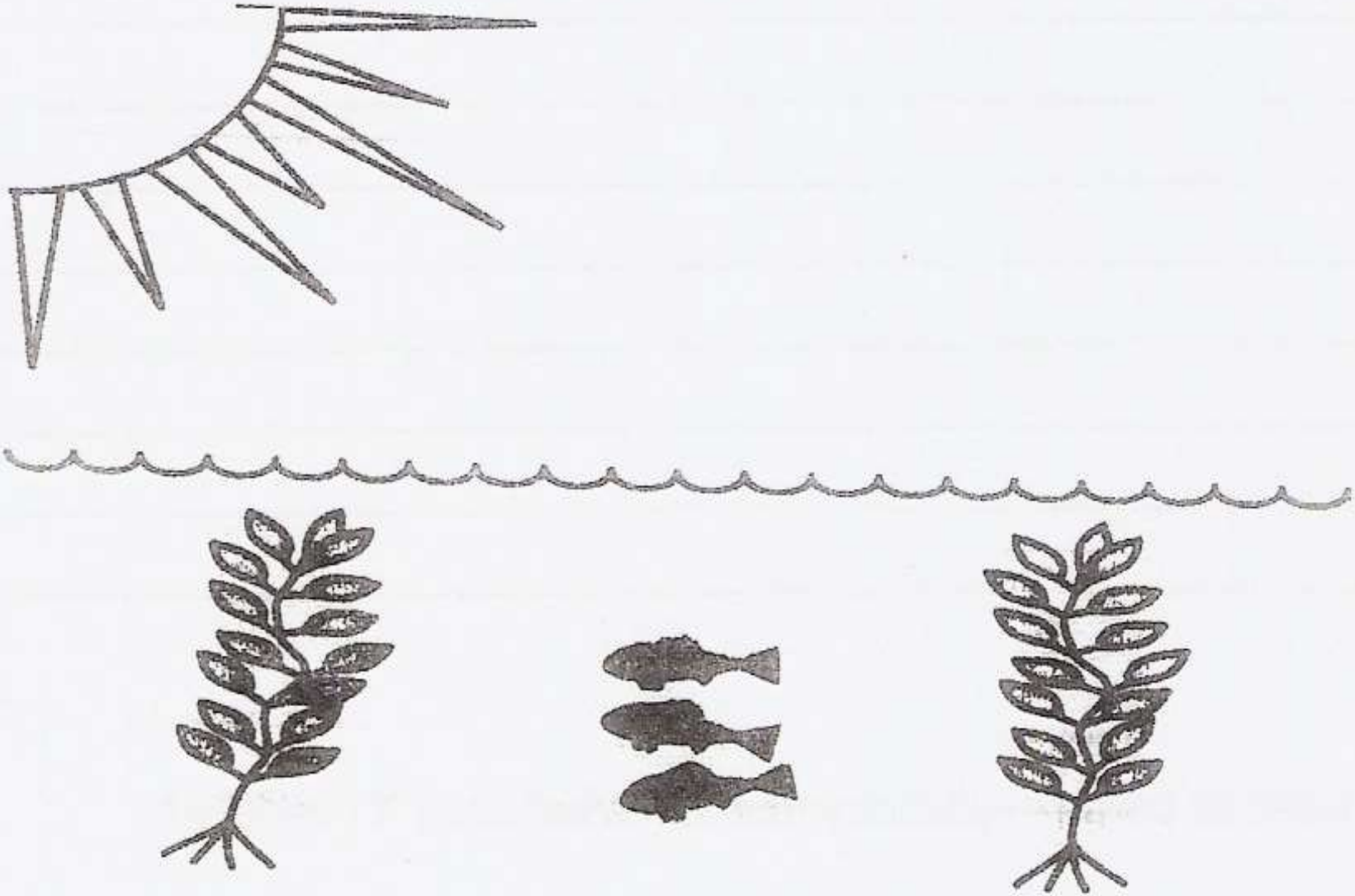
Photosynthesis and Cellular Respiration

Photosynthesis and Cellular Respiration Diagram



How does your body get energy?

EATING!

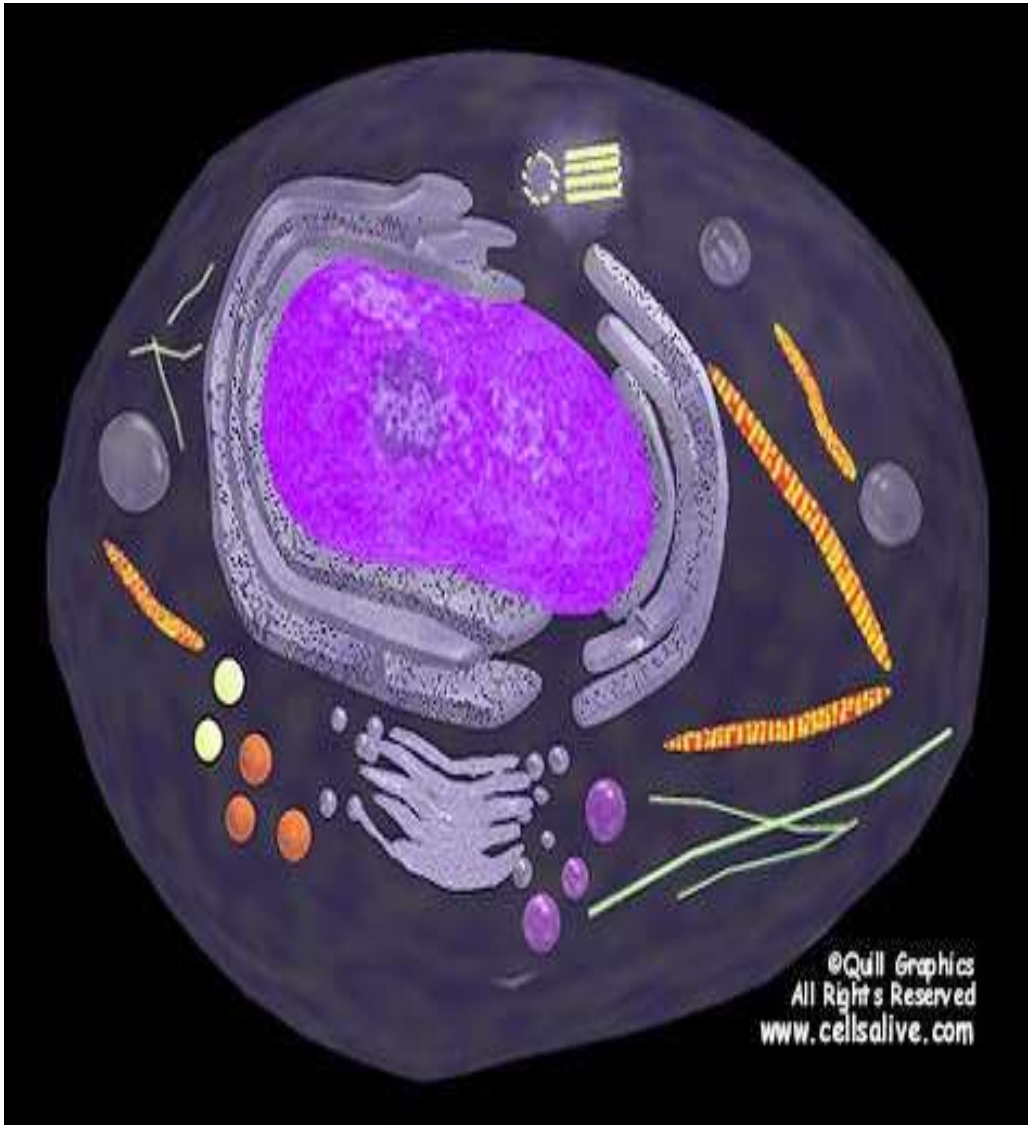
When we eat, our food is broken down in our bodies to get energy out of it.

What is **energy**?

the ability to do work

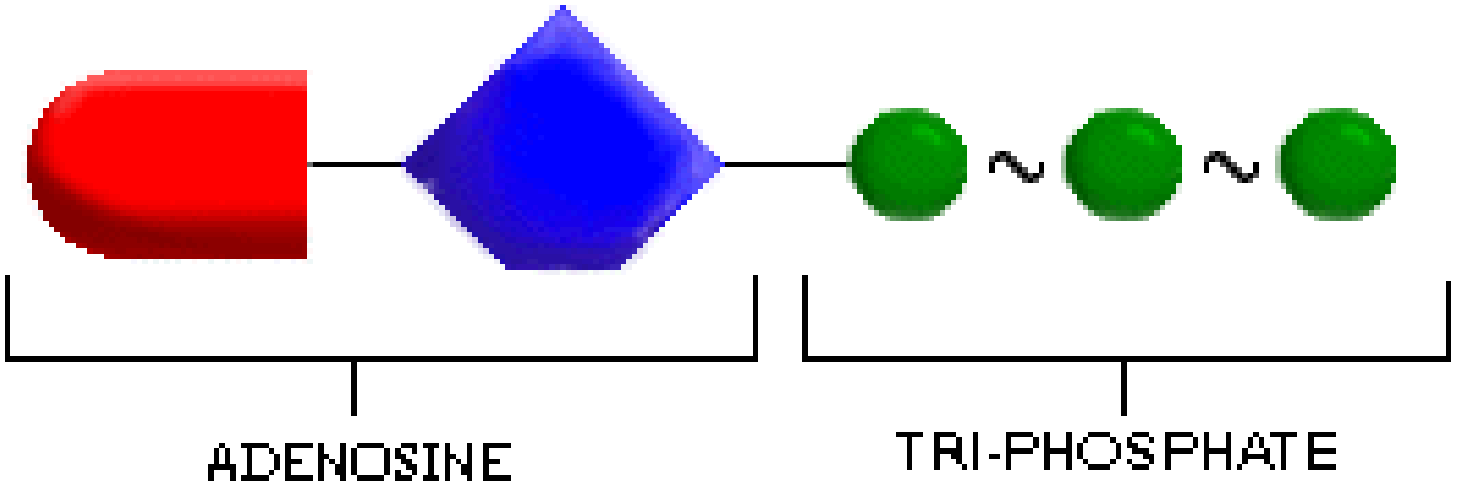
What does energy look like in your cells?

