine Tri Phosphate)</u>* *is the source of free energy (Energy available to do work) for reactions in the cell**

  What is ATP?



Energy for Cells

- **All reactions in the cell require energy**
- **Two types of reactions in a cell**
  - ***Endorgonic**** **- those that require energy**
  - ***Exorgonic*** ***- those that give off energy**
- **Free energy *(the energy needed for work in the cell) is needed to move a muscle, active transport, protein synthesis etc.**



Free Energy to do Work

- **In cells, most of the free energy needed to carry on cell activities, come from ATP, A-P-P-P (adenosine tri-phosphate**
- **Releasing energy from ATP happens when the bond between the phosphates is broken**
  - **The breaking down of ATP is a hydrolysis reaction**
    - **ATP + H_2O → ADP + P_i + Free Energy (P_i is a free inorganic phosphate)**
    - ***ADP is Adenosine di Phosphate***

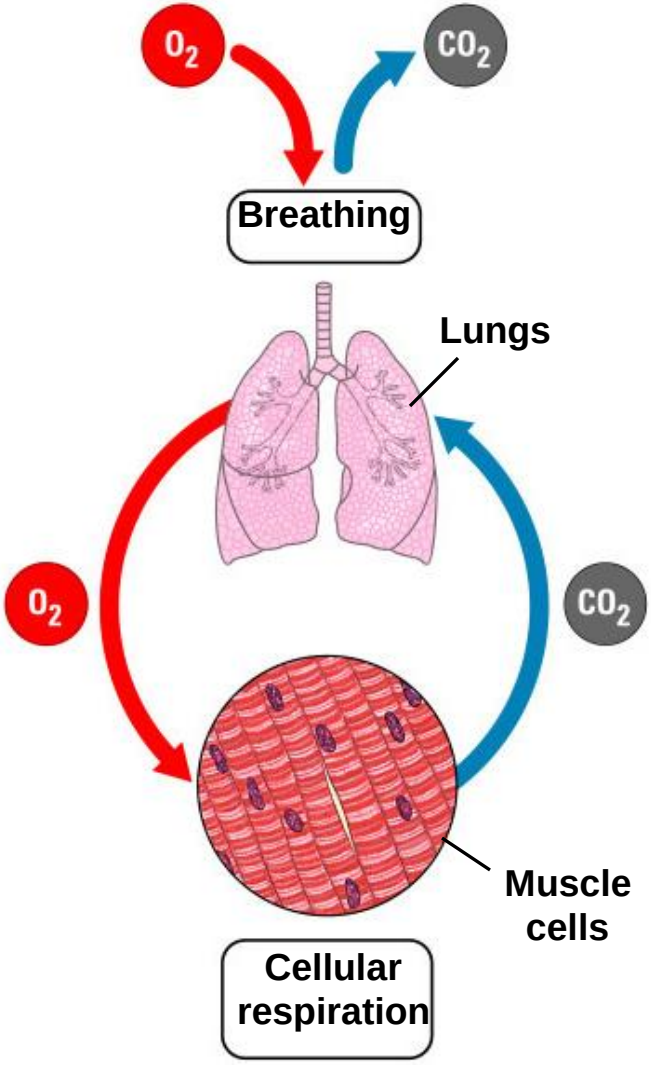
ADP &P_i to ATP*

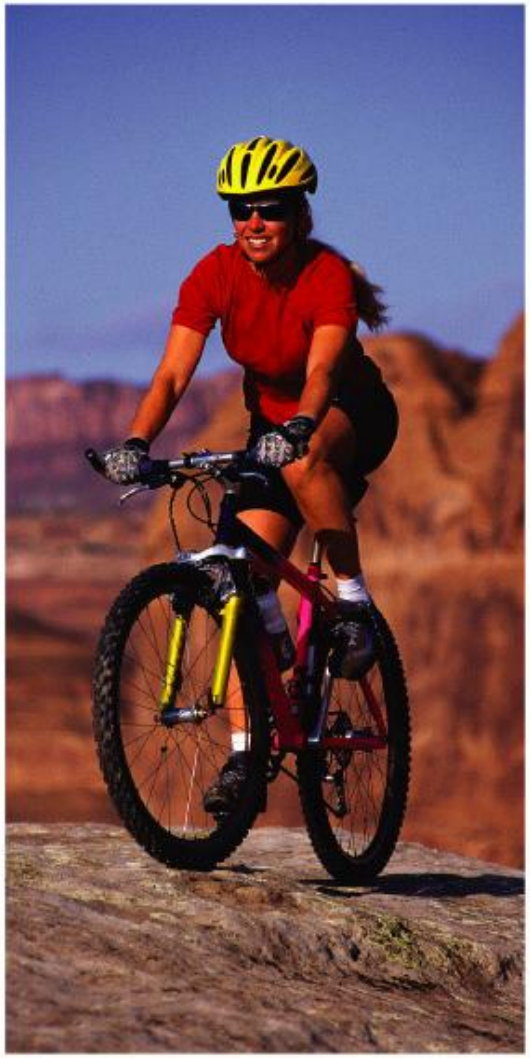
- **Where does ADP P_i get the energy to become ATP again?***
- **Cellular respiration is the process that returns the energy ADP & P_i to form ATP**
- **During respiration energy from energy rich molecules such as glucose are used to change ADP + P_i into ATP***

Is ADP changing to ATP endorgonic or exorgonic?

Cellular Respiration

- Respiration **IS NOT** Ventilation =breathing



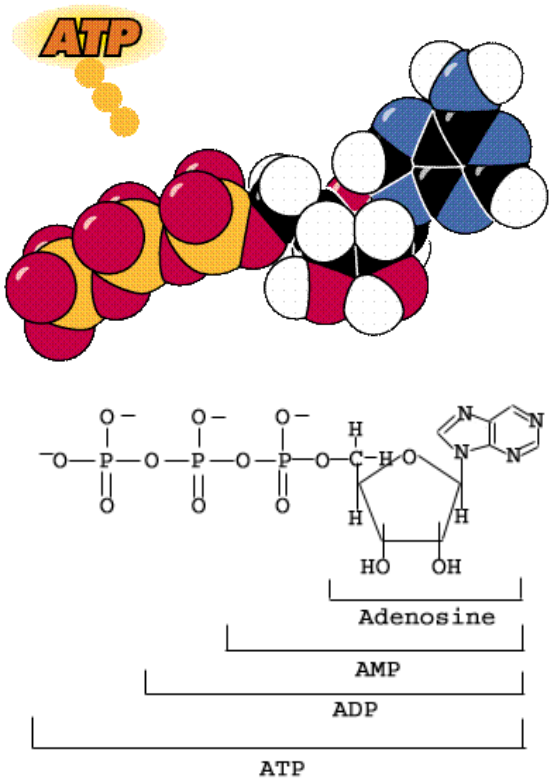


ATP is the universal energy "currency"

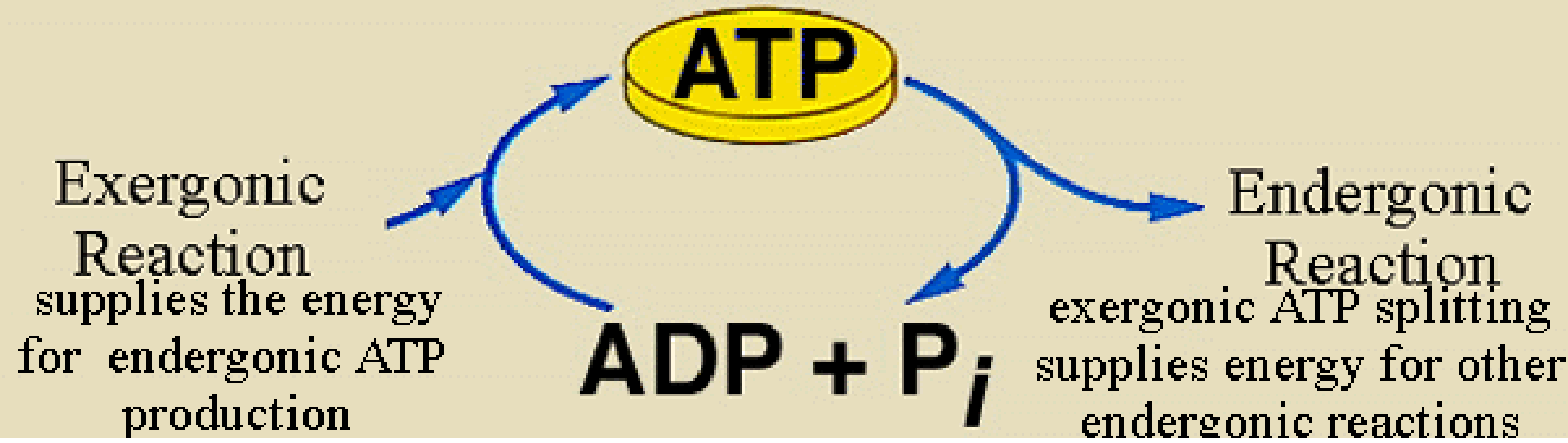
- Used to "purchase " chemical reactions that are energetically unfavorable → to do Work

