BIO103

ENERGY OF LIFE

Lecture: 8, 9

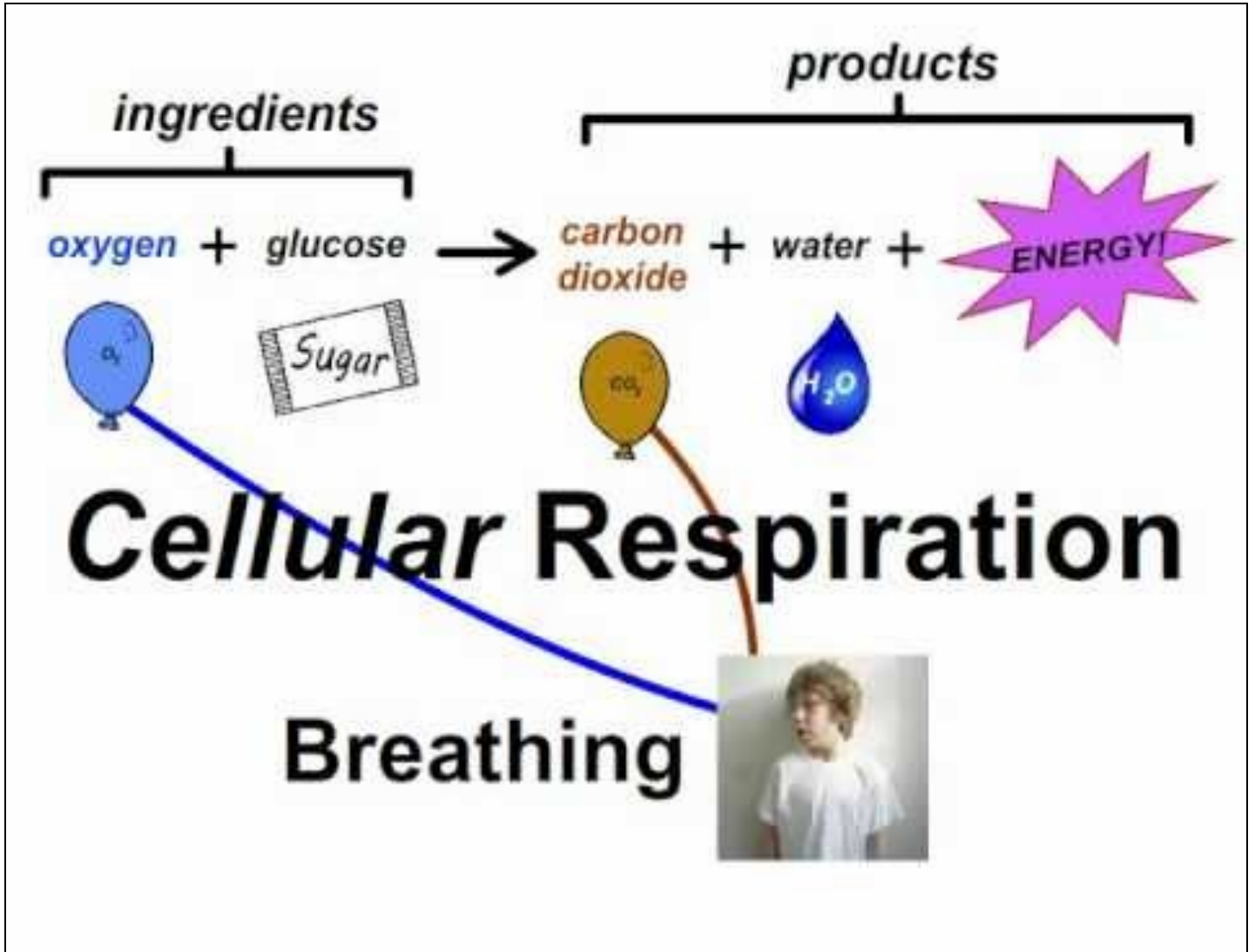
Lecture Outline

- What is cellular respiration?
- The summation equation for cellular respiration.
- Energy transfer by ATP.
- The role of ATP in cellular respiration.
- Anaerobic respiration.
- Enzymes
- Photosynthesis
- Take home message!

What is Cellular Respiration?

- *The process by which living cells break down **glucose** molecules and release stored chemical potential **energy***
- Occurs in **Mitochondria.**
- "Burning" of Glucose also called Oxidation
- **Don't confuse respiration with breathing**

Breathing vs. Cellular Respiration



Oxidation/Burning

Equation for cellular respiration

Enzymes

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_20 + 6CO_2 + \text{energy}$$

(glucose + oxygen → water + carbon dioxide + energy)

Enzymes modulate the reaction.