In cells, energy is stored in the form of **ATP**!



ATP = Adenosine Triphosphate

One big molecule that is made of 5 smaller molecules bonded together.



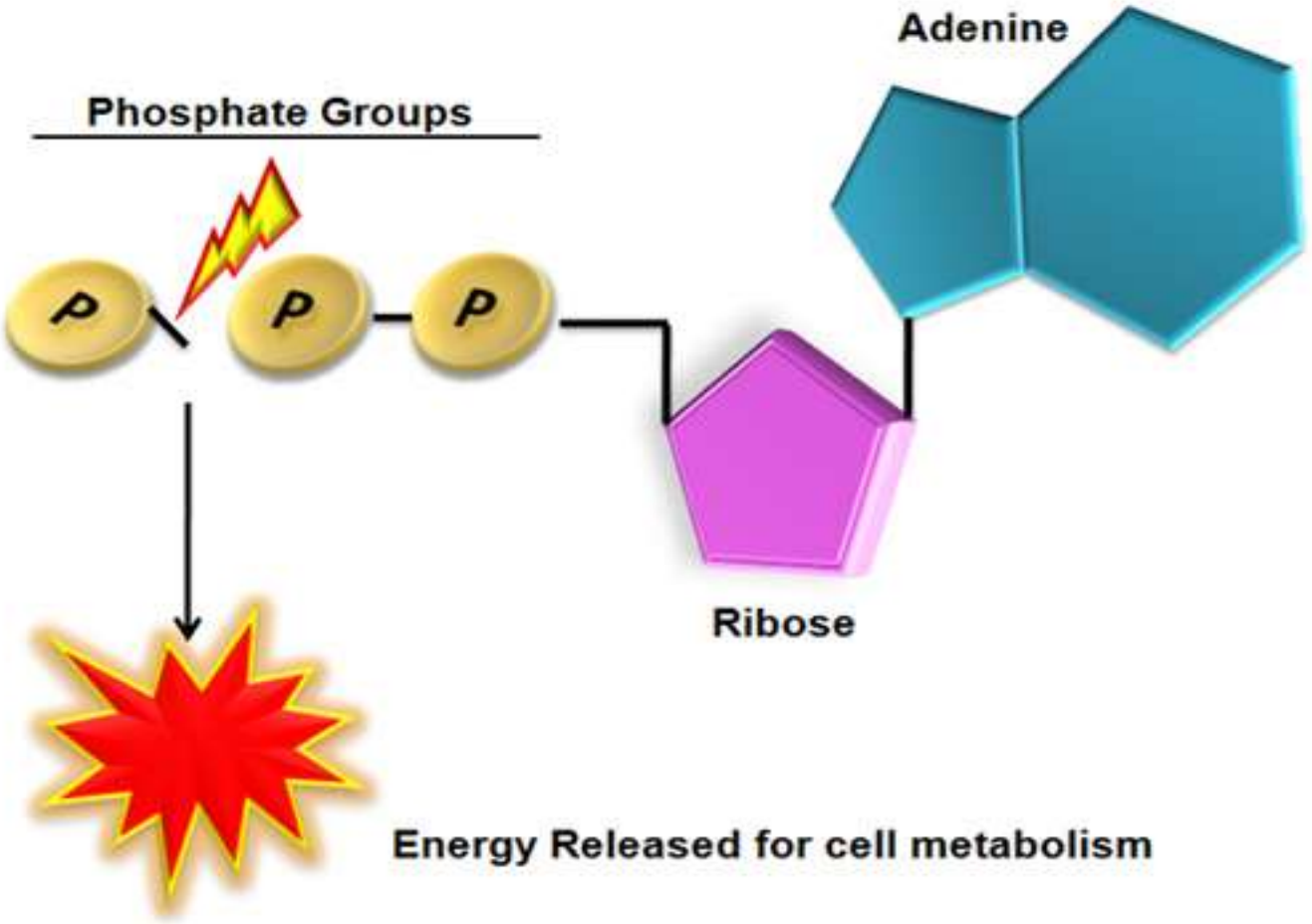
Adenine, ribose, and 3 phosphate groups

How does ATP give cells energy?

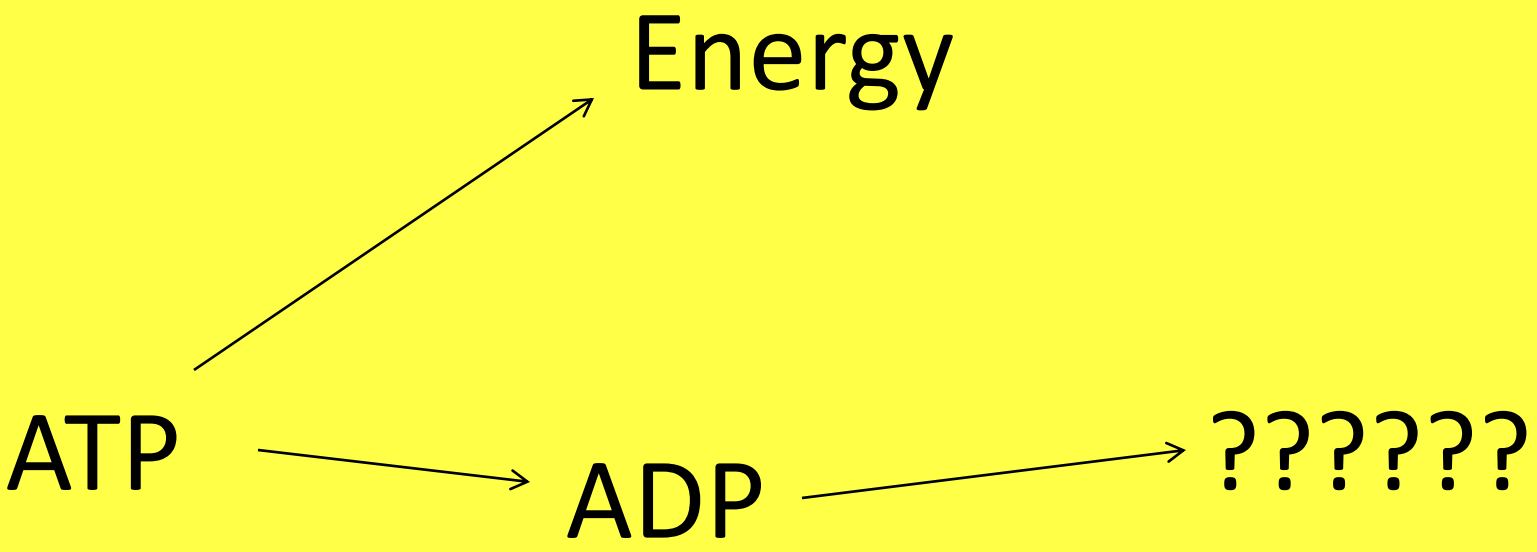
ATP <u>breaks apart</u> and <u>releases its energy</u>.

When ATP breaks apart, it releases energy and loses a phosphate group.

That means that it is now ADP

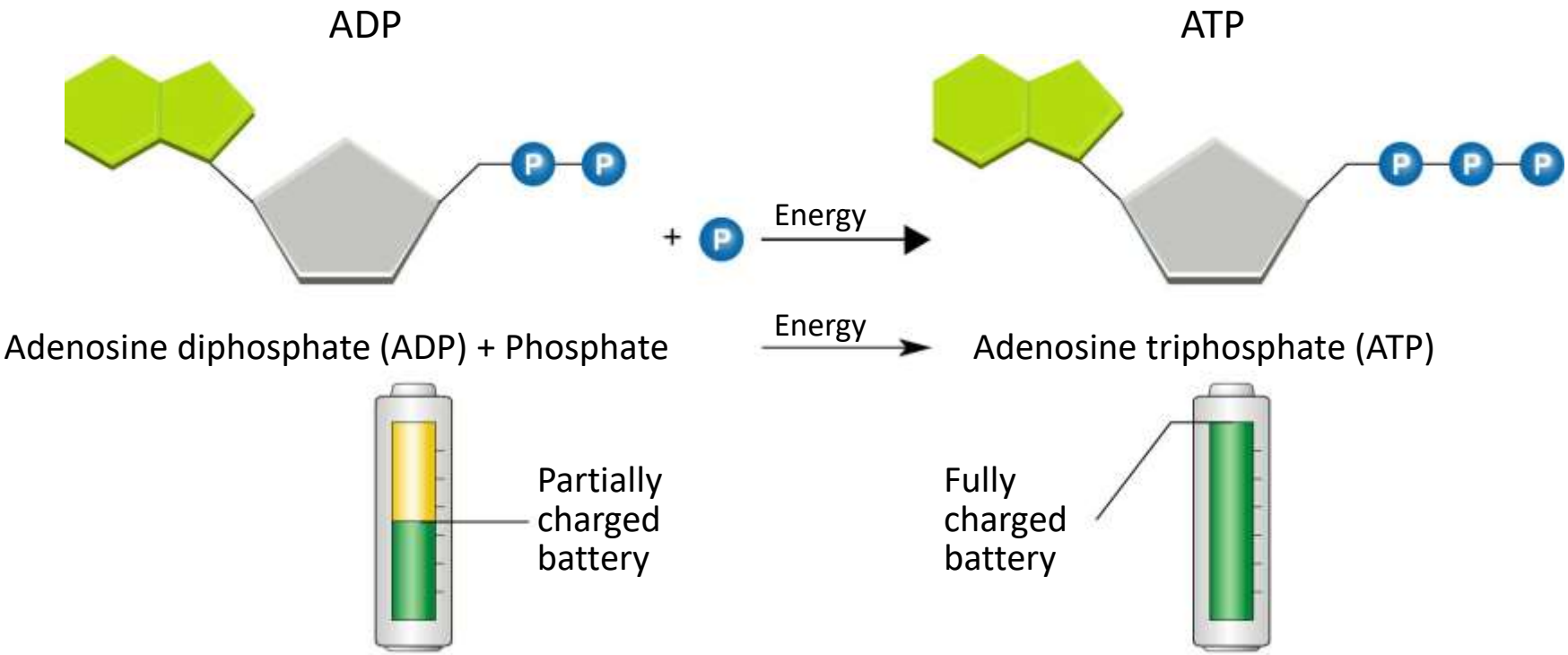


So, after ATP breaks apart and releases its energy, then what happens?