➢ **Basis for electrochemical work – nerve impulses**

➢ **Basis for mechanical work – muscle contractions**



The ATP/ADP Cycle



Respiration with 0_{2*}

Aerobic respiration

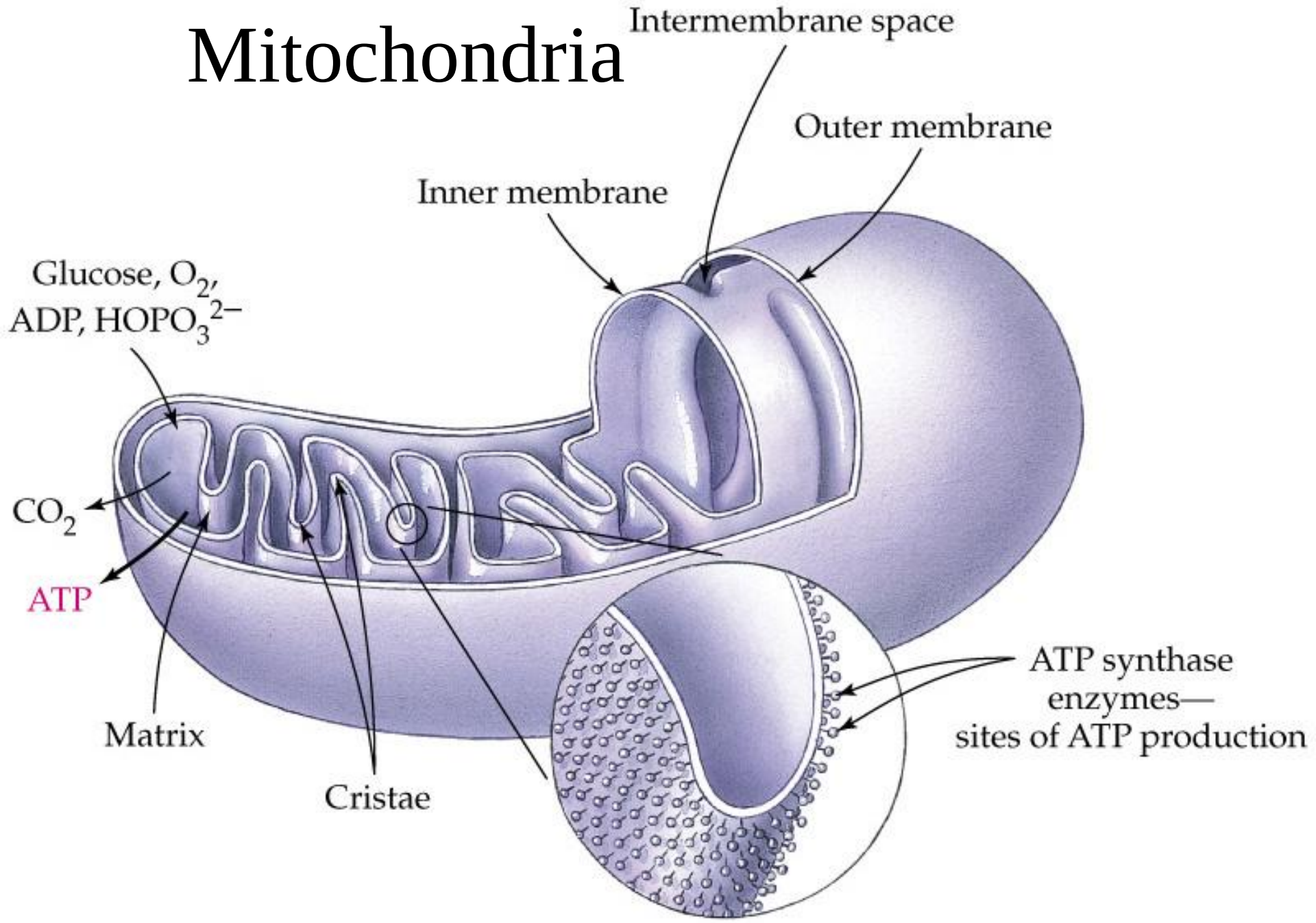
- **Aerobic respiration starts in cytoplasm and finishes in *mitochondria**
- **Aerobic Respiration Summarized**
  - **$C_6H_{12}O_6 + 6O_2 + 38ADP + 38\ P_i \rightarrow 6CO_2 + 6H\text{-}_2O + 38\ ATP$**
    - **Two ATP are used in the cycle to get the process going**
    - **That leaves a net gain of 36 ATP**
  - **A glucose molecule is to much energy for the cell to use all at once**

Where does respiration take place?

Is respiration endorgonic or exorgonic?

What is the chemical formula for respiration?

Mitochondria



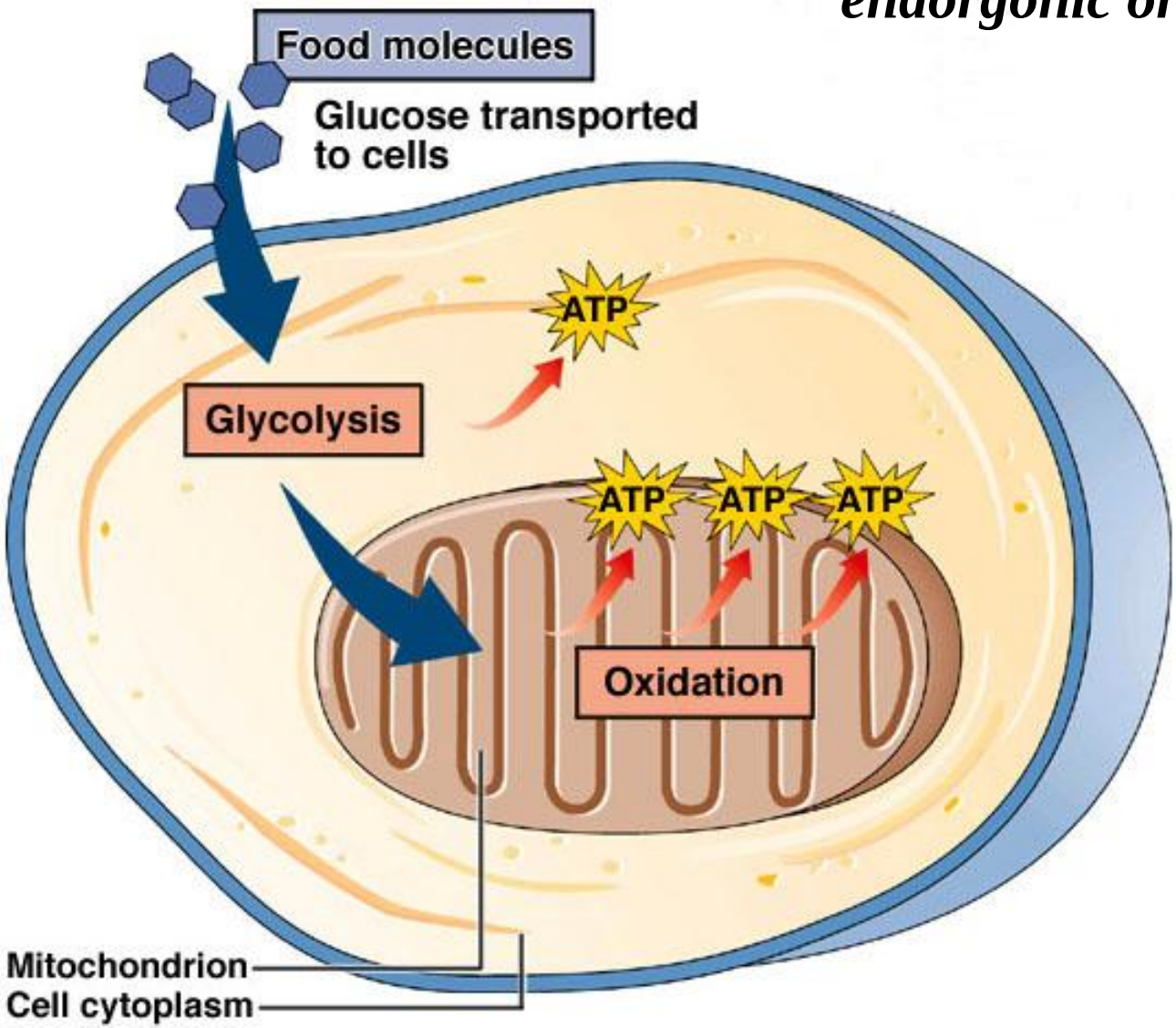
Respiration to ATP Review*

- **Cellular respiration packages energy into useable sized energy packets (ATP)**
- **The ATP then is used again to do the cells work**
- **When the energy is released from the ATP to do work an ADP + P_i is what is left over**
- **In order for ADP + P_i to become ATP again cellular respiration must take place**
- **This is called the ATP, ADP + P_i Cycle**

Cell Respiration is versatile

- Respiration can "burn" other kinds of molecules besides glucose
  - Diverse types of carbohydrates
  - Fats
  - Proteins

Is ATP changing to ADP endorgonic or exorgonic?



Examples

- **The 100 dollar bill example on page 148**
- **Meat packing example**

Anaerobic respiration*

- **respiration that takes place in the absence of O_2**
- **Called Fermentation**
- Two types of Fermentation
  - Lactic Acid
  - Alcoholic

Lactic Acid Fermentation*

- **$C_6H_{12}O_6$ + 4 ADP + 4 P_i → $2CH_3CHOHCOOH$ + 4ATP**
- **2ATP are used to start the process leaving a net gain of 2 ATP**
- ***Lactic Acid is what cause muscle soreness****

What is the product of lactic acid fermentation?

What is the main reason for muscle soreness after a hard workout?

Alcoholic Fermentation*

- $C_6H_{12}O_6 + 4\ ADP + 4\ P_i \rightarrow 2\ C_2H_5OH + CO_2 + 4\ ATP$
- **2 ATP are invested, giving a net gain of 2 ATP**

What causes bread to rise?

What is the distinct order of fresh baking bread?

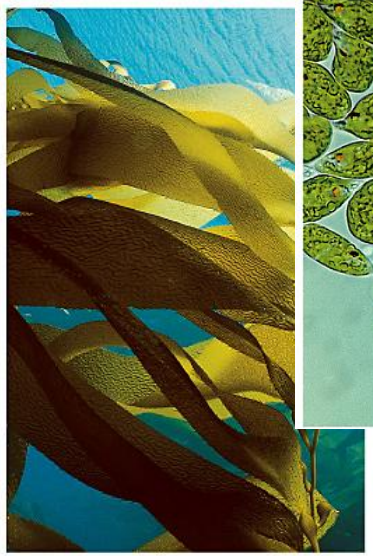
What is the product of alcoholic fermentation?