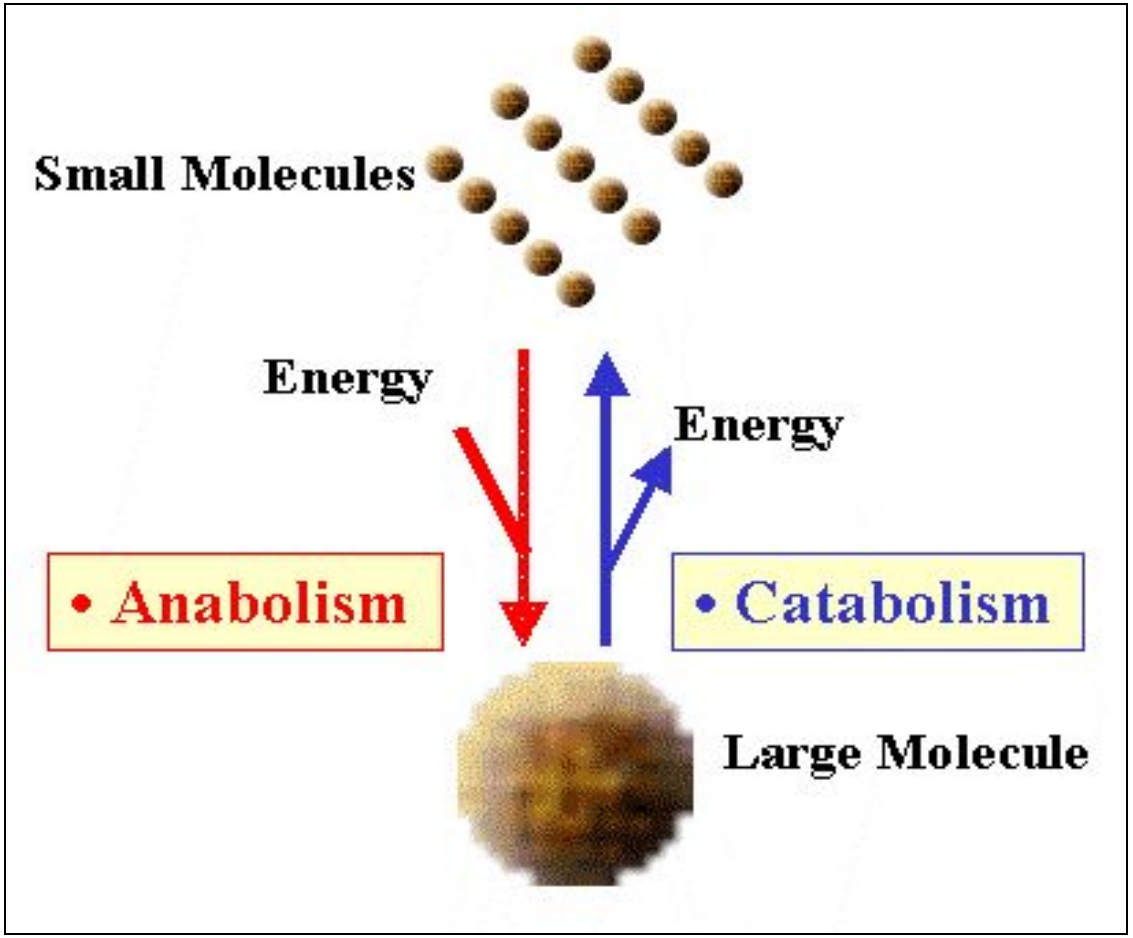
- This is the *'Sum-up'* of main process, tells us about the starting material and end-product of the process
- But how this process occur

Anabolic or Catabolic?

Catabolism VS. Anabolism

		Catabolism	Anabolism
Descriptors of the Overall Process	Purpose	Energy generation	Formation of useful compounds
	Nature of the Process	Oxidative, degradative	Reductive, synthetic
	Energetics	Yields energy	Uses energy
Descriptors of the Chemical Participants	Types of Starting Materials	Highly variable, often complex	Relatively few, simple structures
	Types of Final Products	Relatively few, simple structures	Highly variable, often complex
	Typical Coenzyme/ Cosubstrate Transformations	ADP ----> ATP NAD+ ----> NADH	ATP---> ADP or AMP NADPH ---> $NADP^+$