It is recharged

ADP uses energy and gains an extra P and is recharged back to ATP



What happens to a phosphate bond when energy is…

Released?

Phosphate bond is **broken**

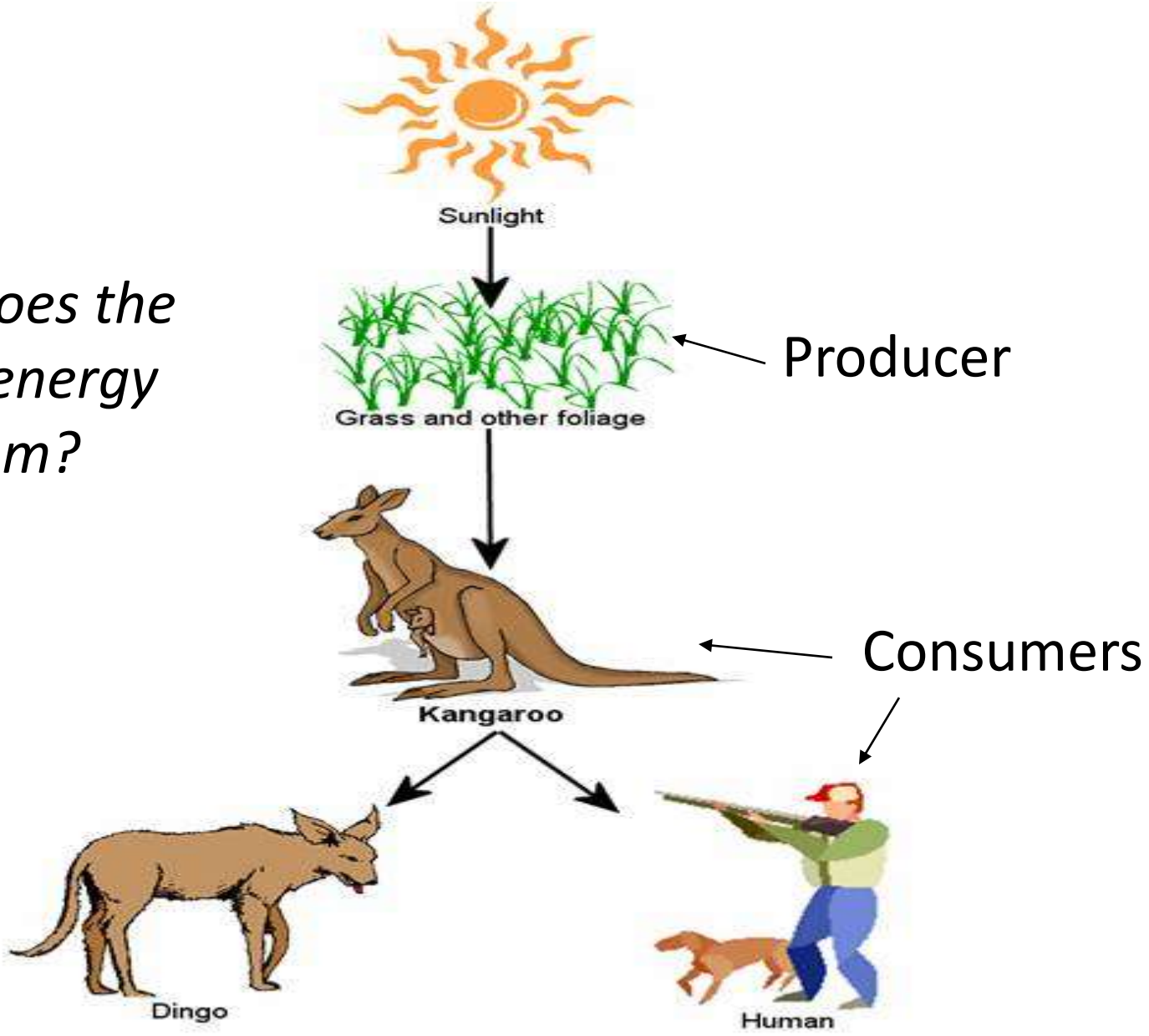
Stored?

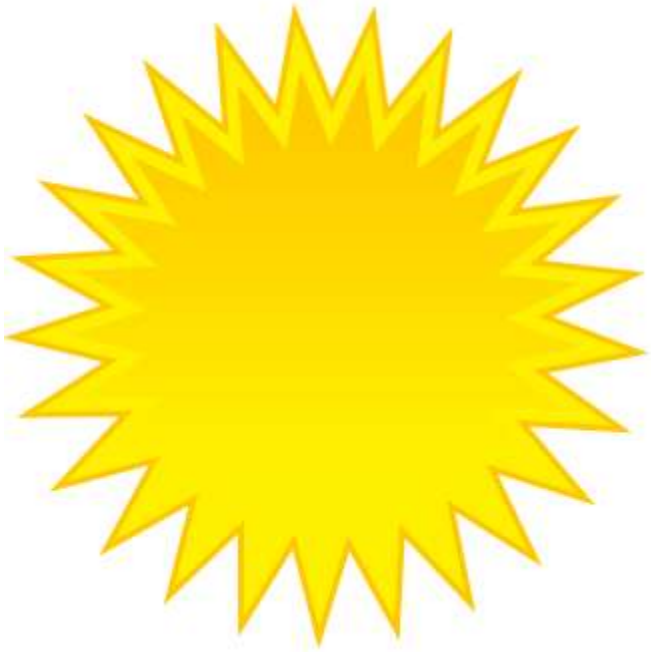
Phosphate bond is **formed**

We eat to get energy. How do the things that we eat get energy?

Remember this?....

Where does the original energy come from?





The **SUN**!!!

The sun is the <u>number one source of energy</u>.

Plants and algae use energy from sunlight to grow and make their own energy.

How do they do this?

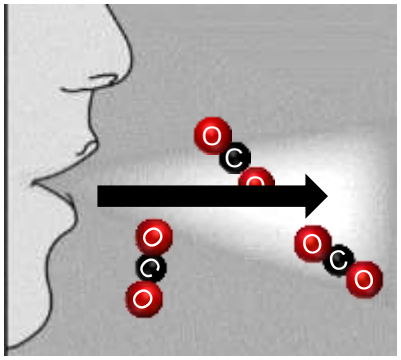
By a process called **photosynthesis**.

Photo-synthesis: "putting together with light"

So when a plant combines the energy from sunlight with water and carbon dioxide from the air, it gets energy!

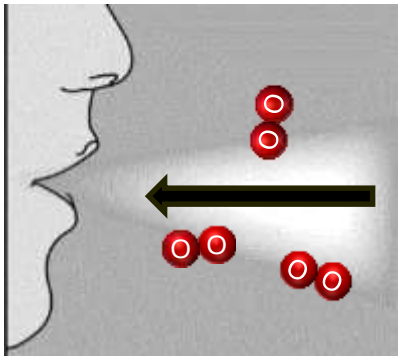
Photosynthesis has a specific reaction that happens every time.

+



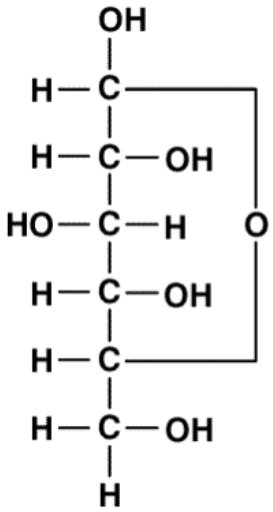
Breathe out

→



Breathe in

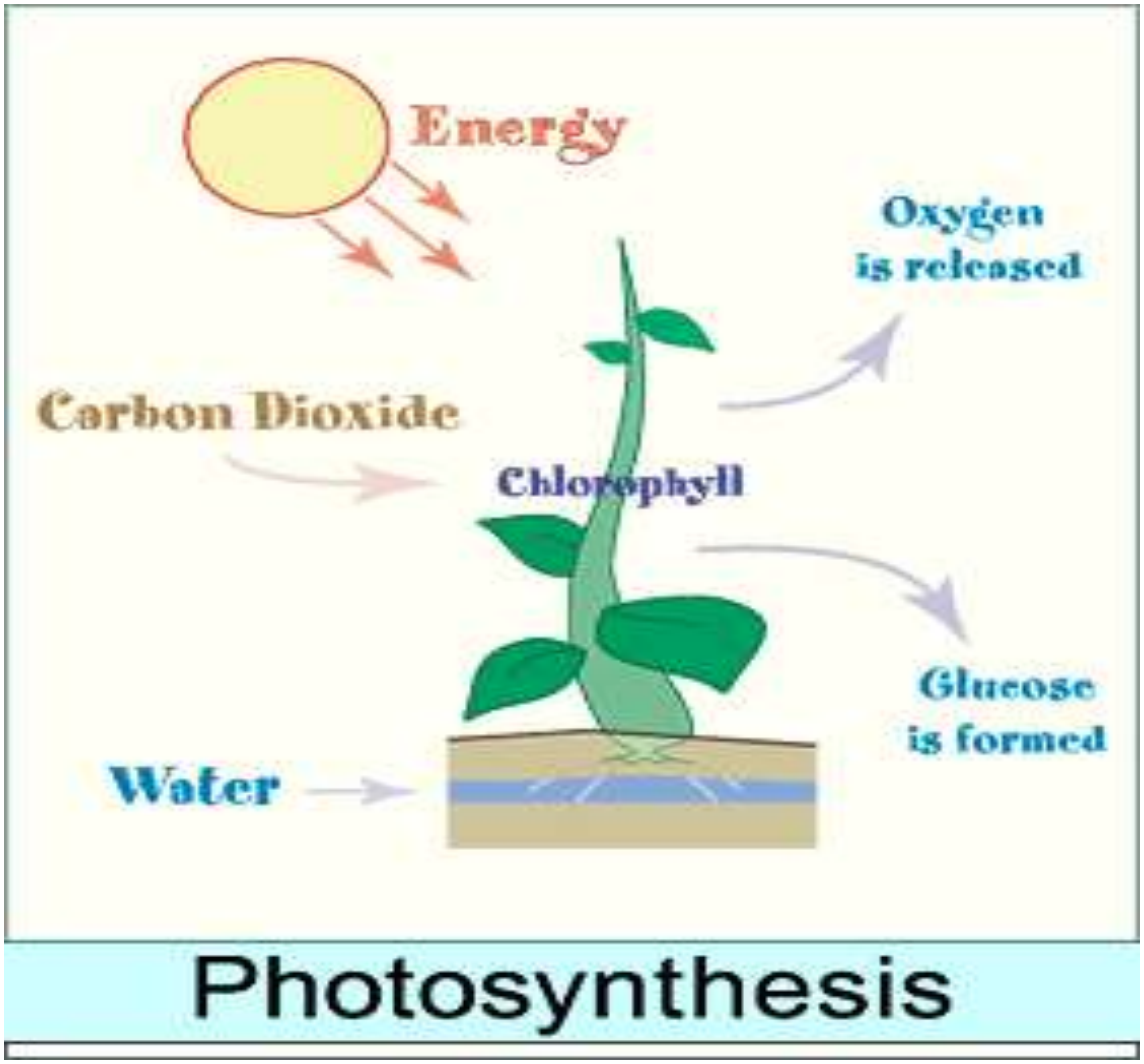
+



Liquid + Gas → Gas + Solid (sugar)