What is the difference between aerobic and anaerobic respiration?

Basics of Photosynthesis

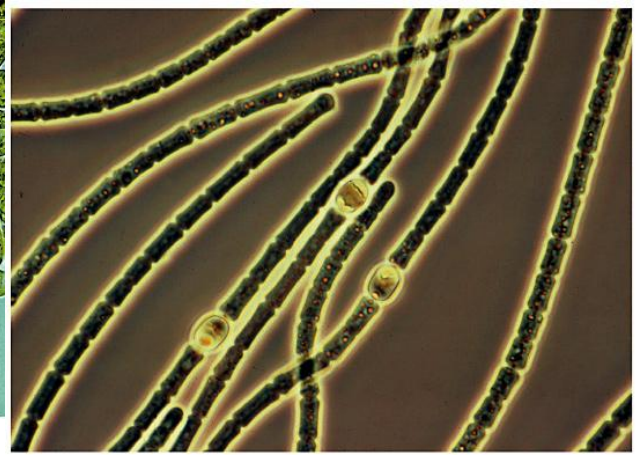
- Almost all plants *photosynthetic autotrophs*, also some bacteria & protists
  - Make own organic matter by photosynthesis; are Earth's *primary producers*

(a) Mosses, ferns, and *flowering plants*



(b) Kelp

(c) *Euglena*



(d) Cyanobacteria

Figure 7.2

Photosynthesis *

- Light used to put CO_2 + H_2O together to form sugar
- Light is radiant energy
- Human eye sees from 400 - 700 nm wavelength
- What we see is called the visible spectrum
  - Red orange yellow green blue violet
- Color is the reflection of light
- The absorption spectrum is what is absorbed by a material.*

Chlorophyll*

- Green pigment in plants responsible for the energy absorption for photosynthesis
- Chlorophyll reflects green and yellow parts of the spectrum and absorbs the other wavelengths
- Chlorophyll *a* is the most common kind of chlorophyll in green plants
- Other light absorbing pigments
  - Chlorophyll b
  - Carotenoids

Chloroplasts:

Sites of Photosynthesis among eukaryotes

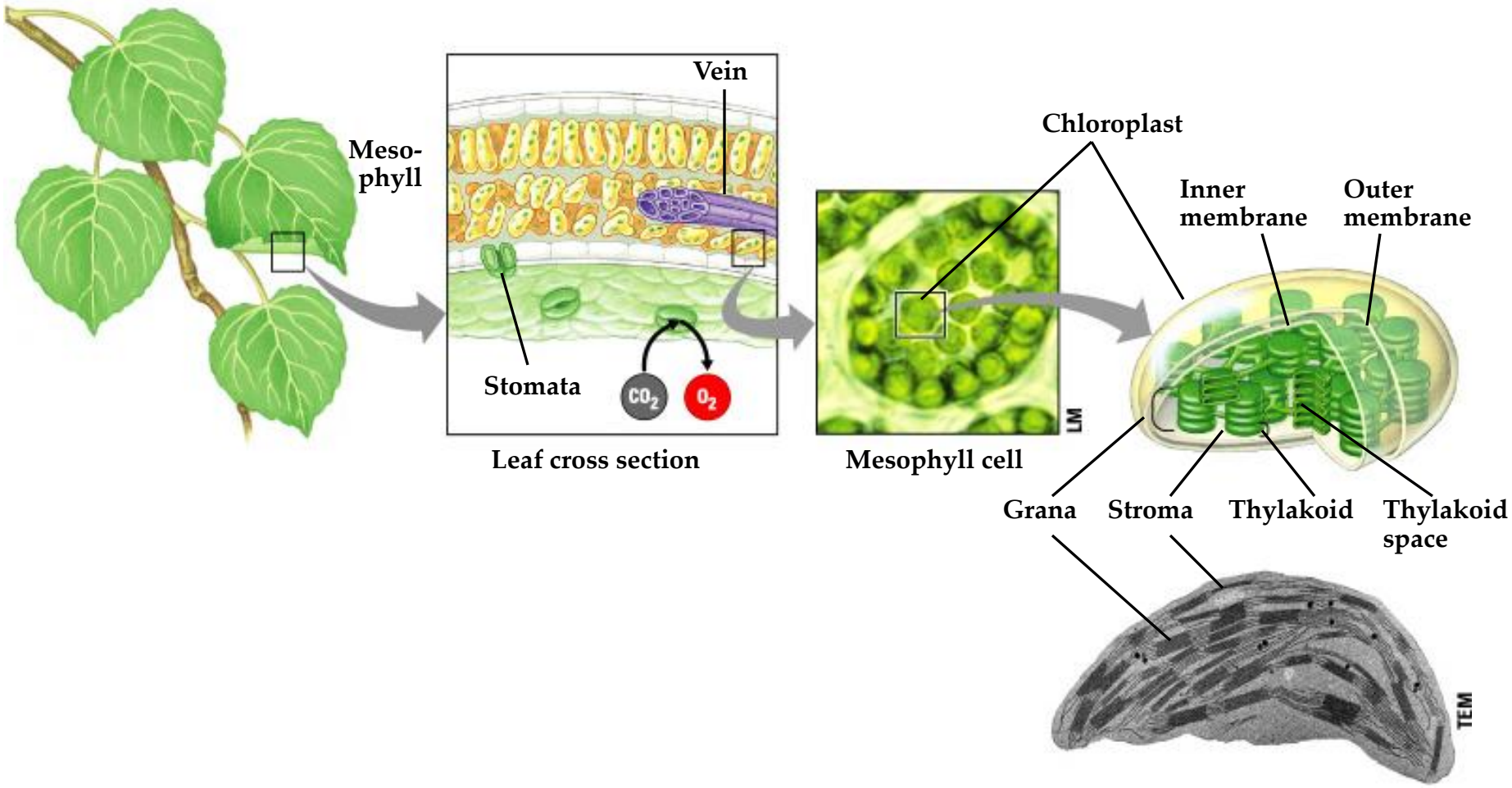
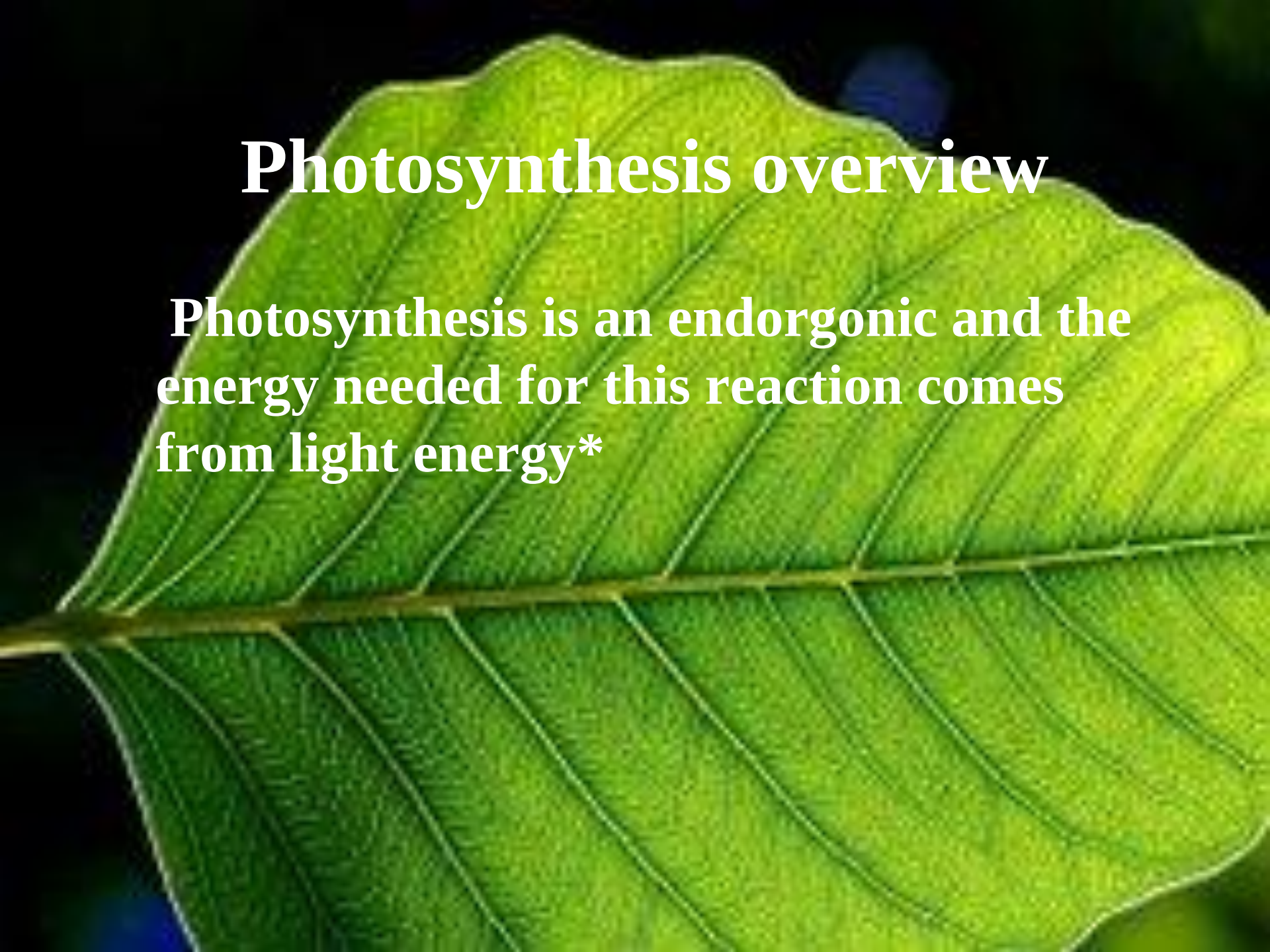