Let's learn it again…

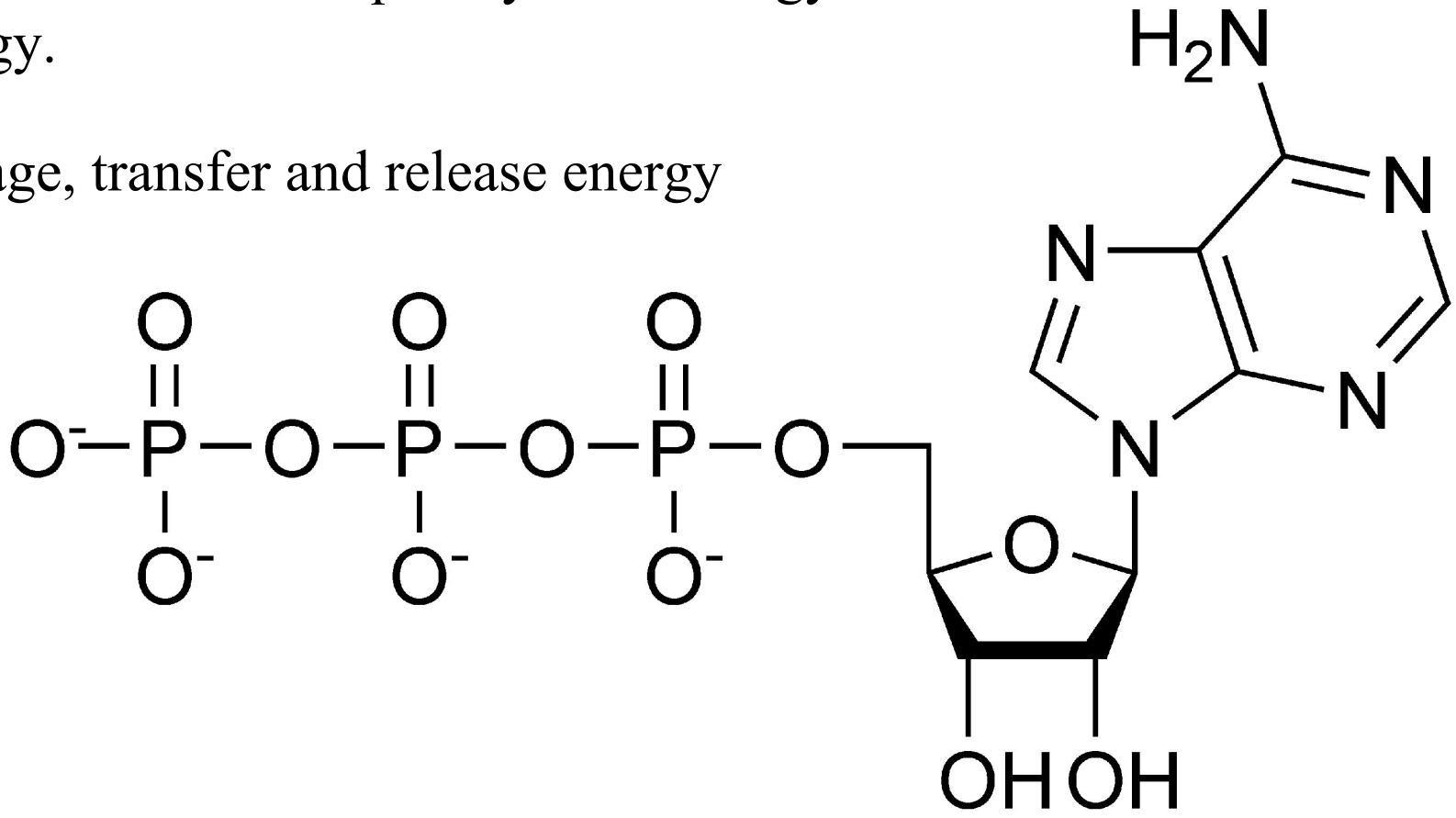


ATP-The major energy currency

For boosting up –need energy.

- This substance can quickly store energy and release energy.

- Storage, transfer and release energy



Energy transfer by ATP.

- ATP has a complex structural formula.
  A —□~□~□.
- The **A** stands for adenosine and each □ stands for one phosphate group.
- The wavy lines (~) represent high-energy phosphate bonds.
- Breaking of each bond releases 7 kilo-calories of energy.

Energy transfer by ATP.

Summarized equation:

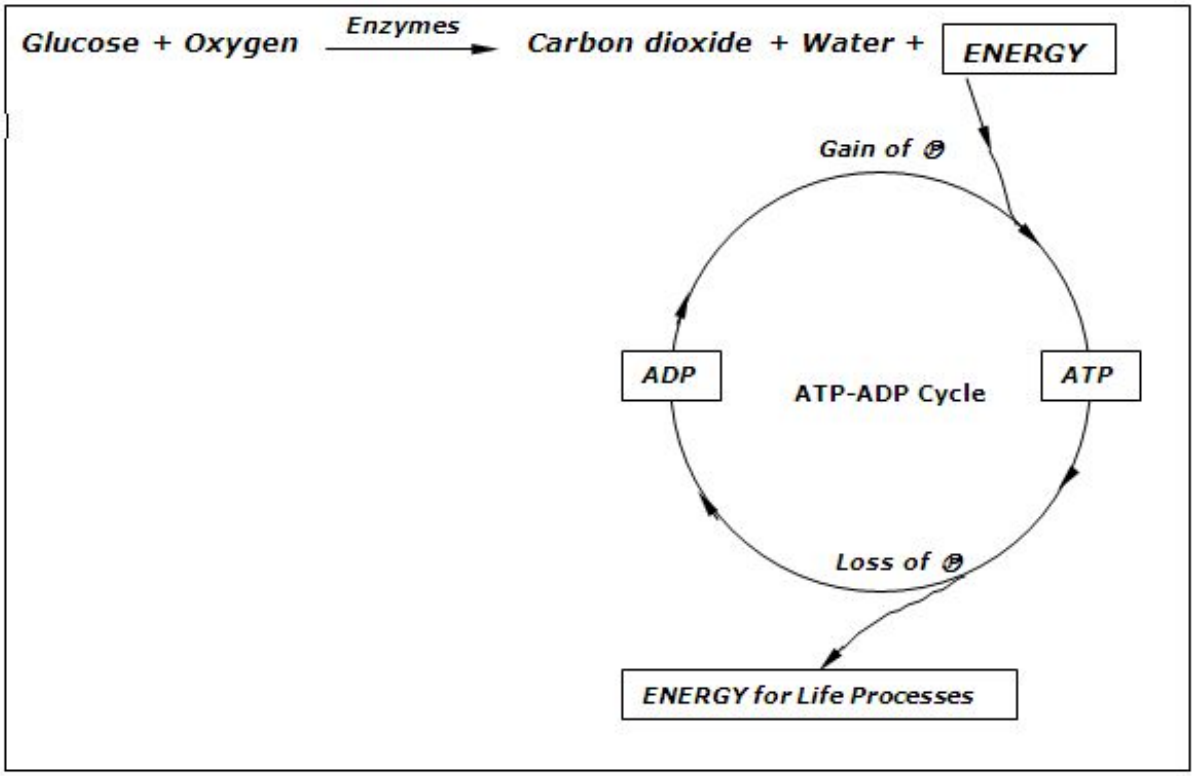
A—□~□~□ □ A—□~□ + □ + Energy

ATP □ ADP + □ + Energy

- Most of the energy-consuming reactions in cells are powered by the conversion of ATP to ADP
- Energy requires for the nerve signals, the movement of muscles, the synthesis of protein, and cell division
- ADP quickly regains the third phosphate unit by using food energy through the cellular respiration.

The Role of ATP in Cellular Respiration

- **ATP-ADP cycle** connects with the process of cellular respiration.
- Every molecule of Glucose is oxidized to 38 molecules of ATP.



Reaction Summary

Store Energy

$$\text{Glucose} + 6O_2 + 38\ \text{ADP} + 38\ \text{P} \longrightarrow 6CO_2 + 6H_2O + 38\ \text{ATP}$$

Aerobic Vs. Anaerobic respiration

Aerobic respiration:

Reaction that needs free oxygen

Cellular respiration is aerobic respiration

Anaerobic Respiration:

Some organisms can live/ maintain their life process without free oxygen.

This type of respiration/

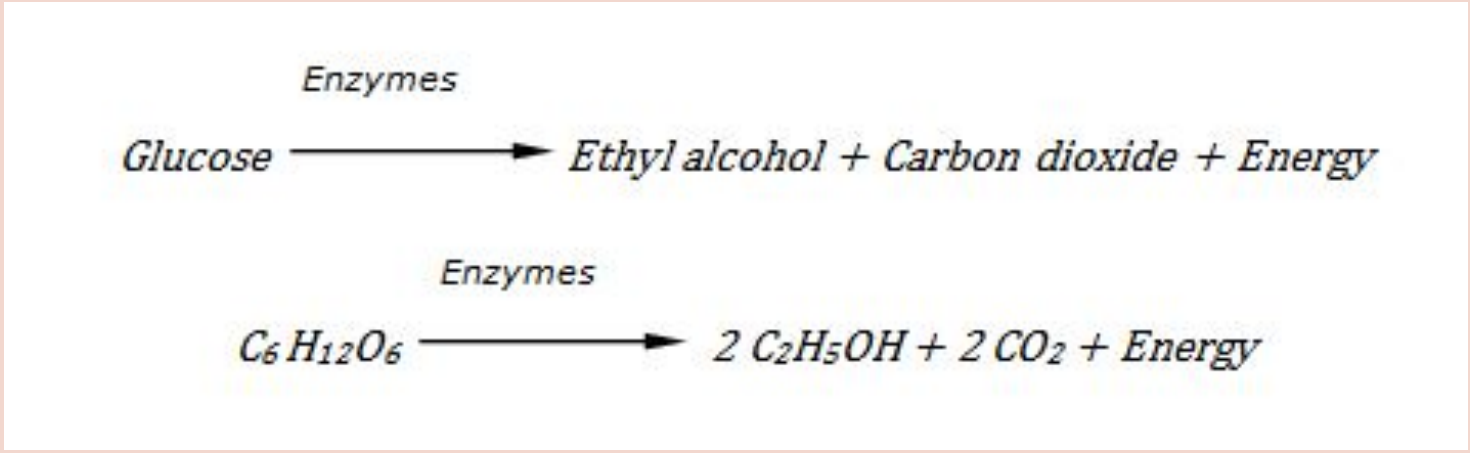
burning is called anaerobic respiration.

Anaerobic respiration- two types:

Alcohol fermentation

- Occurs in bacteria, yeast, that live in oxygen less environments.

Summary equation:

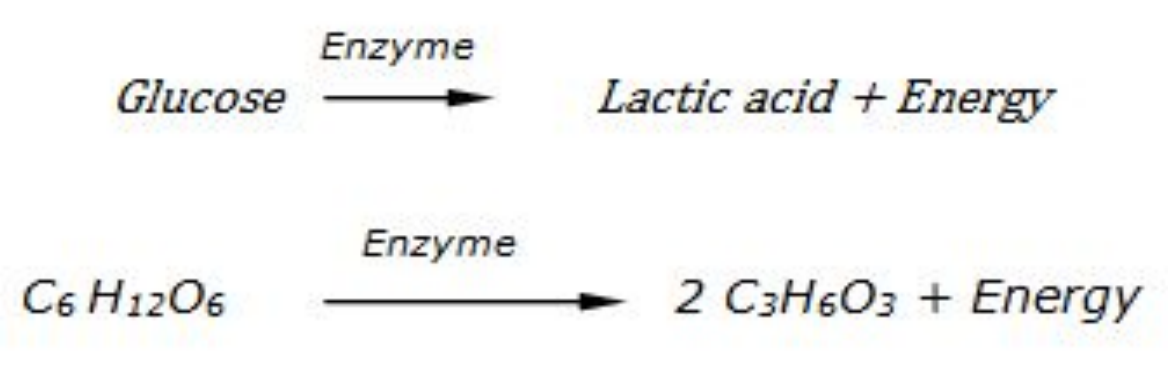


Anaerobic respiration- two types:

Lactic acid fermentation

- During periods of heavy physical activity, muscle cells may not be able to get oxygen fast enough to carry out the usual aerobic cellular respiration.
- When this occurs, muscle cells begin to respire anerobically.