The reaction needs energy from the sun to take place!

The chemical reation of photosynthesis is…



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

Water enters through the..

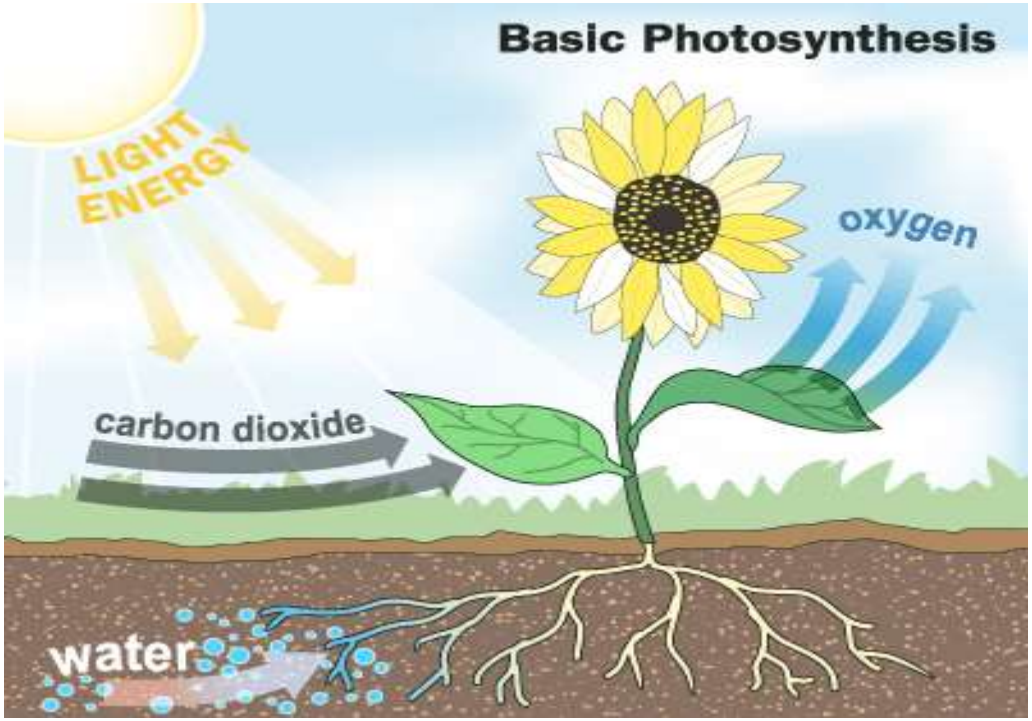
a. enters the plant first thru the roots (root hairs) then to the xylem then on to all parts

b. Water gets oxidized to oxygen (hydrogen and oxygen split)

c. transpiration -evaporation of water at the leaves….

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

Plants take in carbon dioxide through the stomata, break it down to –CHO, and release oxygen. The stomata can release water vapor. Stomata are on the underside of leaves!



Glucose: $C_6H_{12}O_6$

Used in Cellular Respiration to make ATP (Adenosine Triphosphate) → ENERGY!

Carbon is bonded to Oxygen (O_2) to make CO_2

REMEMBER: excess sugar is stored as STARCH in clusters within the plant:

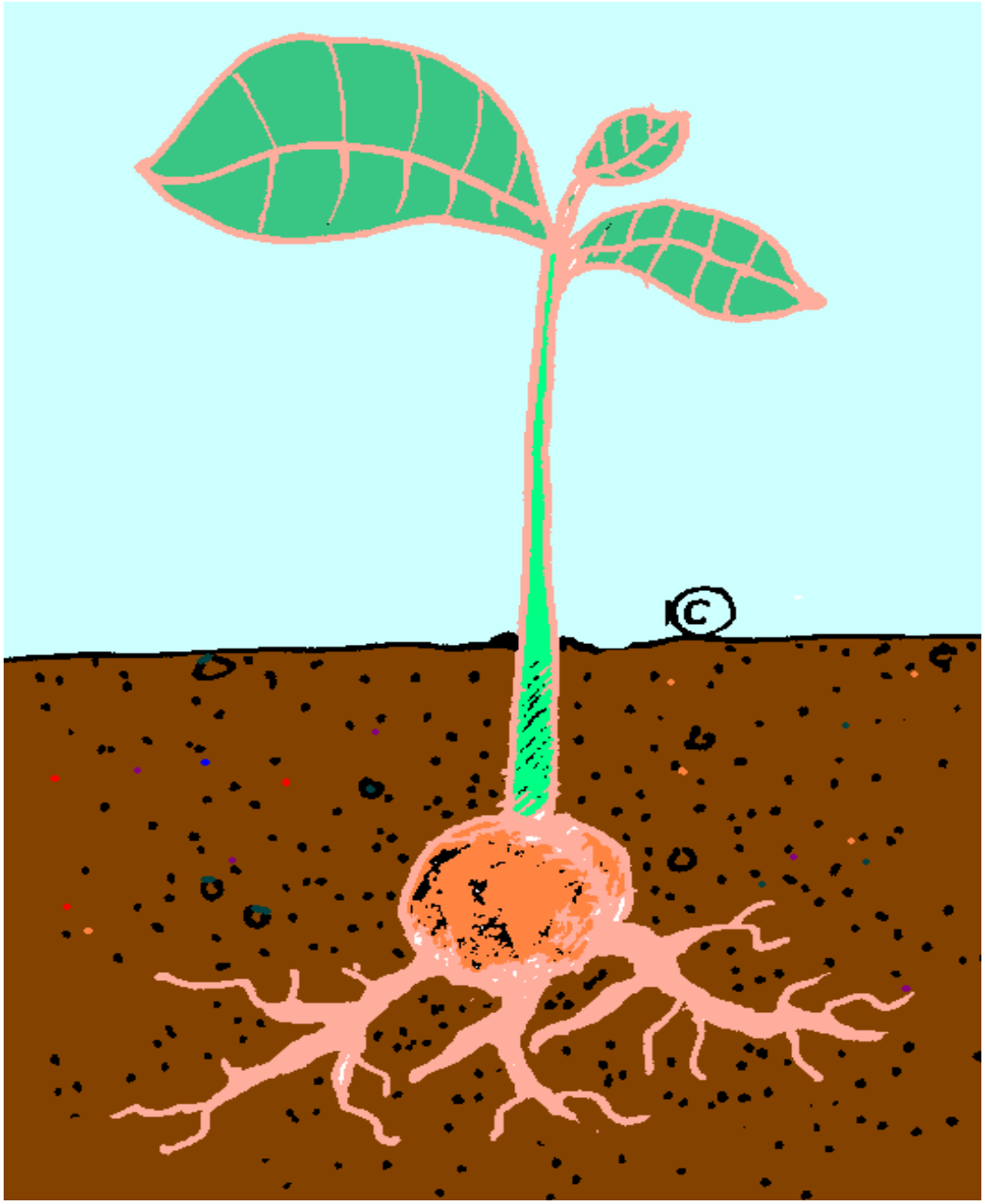
Cells of fruit, seeds, stems, modified roots, or converted to oil & stored in seeds

OXYGEN (O_2)