Figure 7.3



Photosynthesis overview

Photosynthesis is an endorgonic and the energy needed for this reaction comes from light energy*

- Chloroplasts absorb light energy so that it can be converted to chemical energy

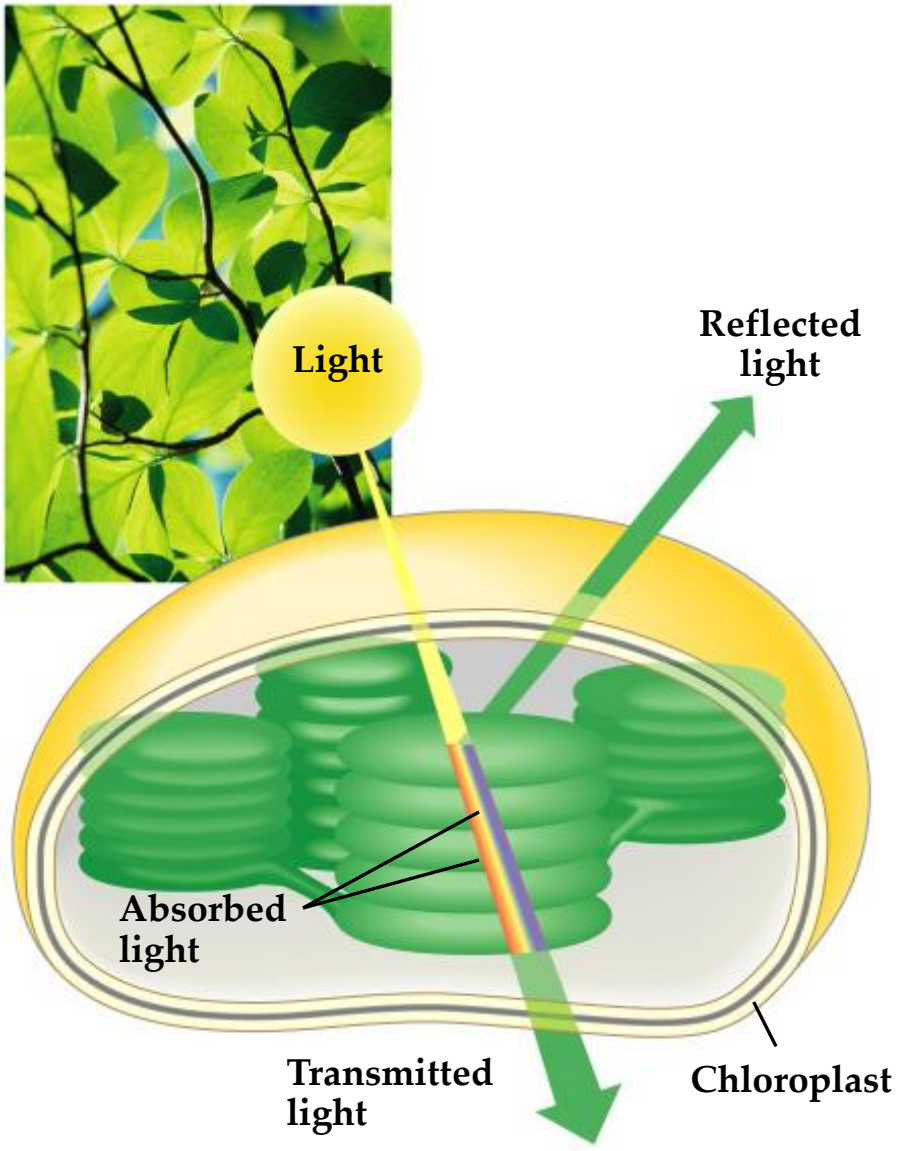


Figure 7.6

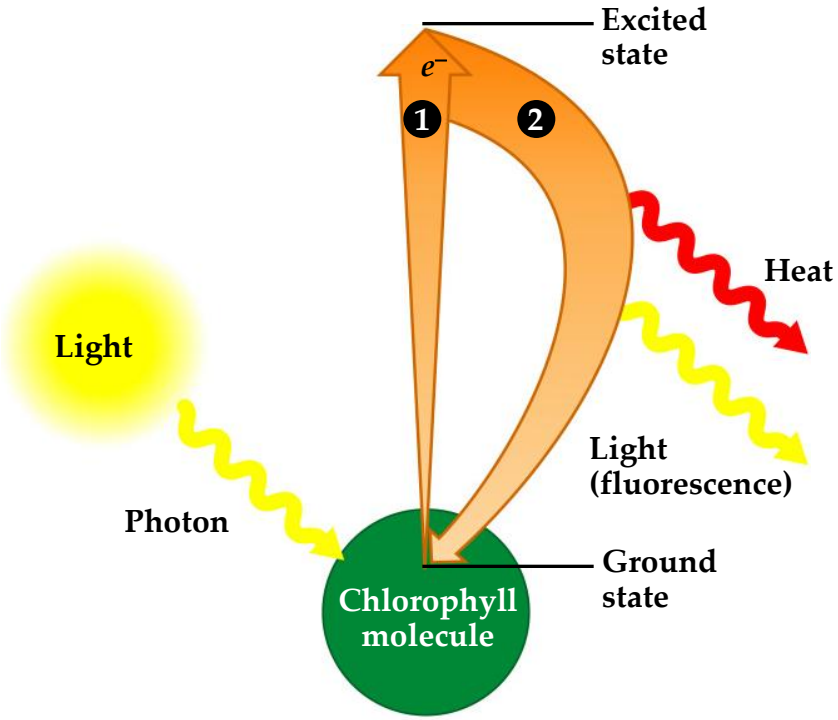
Photosynthesis **summarized**

$6CO_2 + 6H_2O$ + Chlorophyll and light energy → $C_6H_{12}O_6 + 6O_2$

What is the chemical reaction for photosynthesis?*

How Photosystems Harvest Light Energy

- Light behaves as photons, discrete packets of energy
- Chlorophyll molecules absorb photons,
- Energy released & used