Summary equation:



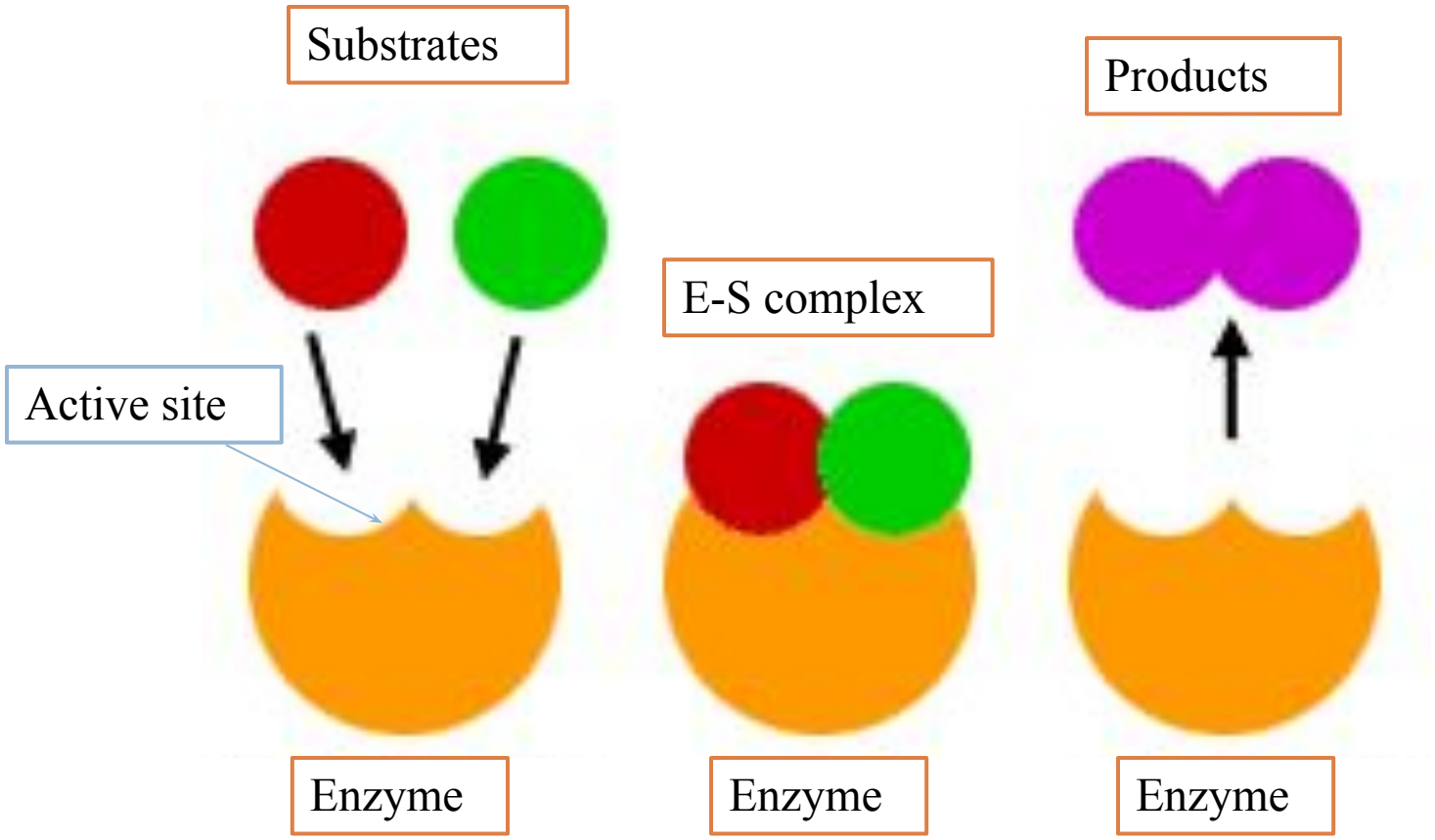
Aerobic vs. Anaerobic Respiration

From 1 Glucose molecule-

- Aerobic respiration gives more energy [as it breaks all bonds]
- Anaerobic respiration gives relatively less energy [not all bonds of glucose are broken]

Enzymes

- **Enzymes** are complex chemicals that control reactions in living cells.
- They are biochemical catalysts speeding up reactions that would otherwise happen too slowly.
- The chemical in which an enzyme works on is called its **substrate**.
- An enzyme combines with its substrate to form a short-lived **enzyme/substrate complex**.
- Once a reaction has occurred, the complex breaks up into **products and enzyme.**


Substrates
Products
E-S complex
Active site
Enzyme
Enzyme
Enzyme

The Chemical nature of enzymes

- Enzymes are **specific:** each enzyme usually **catalyses only one type of reaction**.
- Enzymes combine with their substrates to form temporary **enzyme-substrate** complex.
- Enzymes are **not altered or used up** by the reactions they catalyze, so can be used again and again.
- Enzymes are **sensitive** to **temperature and pH**.
- Many enzymes need **cofactors** in order to function.
- Enzyme function may be slowed down or stopped by **inhibitors**.