a. exits thru the stomata

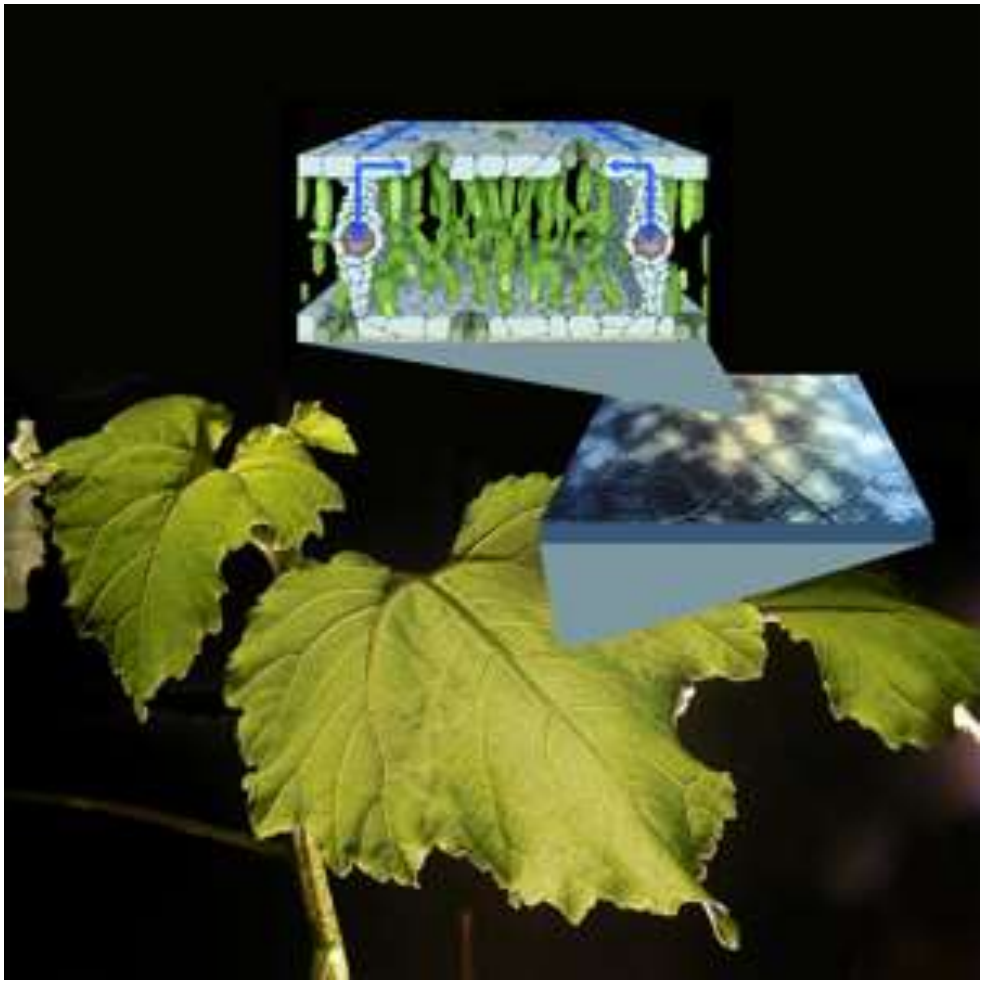
b. VERY important byproduct for living organisms

Think about what photosynthesis is… what part of the plant do you think it takes place?



Photosynthesis happens in the leaves of the plant!

We take in oxygen by breathing. How does carbon dioxide get into the leaves of the plants?

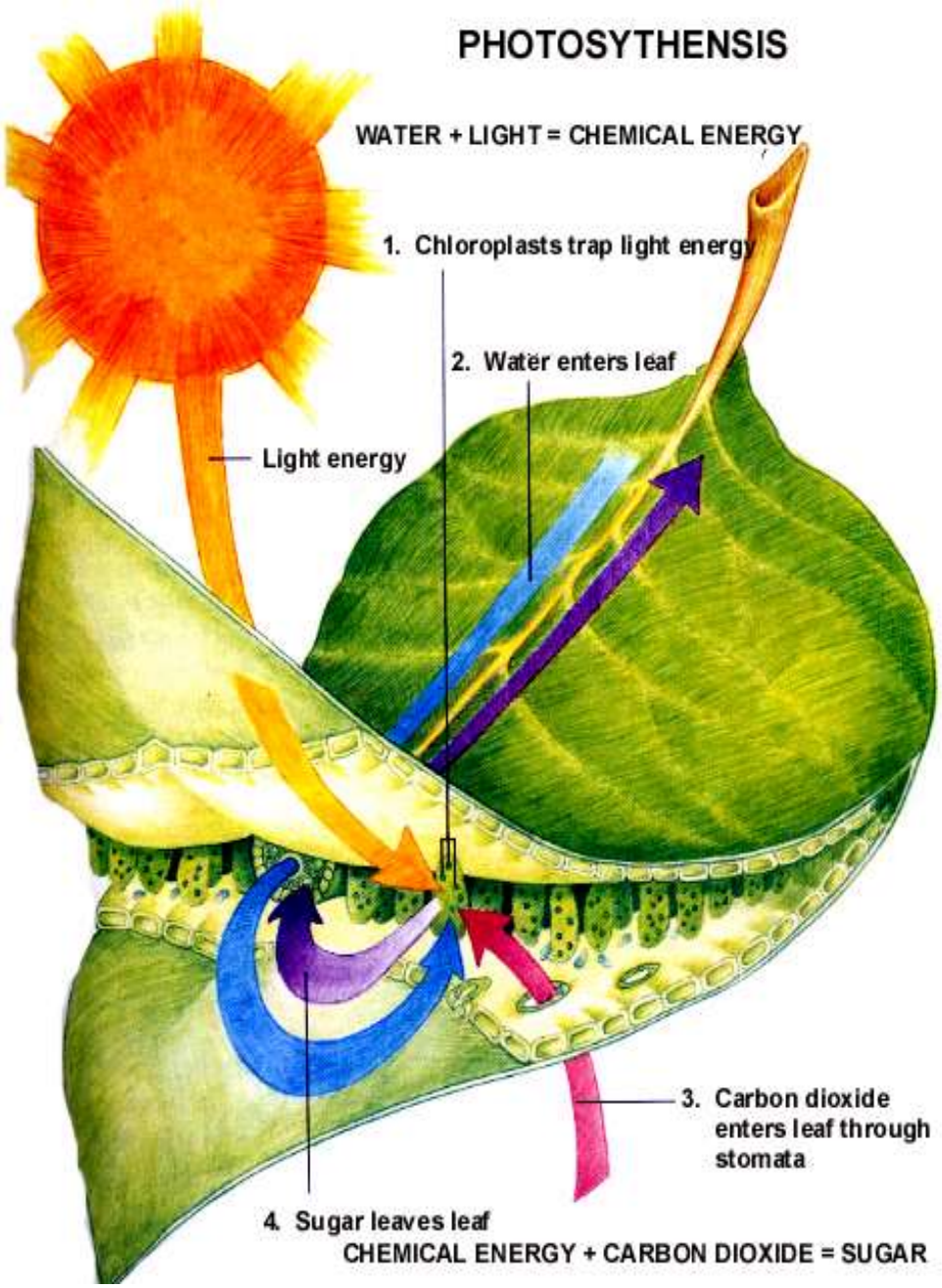


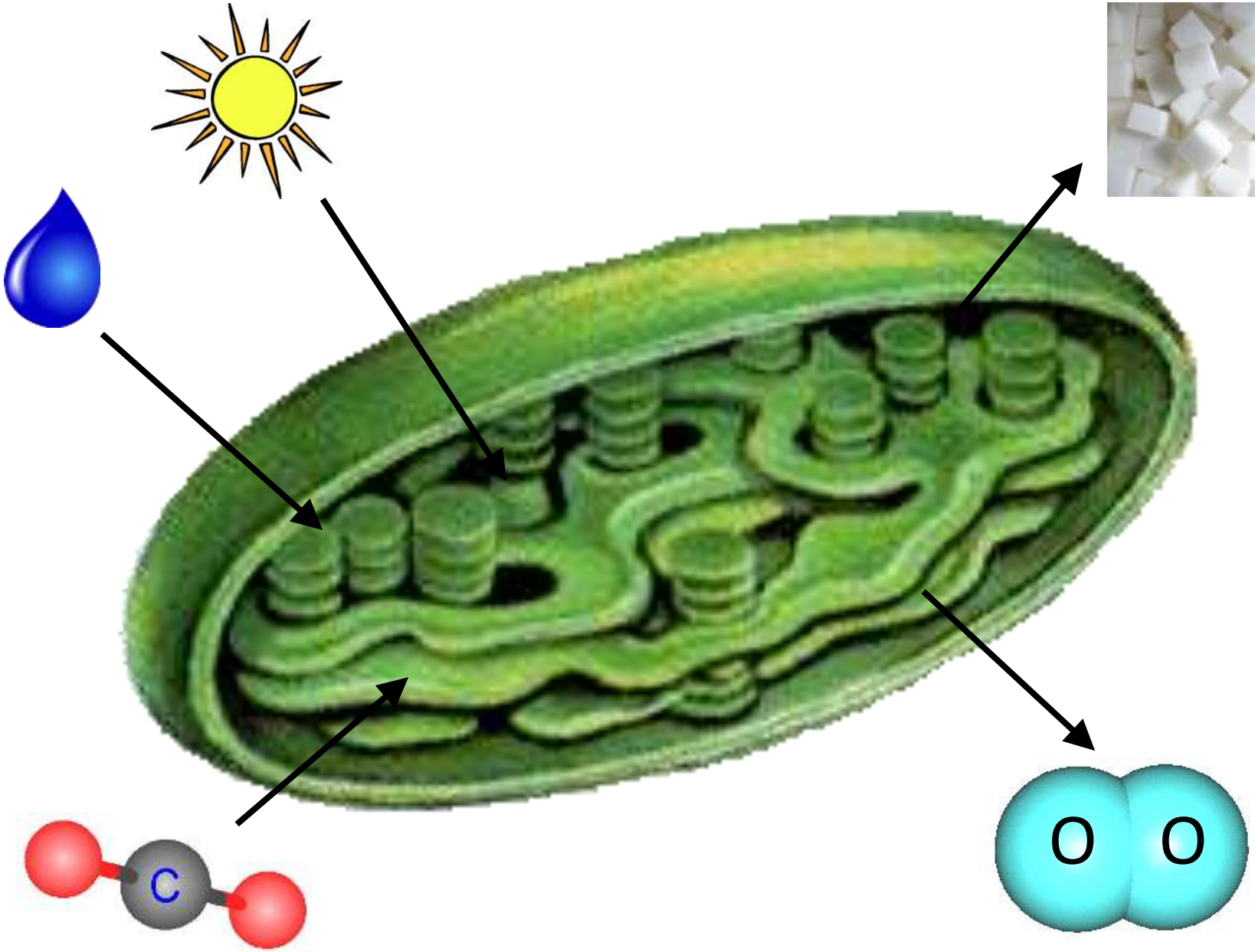
The **stomata**!