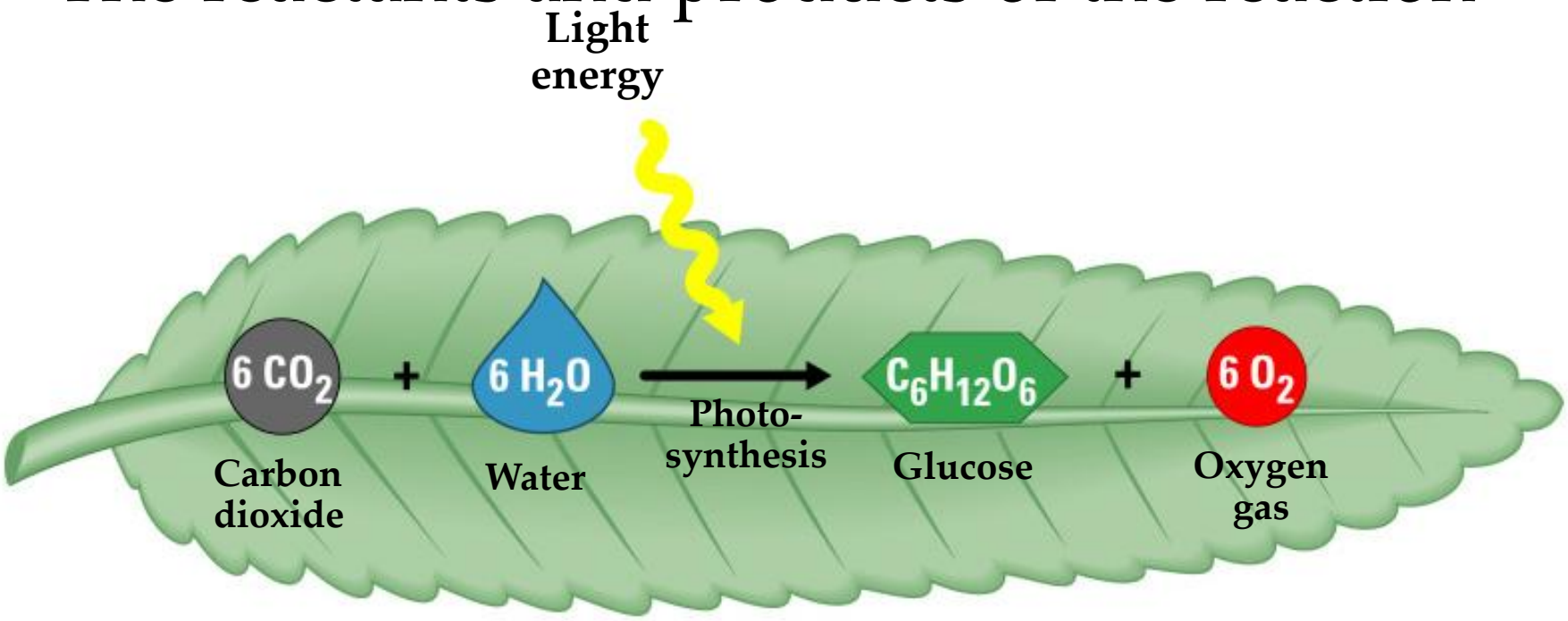
(a) Absorption of a photon

(b) fluorescence of isolated chlorophyll in solution

(c) Fluorescence of a glow stick

The Overall Equation for Photosynthesis

- The reactants and products of the reaction



Photosynthesis has two parts

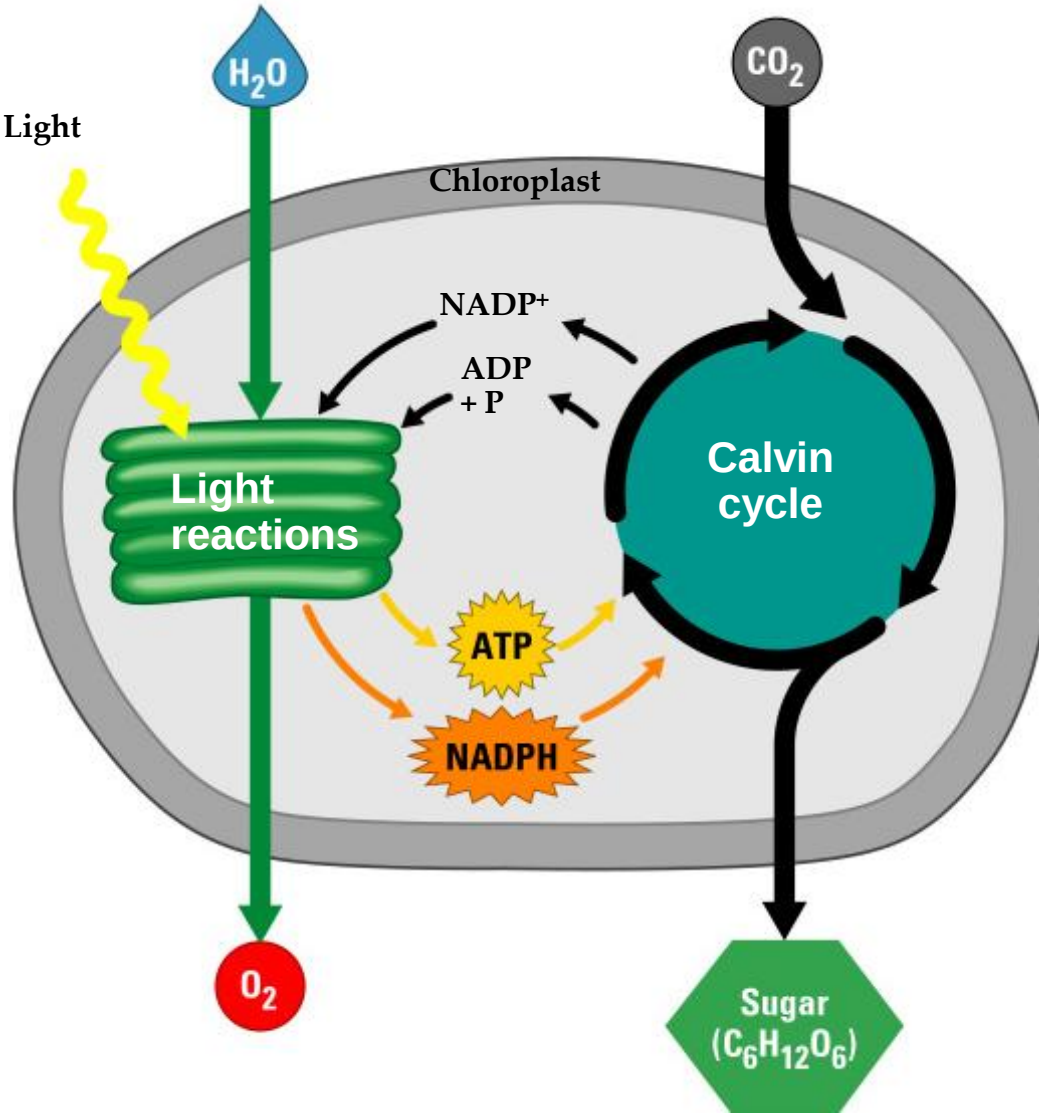
- Light Reaction*
- Calvin Cycle*

*What are the two parts of photosynthesis?**

A Roadmap for Photosynthesis

- Energized e^- added to CO_2 to make glucose
- Sunlight provides E
- Is a 2-step process

- **Light reactions convert solar E to chemical E**
- **Calvin cycle makes sugar from CO_2**



- **The light gathering "photosystem"**
  - Is an organized group of chlorophyll and other molecules
  - Is a light-gathering antenna

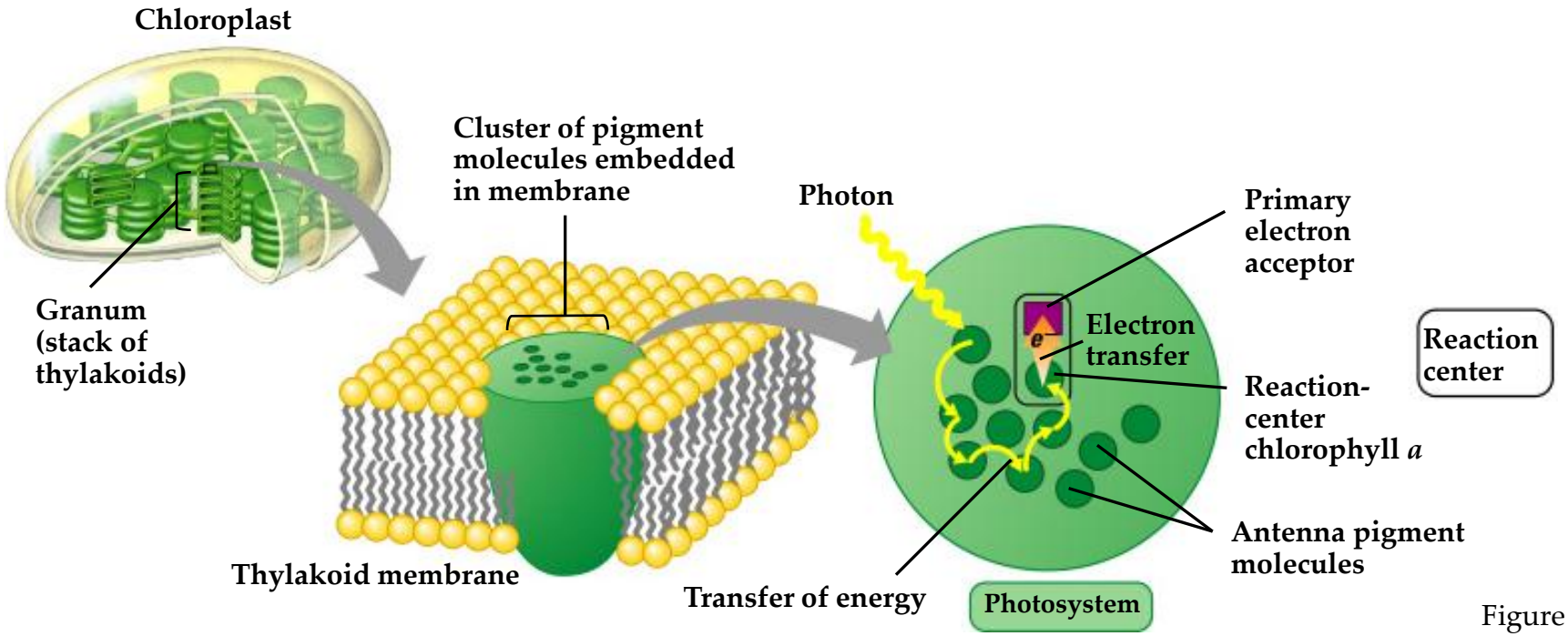


Figure 7.9

Know the parts of the chloroplast.