Enzyme Classification

There are 6 types of reaction they can catalyze-

- **Oxidoreductase**: These catalyze oxidation and reduction reactions.
- **Transferase:** These catalyze the transfer of a chemical group from one compound to another.
- **Hydrolase:** These catalyze hydrolysis (splitting by use of water) reactions.

Most digestive enzymes are hydrolases.

- **Lyase:** these catalyze the break down of molecules by reactions that do not involved hydrolysis.
- **Isomerase:** These catalyze the transformation of one isomer into another
- **Ligase:** These catalyze the formation of bonds between compounds,

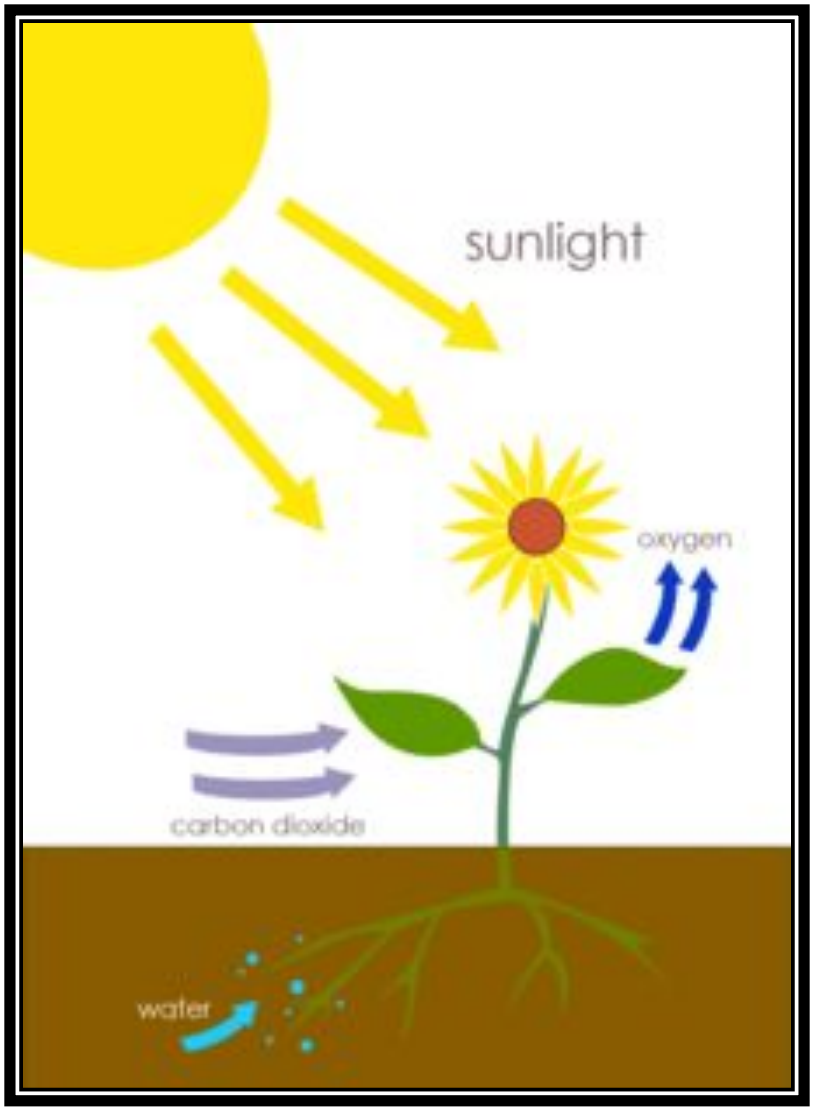
often using the free energy made available from ATP hydrolysis.

Photosynthesis

The Need for Energy

- All living things need continuous supply of energy.
- Almost all energy used by living organisms comes from sun.
- Energy from the ‘SUN’ is captured and stored by green organisms in the bonds of ‘GLUCOSE’: a process known as **Photosynthesis**

Photosynthesis



❑AUTOTROPHS:

Organisms that can produce their own food from the substances available in their surroundings using light (photosynthesis) or chemical energy (chemosynthesis).

❑HETEROTROPHS:

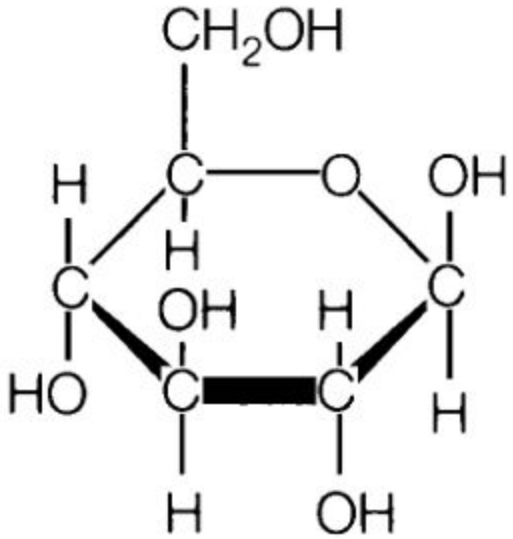
Heterotrophs cannot synthesize their own food and rely on other organisms -- both plants and animals -- for nutrition.