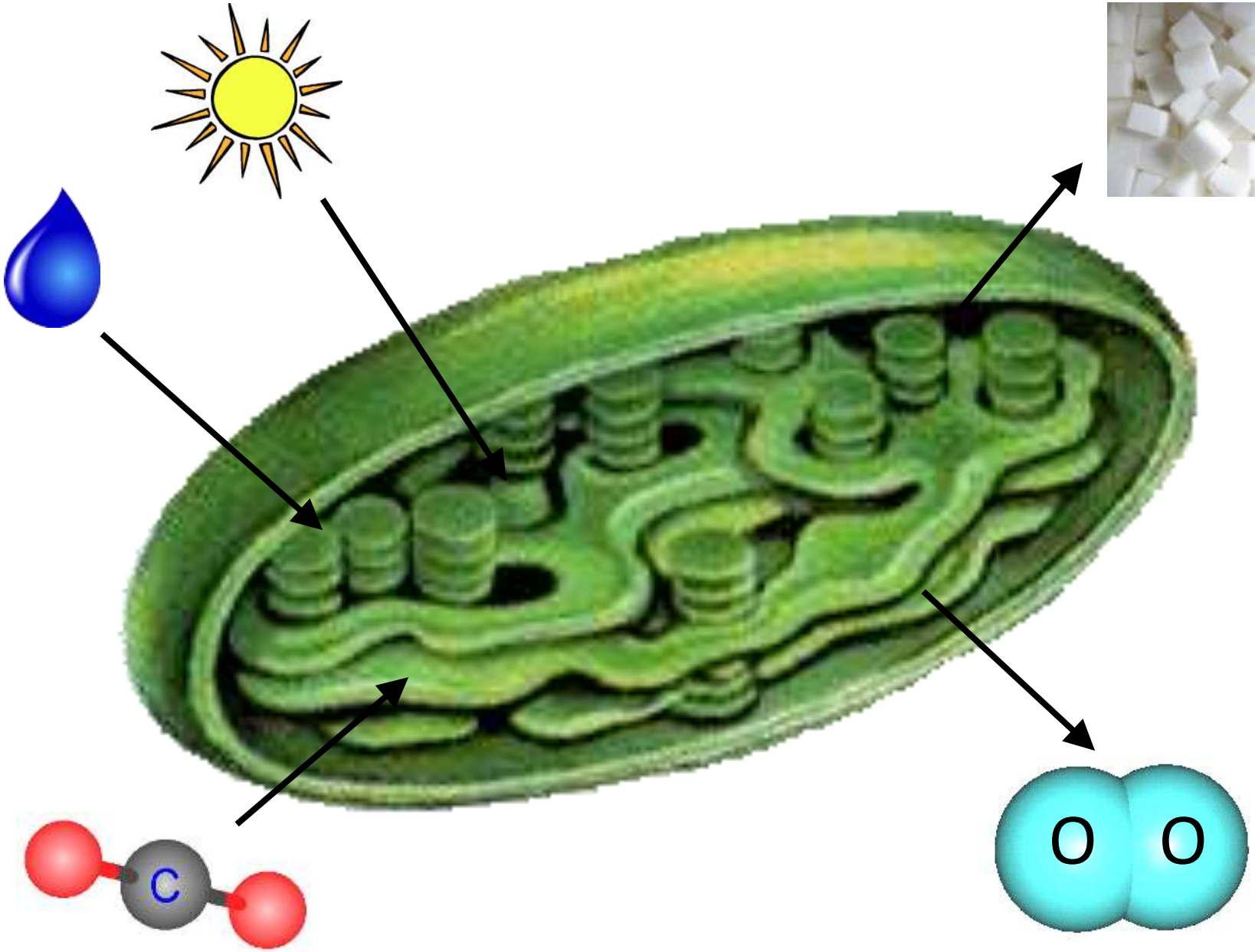
small openings in the leaves of the plant.

Leaves have special parts called **chloroplasts**!

Inside each chloroplast is <u>where the photosynthesis reaction takes place</u>.




C
O O


C
O O

Why don't we get energy from sunlight when we spend time outside??

Chloroplasts in plants have a molecule called **chlorophyll** that has the ability to <u>absorb</u> the energy from sunlight. WE SEE PLANTS AS GREEN BECAUSE THAT IS THE REFLECTED WAVELENGTH!

Chloroplast has 2 main parts:

a. thylakoid… -flattened membrane-bound sacs called granum

b. stroma… -chlorophyll is embedded here -fluid matrix of the chloroplast -contains enzymes…

Chlorophyll is a pigment

A **pigment** is a light absorbing molecule.

Chlorophyll is what gives leaves their green color.

3 TYPES OF PIGMENTS – We see them ALL in the FALL

1. Chlorophyll a

a. primary pigment- has atoms that absorb light

b. absorbs violet and orange/reds (we see green)

c. reflects green light

2. chlorophyll b

b. xanthophyll -reflects yellow (Squash)

c. carotenoids -reflects orange (Carrots)

If plants get their energy from sunlight, how do they survive at night?

Photosynthesis has 2 parts called photosystems, one that takes place in light and one that takes place in dark.

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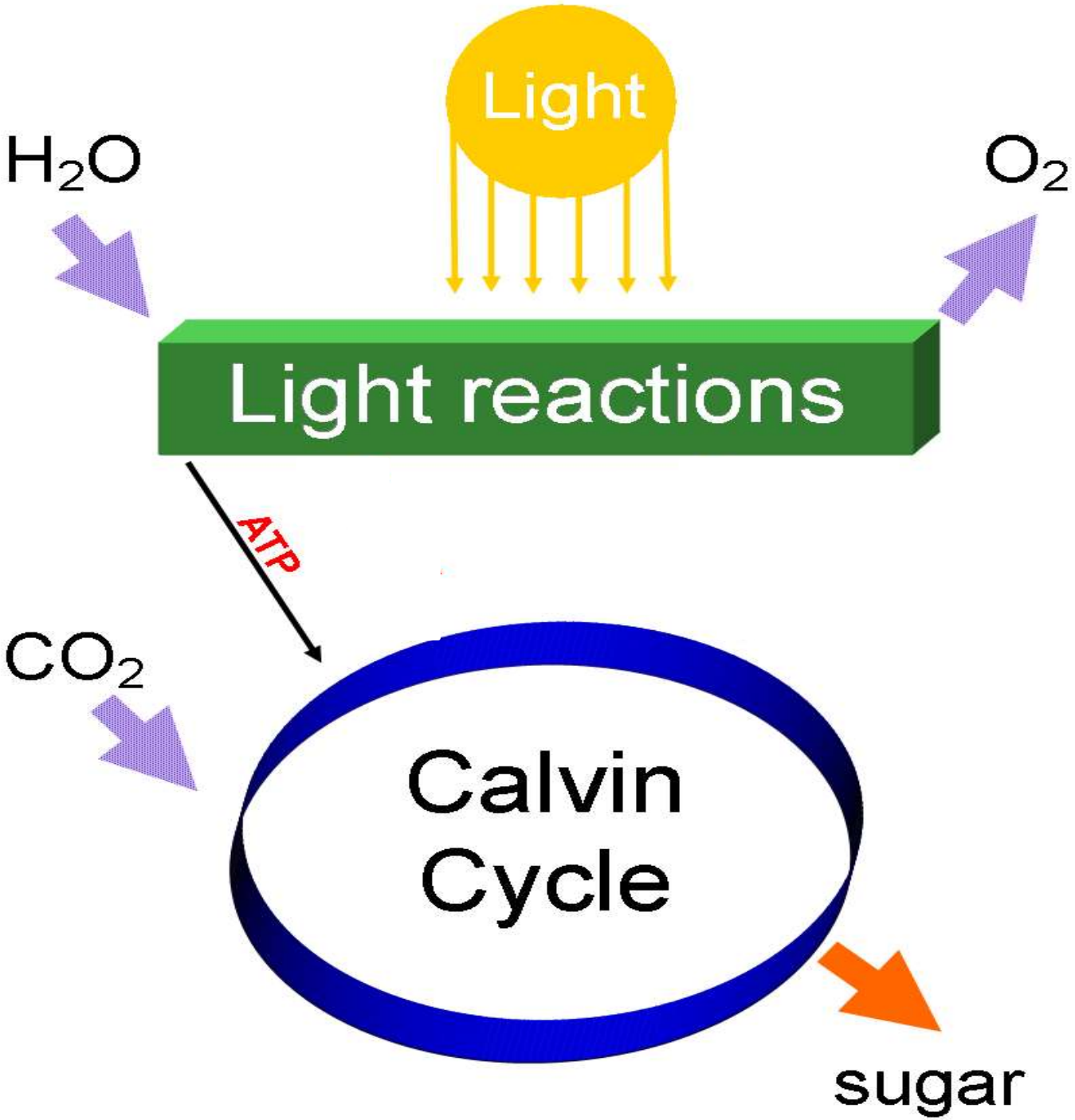
2 kinds of photosystems:

Photosystem I: wavelength 700nm

Photosystem II: wavelength 680nm

Photosynthesis has 2 parts called photosystems, one that takes place in light and one that takes place in dark.


Light
H_2O
O_2
Light reactions
ATP
CO_2
Calvin Cycle
sugar

II. Photosystem II (make ATP)

A. How does it work?

1. sunlight is absorbed by pigments in the thylakoid
2. photons boost the e- to a higher E level
3. e- are sent to reaction center..
4. reaction center donates e- to electron transport chain (ETC)

a. ETC is a series of redox rxn

b. stairs analogy

II. Photosystem II (make ATP)

5. The ETC contains a proton pump

a. pumps H+ into the thylakoid …

b. b. [H+] increases and builds up pressure

6. ETC donates its electrons to Photosystem I

a. splitting of 2 H_2O molecules: 2 H_2O -> 4 H+ + 4e- + O_2

b. H+ are left inside the thylakoid & O_2 diffuses out of plant

7. In the meantime…

a. ATP synthase is used for ADP-> ATP

b. chemiosmosis

Photosystem I (make NADPH)