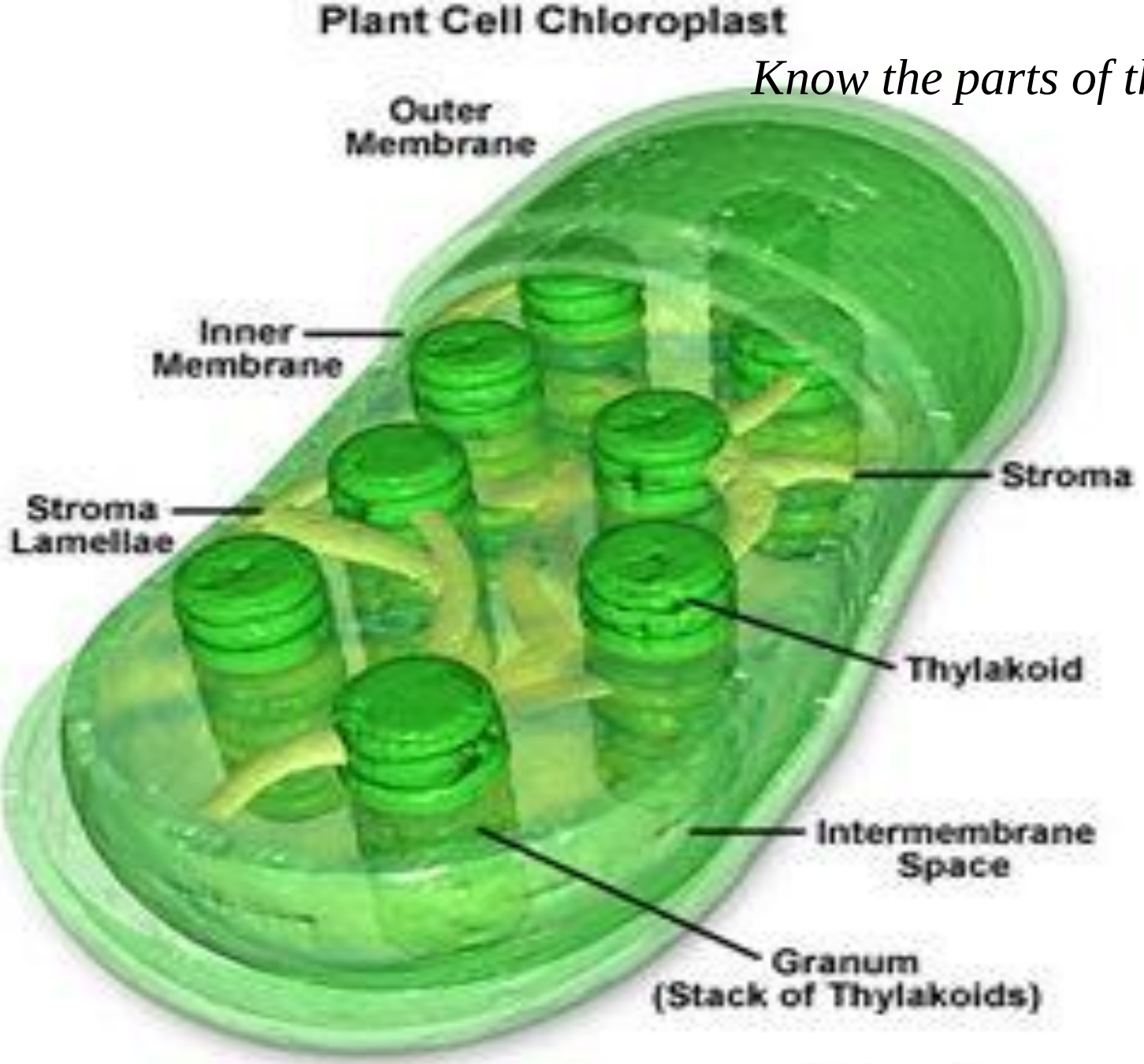
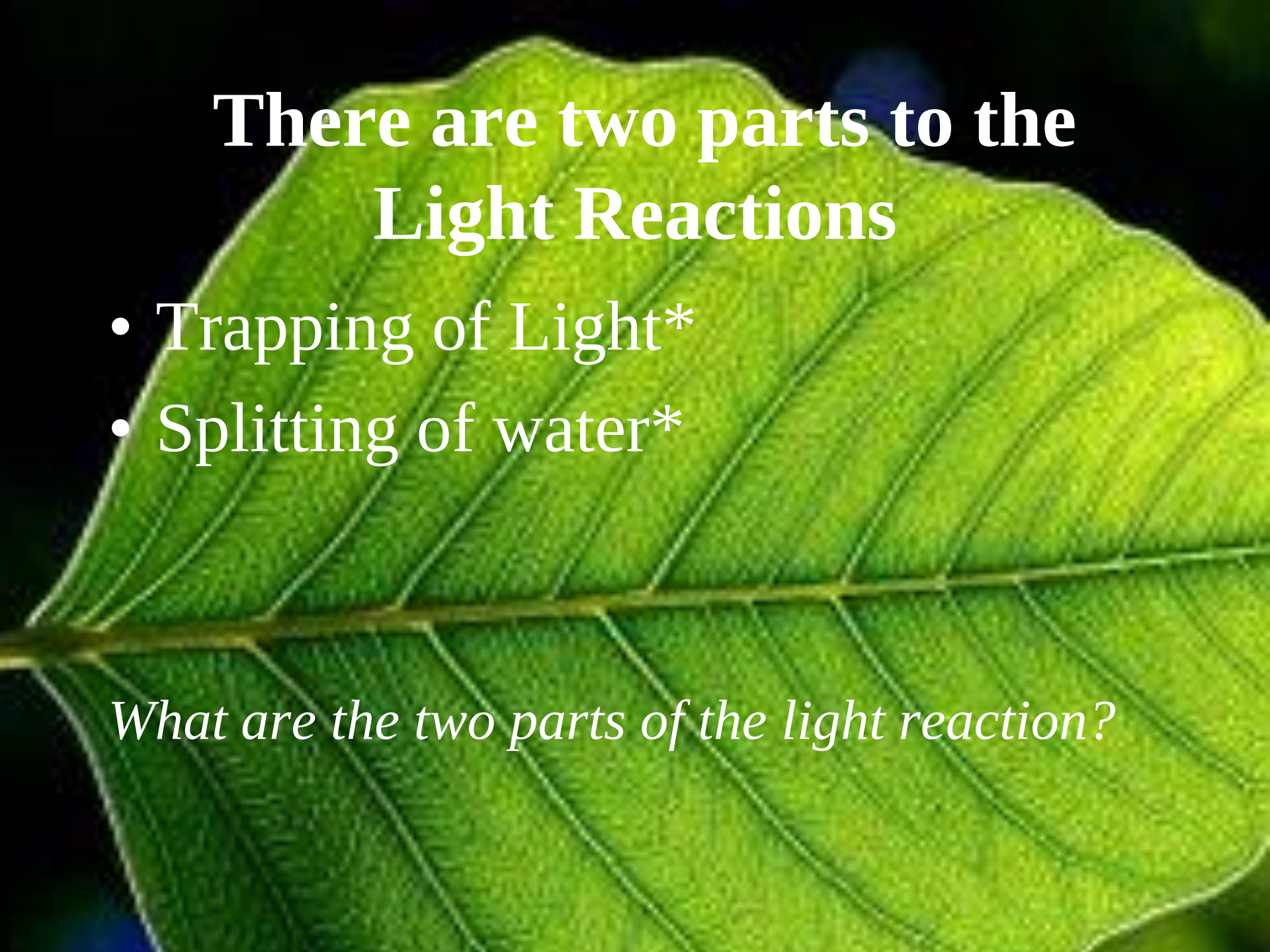


Figure 1

Part I of photosynthesis

- **Light Reaction**
- **Light changed to chemical Energy**
- **Chloroplasts contain inner membranes called thylakoid membranes**
  - **Thylakoid membrane is where the light reaction takes place ***

Where does the light reaction take place?



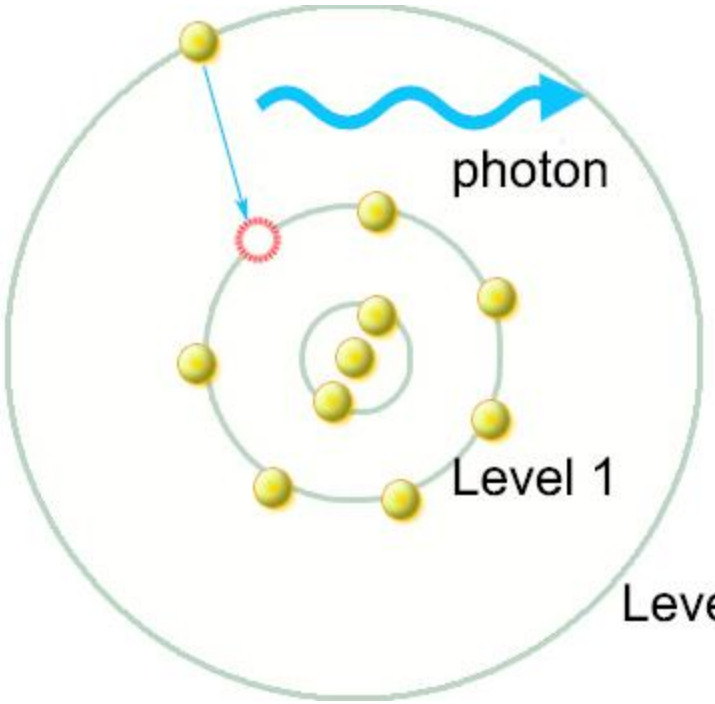
There are two parts to the Light Reactions

- Trapping of Light*
- Splitting of water*

What are the two parts of the light reaction?

First is the trapping of light*

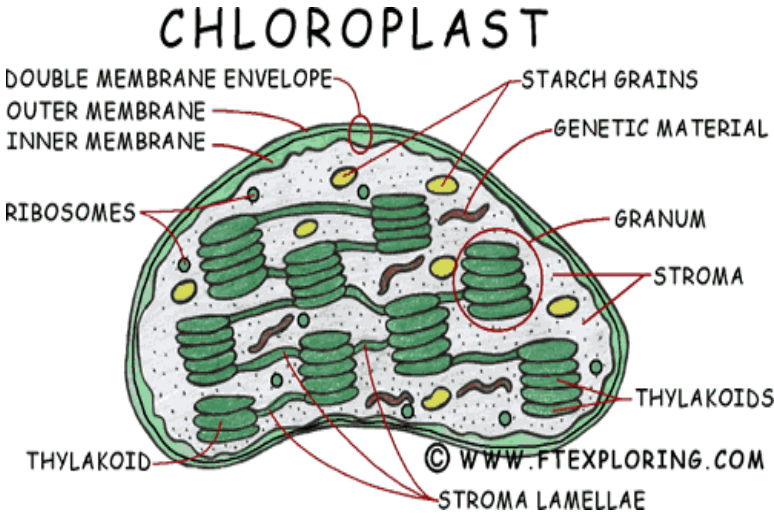
- **The thylakoid membranes in stacks are called grana***
- **Light reactions occur on thylakoid membranes**
- **Light is absorbed by chlorophyll**
- **Electrons in chlorophyll absorb energy causing them to become excited and leave the molecule**
- **The excited electron is used to change ADP + P_i to ATP making energy from light available to do biological work**



Part II of the light reaction

- **is the splitting water***
- **Light energy splits H_2O in to H^+, electrons and O_2**
- **Electrons from splitting the water are used to replace electrons lost in the chlorophyll**
- **O_2 is given off as a bi-product**

2) H^+ Ions attach to coenzyme NADP and form NADPH to be used later in Calvin Cycle