Glucose

- Unit of Energy
- Single unit of Carbohydrate family.
- $C_6(H_2O)_{6:}$: contains Carbon.
  - Hydrogen & Oxygen as Water
- Main Fuel for all Living things- bacteria, virus, animals, plants.
- Glucose -- bond breaks-- energy release as ATP(adenosine tri phosphate)

Molecular formula:

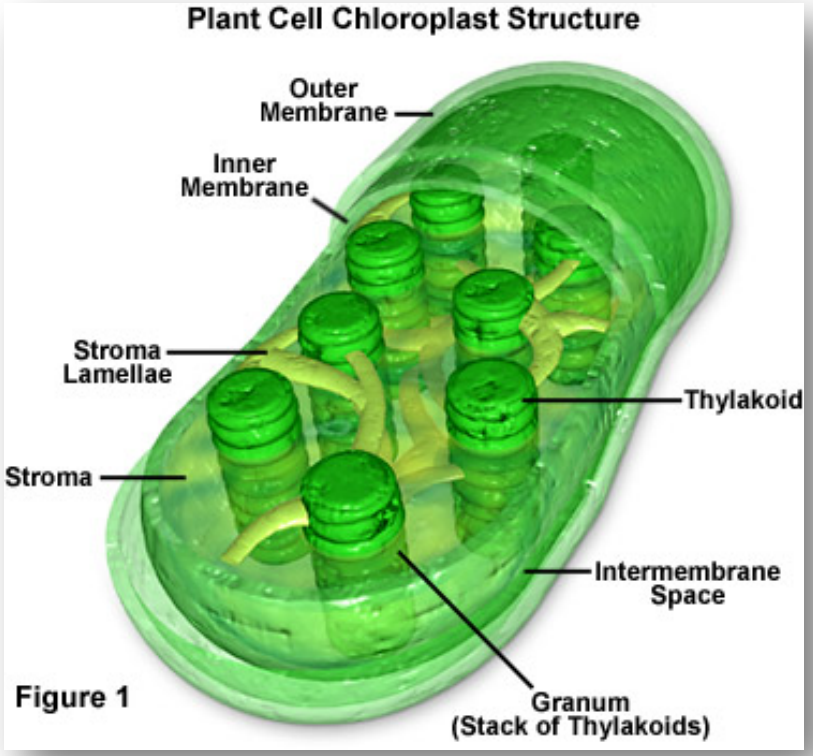
$C_6H_{12}O_6$



Photosynthesis

- ***Photosynthesis*** *is the process by which light energy is changed to chemical potential energy and stored in the bonds of glucose molecules.*

Occurs in organism which contains
“ Chlorophyll”



Reaction in Photosynthesis

$$6CO_2 + 12\,H_2O \xrightarrow[\text{plant enzymes}]{\text{LIGHT}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