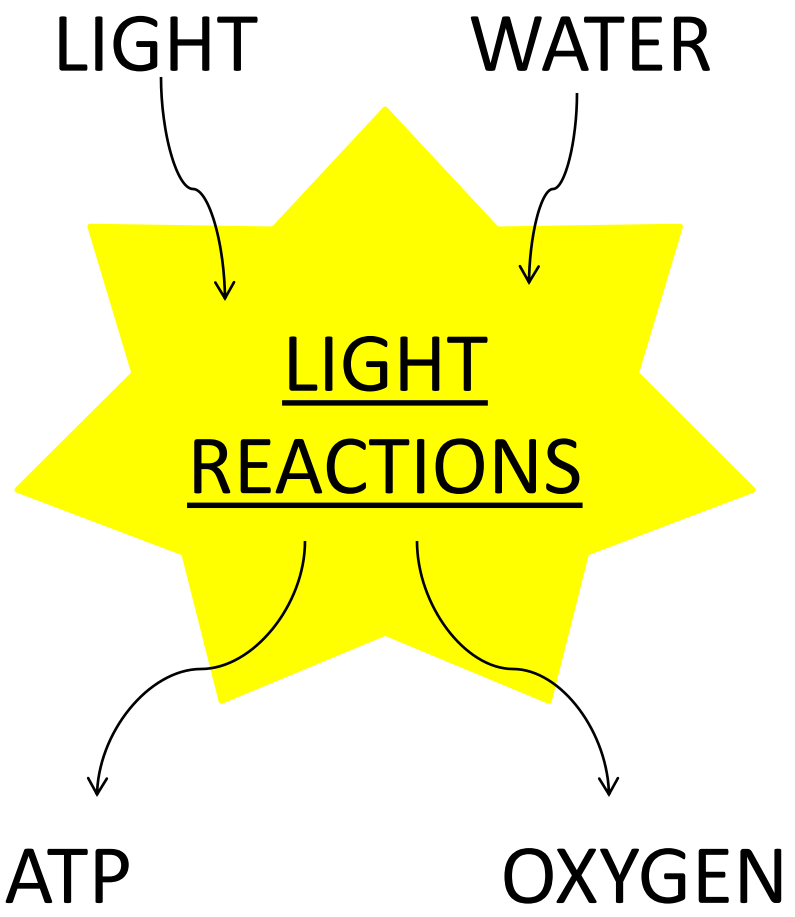
A. How does it work?

1. sunlight is absorbed by pigments in the thylakoid
2. e- from photosystem II are transferred to reaction center of Photosystem I…
3. e- are sent to reaction center..
4. reaction center donates e- to electron transport chain (ETC)
5. e- are transferred to a reducing protein

a. NADP+ to NADPH

Light Reactions

The "photo" part!



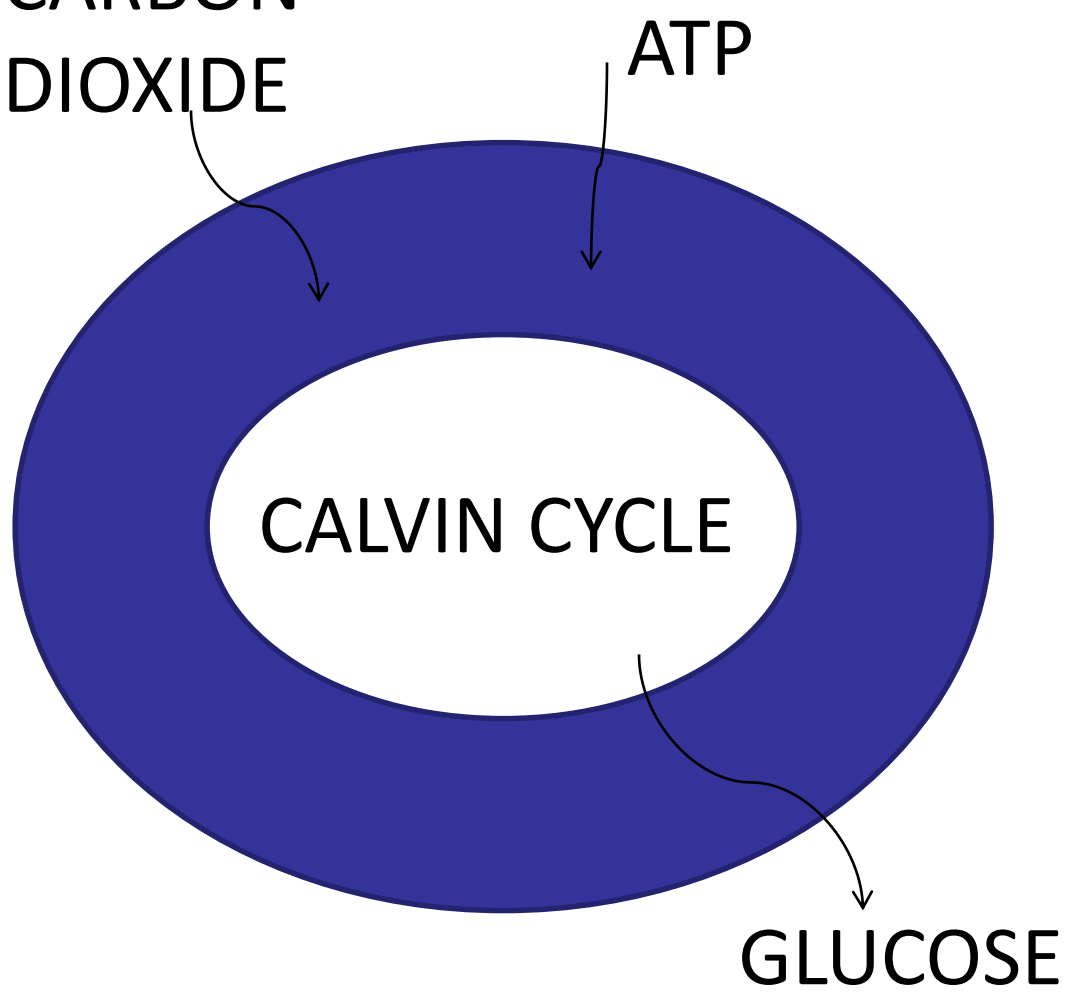
Purpose: to take sunlight and turn it into chemical energy (ATP)

Needs chlorophyll!

Calvin Cycle (Dark Reaction)

The "synthesis" part

A. Carbon Fixation 1. CO_2-> CHO 2. enzymes incorporate C atoms from CO_2 into organic molecules



Purpose: <u>to take carbon dioxide and make glucose</u>

Calvin Cycle (Dark Reaction)