- The light reactions in the thylakoid membran

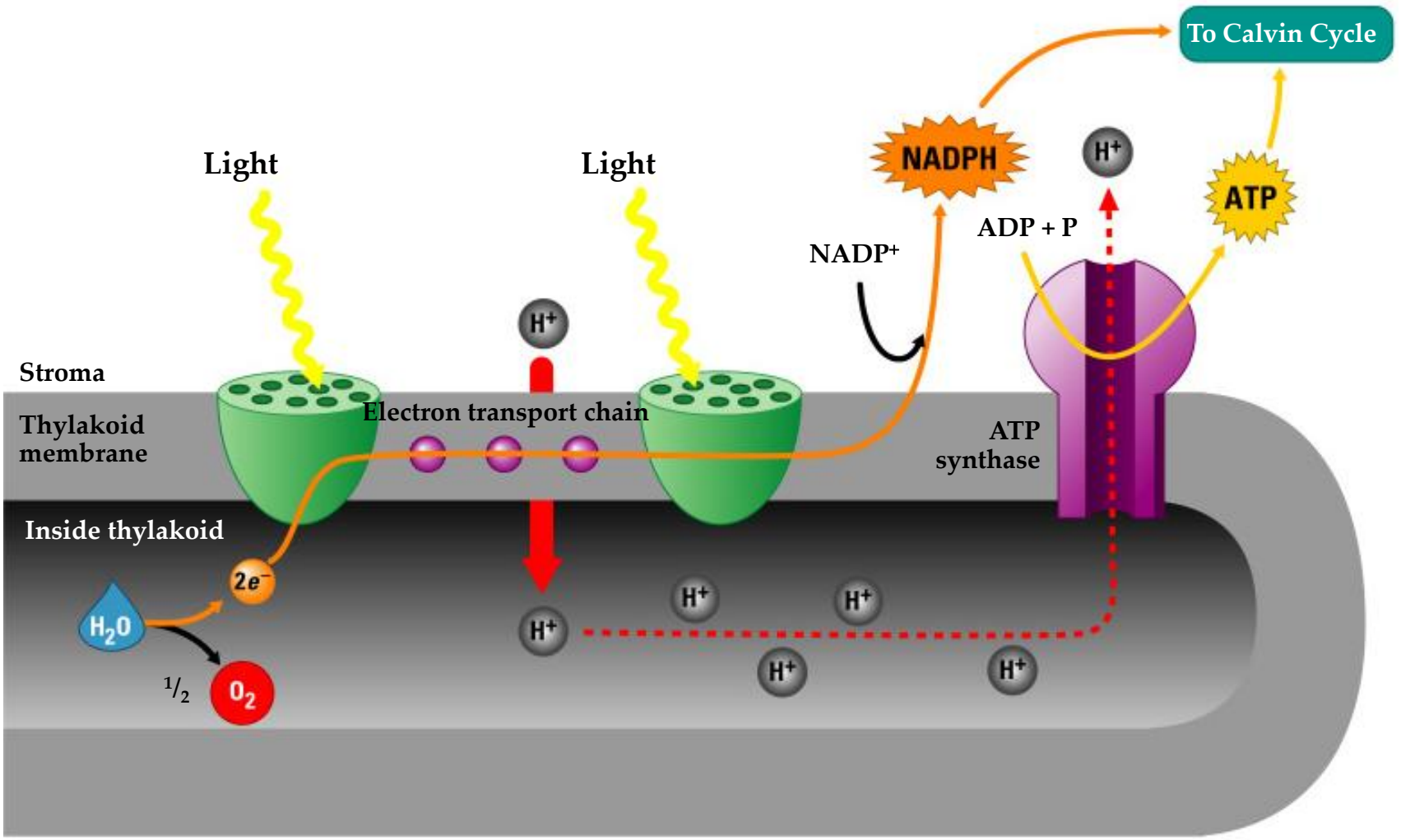
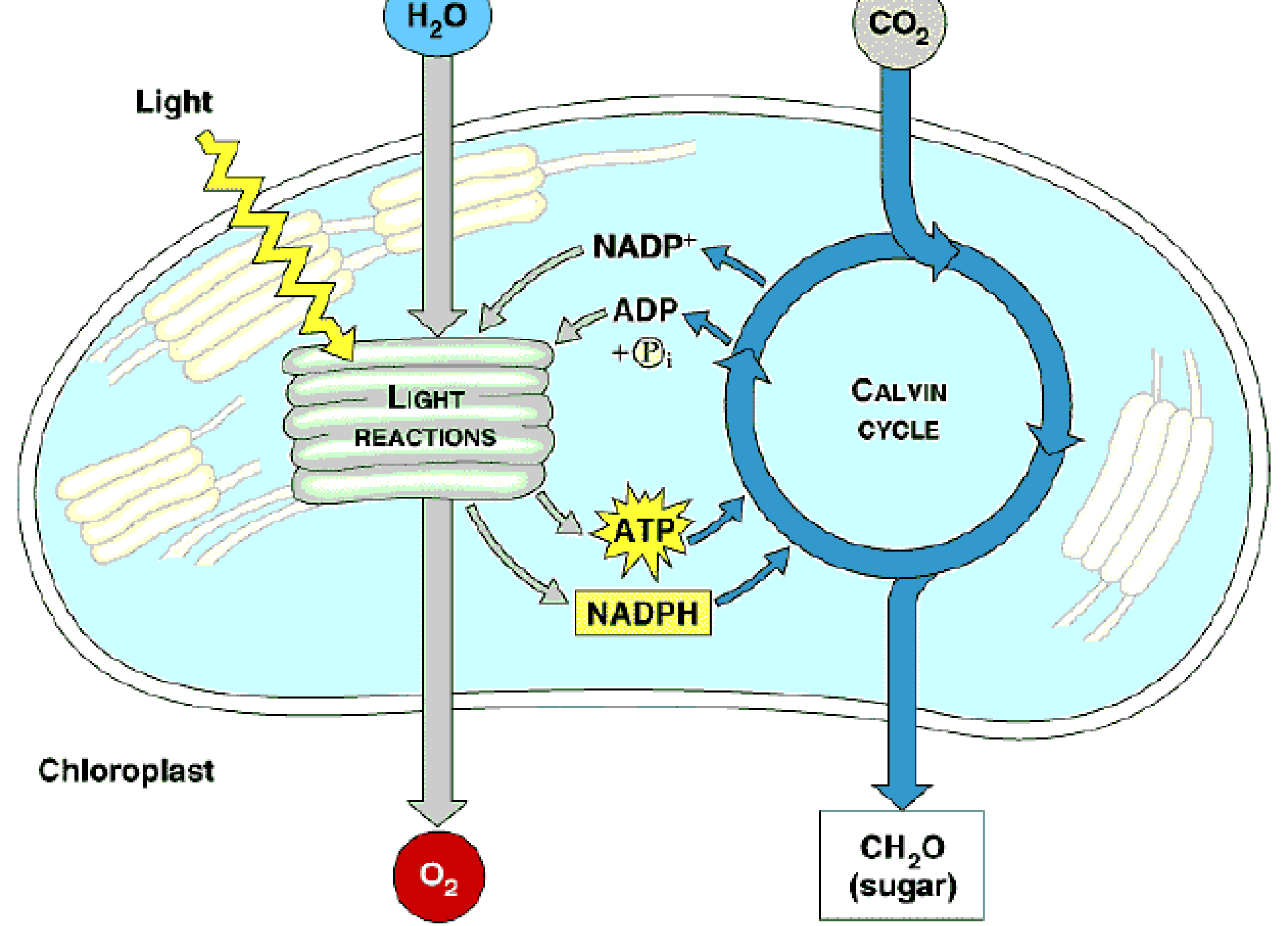