six molecules of carbon dioxide

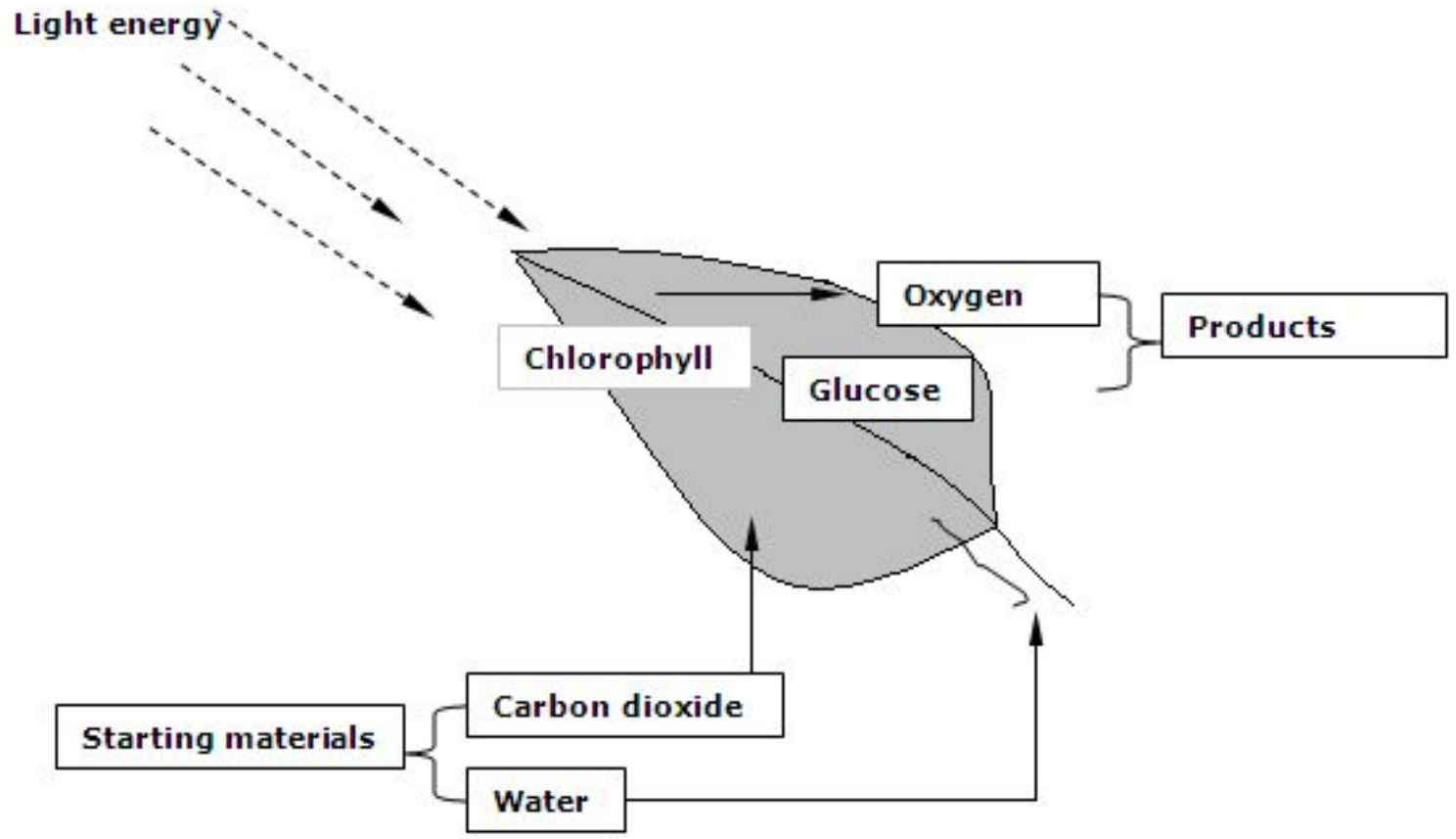
twelve molecules of water

one molecule of glucose (plant biomass)

six molecules of oxygen

six molecules of water

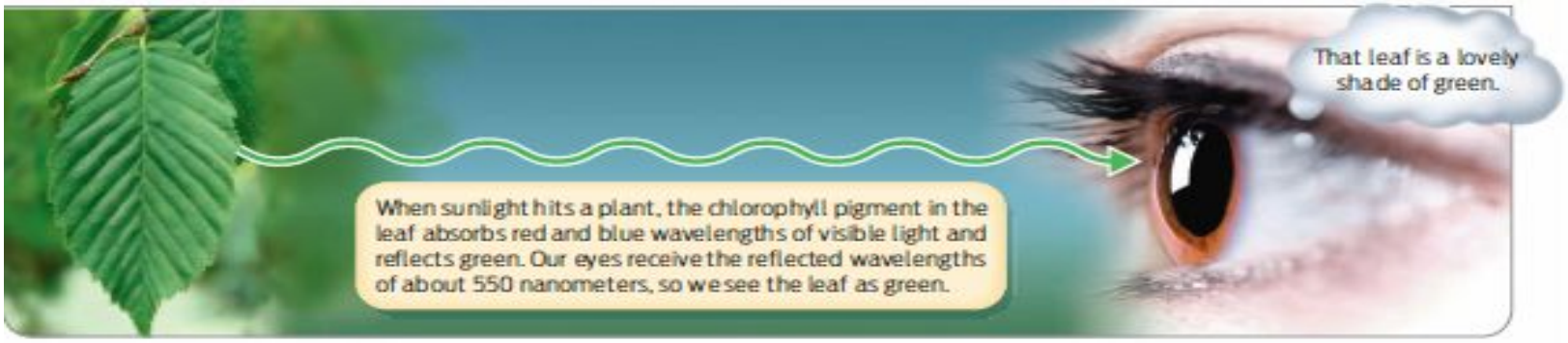
Reaction in Photosynthesis



The diagram sums up what happens during photosynthesis. Water and carbon dioxide enter the leaf. Glucose and oxygen are produced.

Photosynthesis and Chlorophyll

- Green leaf chlorophyll contains pigments.
- This pigments must absorb BLUE and RED colour but <u>not</u> the GREEN.



- There are at least 5 chlorophyll molecules.(almost similar in their structure)
- Two major chlorophylls are_
    1. **Chlorophyll a**
    2. **Chlorophyll b**

The Role of Chlorophyll

- Chlorophyll is found in Chloroplast
- **Works as a <u>CATALYST</u> in photosynthesis Reaction speed up the process.**

- Other pigments _
  - **Carotenes orange**
  - **Xanthophylls yellow**
- They assist photosynthesis reaction by absorbing different colors and help Chlorophyll

Take home message!

Differences between Photosynthesis and Respiration

Photosynthesis	Respiration
Photosynthesis is the process by which plants prepare their own food using CO_2 and water in the presence of sunlight and chlorophyll.	Respiration is a process by which the food is burnt in the presence of oxygen to release energy.
$CO_2 + H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Carbohydrates} + O_2$	$\text{Glucose} \xrightarrow{\text{Oxygen}} CO_2 + H_2O + \text{Energy}$
During photosynthesis, CO_2 is absorbed and O_2 is released.	During respiration, O_2 is absorbed and CO_2 is released.
Photosynthesis is an anabolic process.	Respiration is a catabolic process.
Photosynthesis occurs only in plants and some photosynthetic bacteria.	Respiration occurs in all living organisms.

Thank You!!!

Any Questions?