Figure 7.12

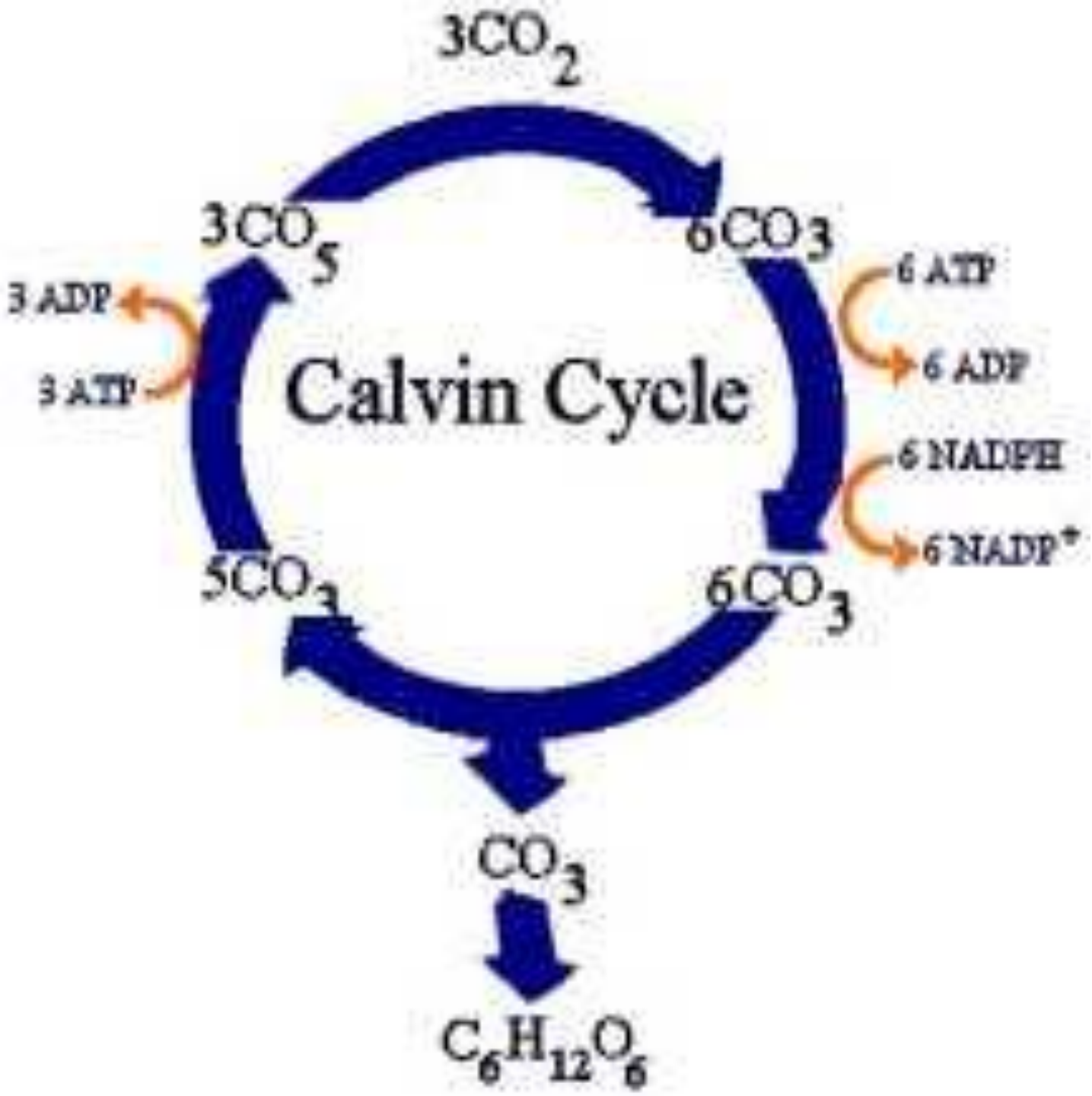


Part II of Photosynthesis
The Calvin Cycle *

- **synthesizing of sugars takes place in the stroma***
- **CO_2, and H_2, in stroma are put together with the help of the ATP and coenzyme NADPH to form simple sugars usually 3 carbon sugars that combine to form different Starches**
- **It is important to think of photosynthesis and respiration together, not as separate cycles. They are interdependent processes p. 160**

Is the Calvin Cycle endorgonic or exorgonic?

Where does the Calvin cycle take place?


3CO2
3CO5
6CO3
3 ADP
3 ATP
Calvin Cycle
6 ATP
6 ADP
6 NADPH
6 NADP+
5CO3
6CO3
CO3
C6H12O6

Photosynthesis has huge impact on Earth's atmosphere

- A source of O_2, a sink for CO_2
- Old-growth forests
  - Are important for lumber
  - Are important for moderating world climates

Energy flow and Chemical Cycling in the Biosphere

Glycolysis+Respiration

in many respects they are the *reverse* of Photosynthesis

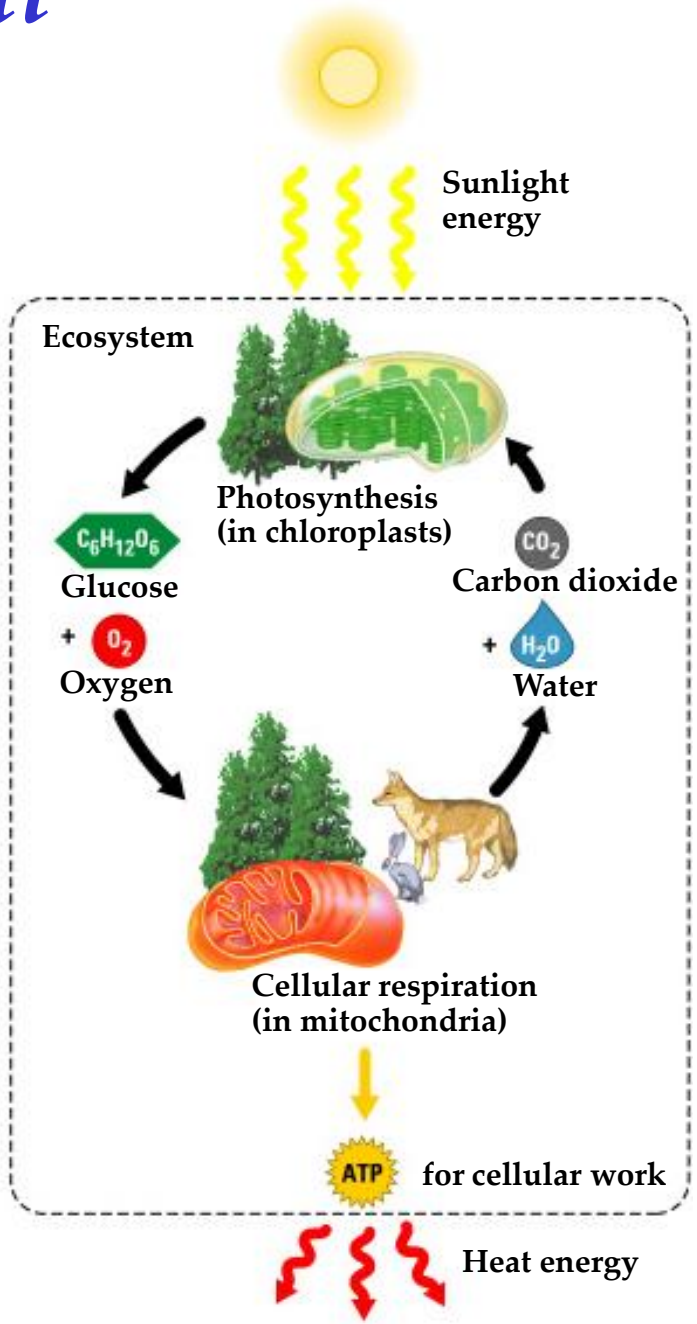
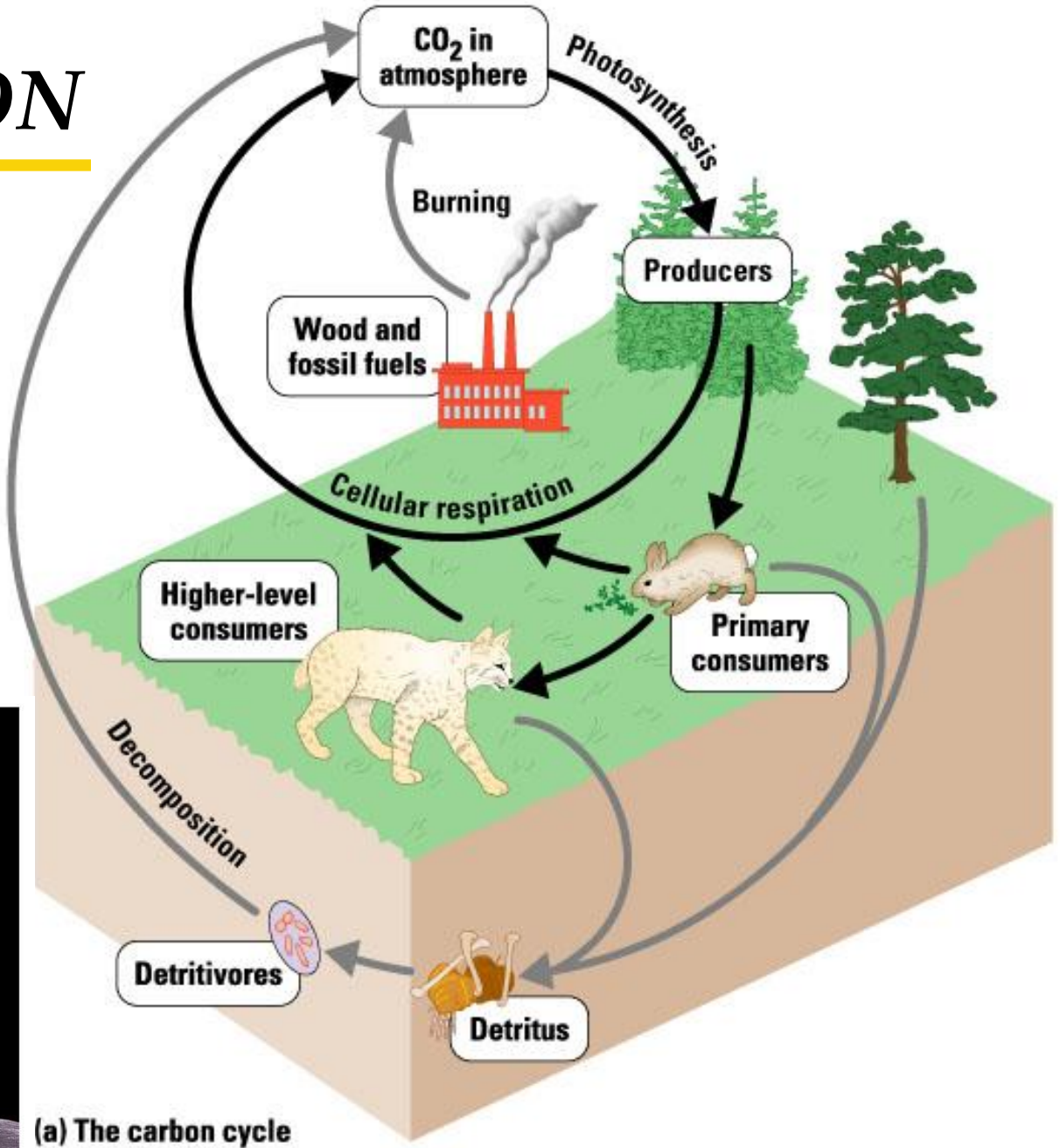


Figure 6.3

Biogeochemical cycle of CARBON

What are the CO_2 <u>SOURCES</u>?
What are the CO_2 <u>SINKS</u>?



(a) The carbon cycle

Quiz

1. What is the chemical that cells use for energy?
2. What happens to the ATP after the energy is released?
3. How is ADP + P_i changed back to ATP?
4. What are the two types of Respiration?
5. What are the two types of fermentation?
6. What are the two parts of photosynthesis?
7. Where does each part of photosynthesis take place?
8. What are the two parts of the light reaction?
9. What happens during the second part of photosynthesis?
10. Is the Calvin Cycle endorgonic or exorgonic?