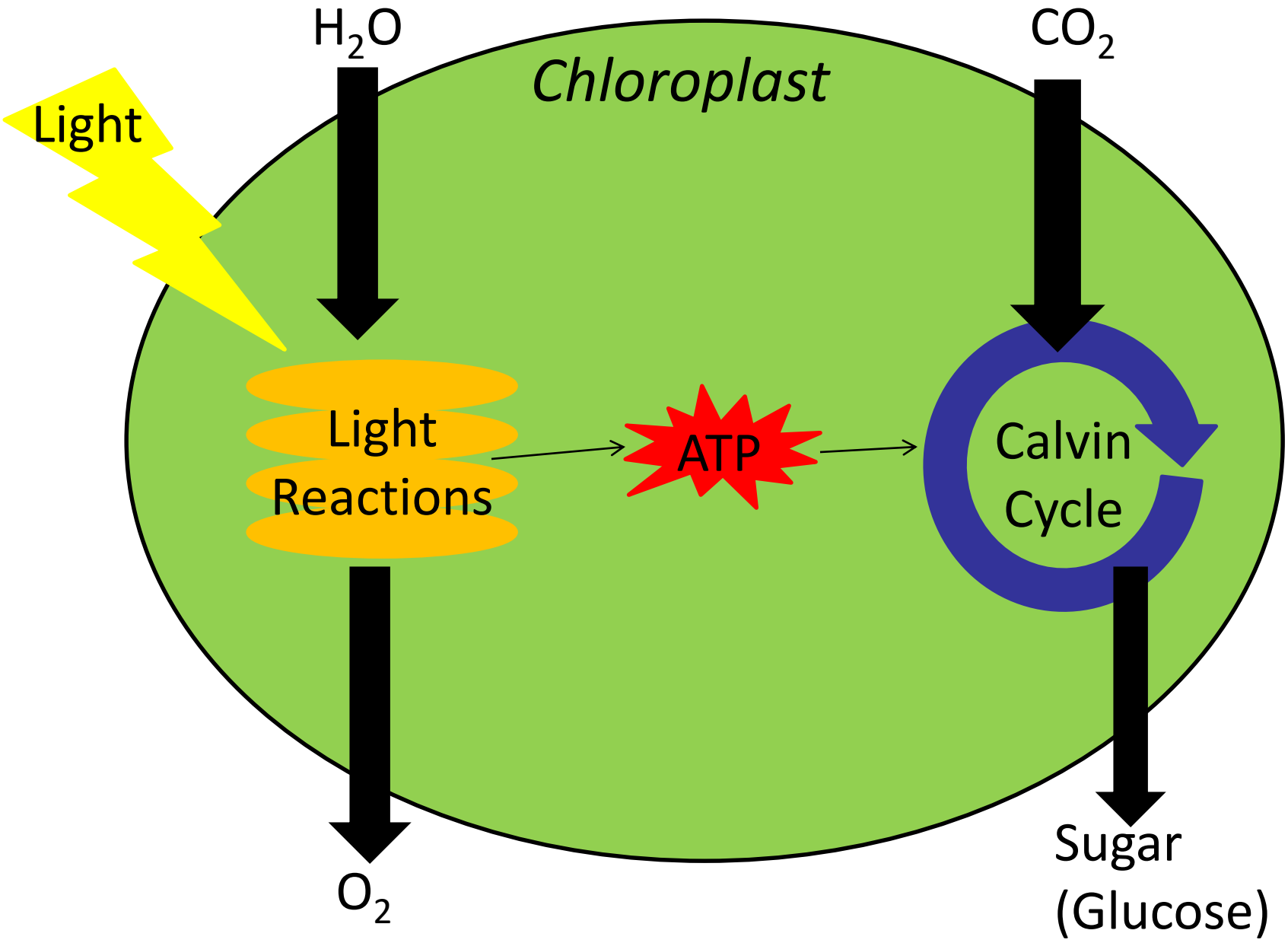
The "synthesis" part

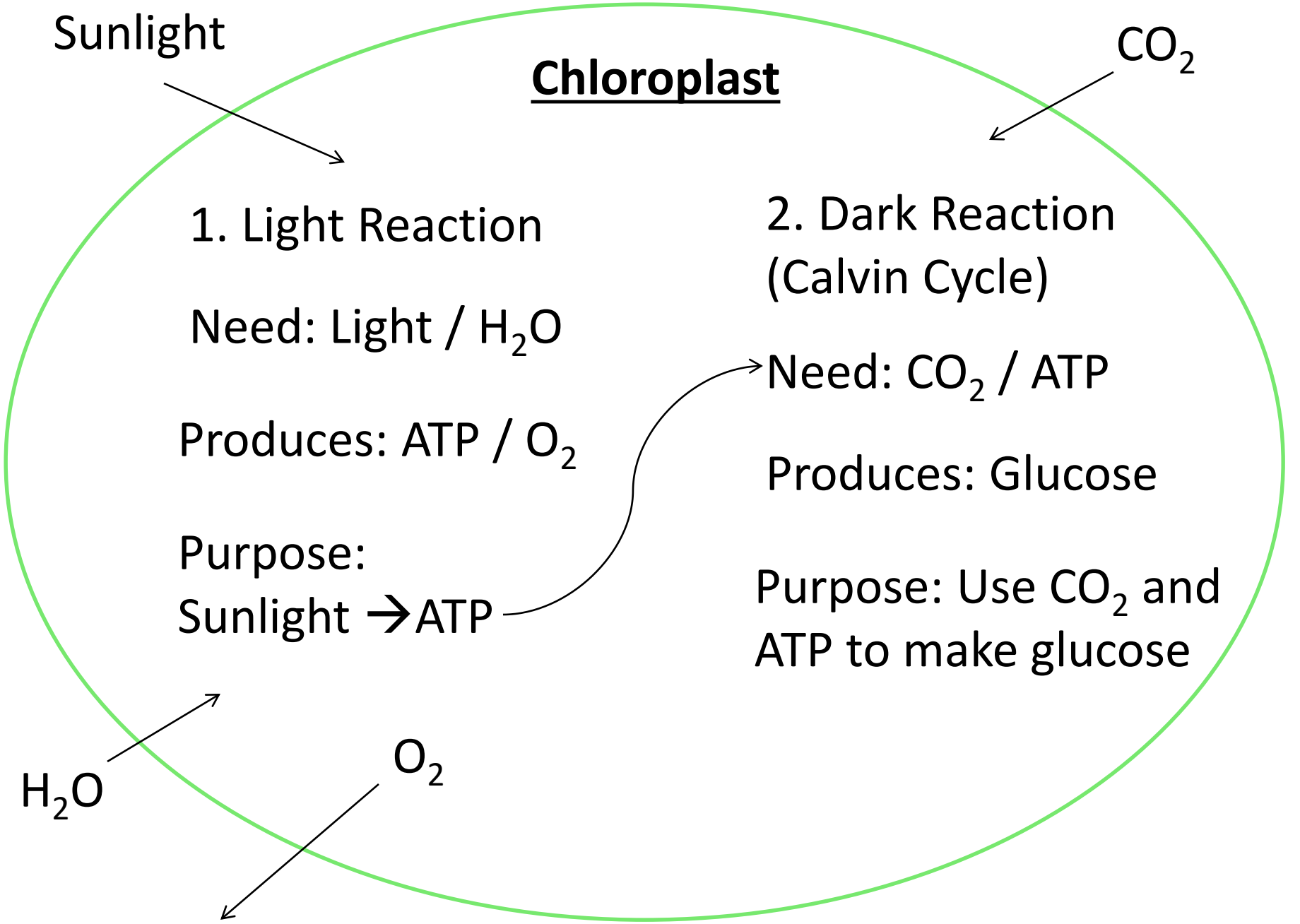
Light independent reactions

a. does NOT require light directly but does require ATP & NADPH

b. requires CO_2 that enters thru the stomata

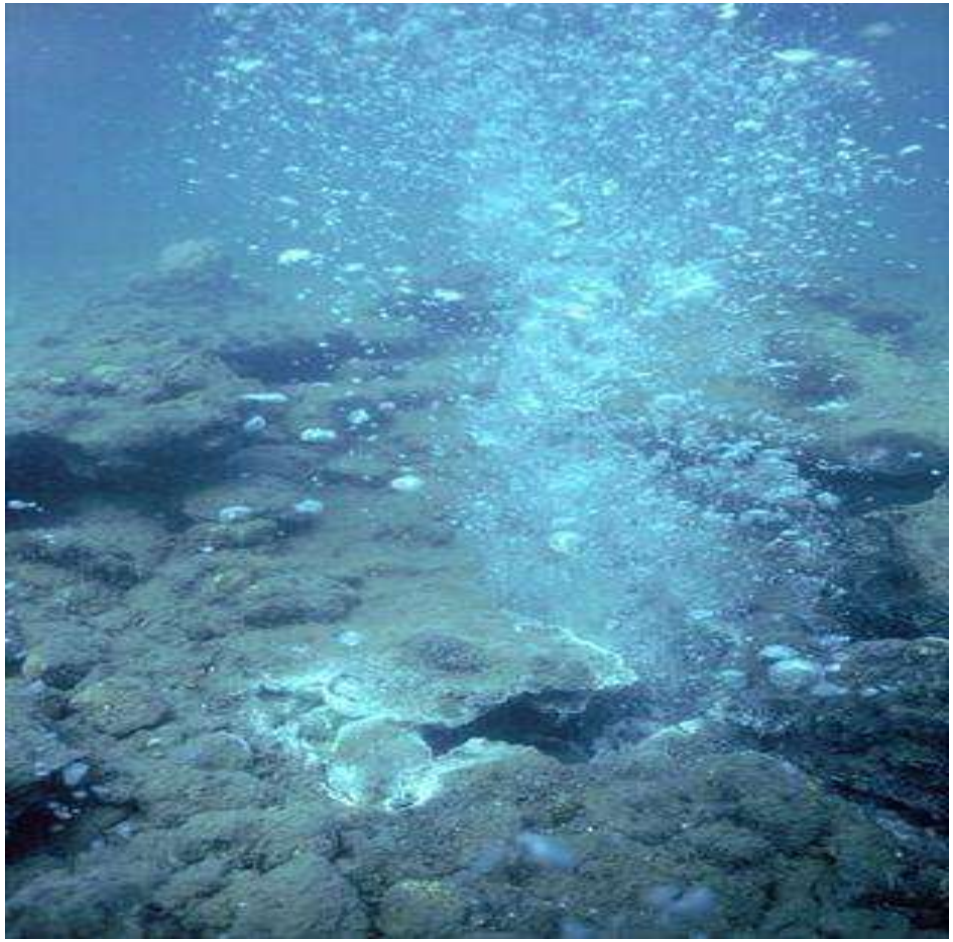
There are several ways C is fixed during PS….


H_2O
CO_2
Chloroplast
Light
Light Reactions
ATP
Calvin Cycle
O_2
Sugar (Glucose)


Sunlight
CO_2
Chloroplast
1. Light Reaction
Need: Light / H_2O
Produces: ATP / O_2
Purpose:
Sunlight →ATP
2. Dark Reaction
(Calvin Cycle)
Need: CO_2 / ATP
Produces: Glucose
Purpose: Use CO_2 and
ATP to make glucose
H_2O
O_2

There is another type of producer that uses chemicals to make food instead of light.

This process is called **chemosynthesis**.



Example of a chemosynthesizer is bacteria found in deep sea vents where there is little light and food.

Looking at chlorophyll…

Leaf Chromatography!

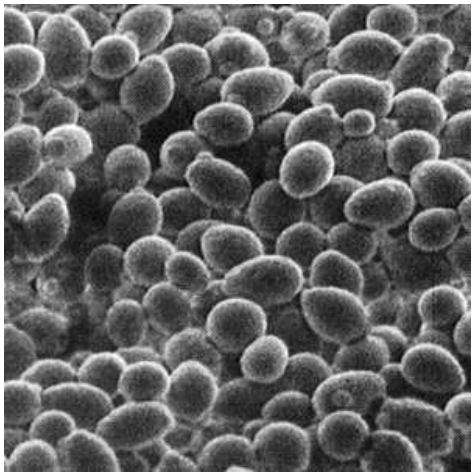
How do we know that photosynthesis takes place?

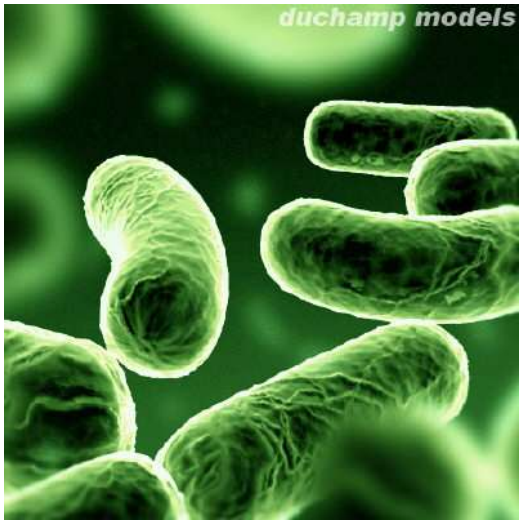
PART 2: How do our bodies take food and make it into energy?

Cellular Respiration!

Cellular respiration is a *chemical process* in which glucose molecules are broken down to release energy (ATP) for cellular functions

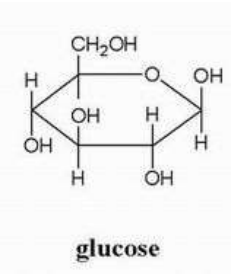
What types of organisms undergo cellular respiration?

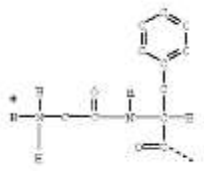




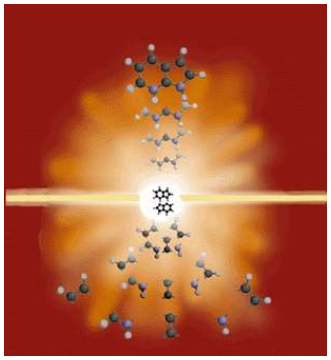
Cellular respiration occurs in ALL living cells!

What happens to the food we eat?





1. We break our food down into small molecules



2. We use the energy stored in the bonds in our food to make ATP

3. A small amount of the food becomes waste

What are some of the things that our body does that requires energy?

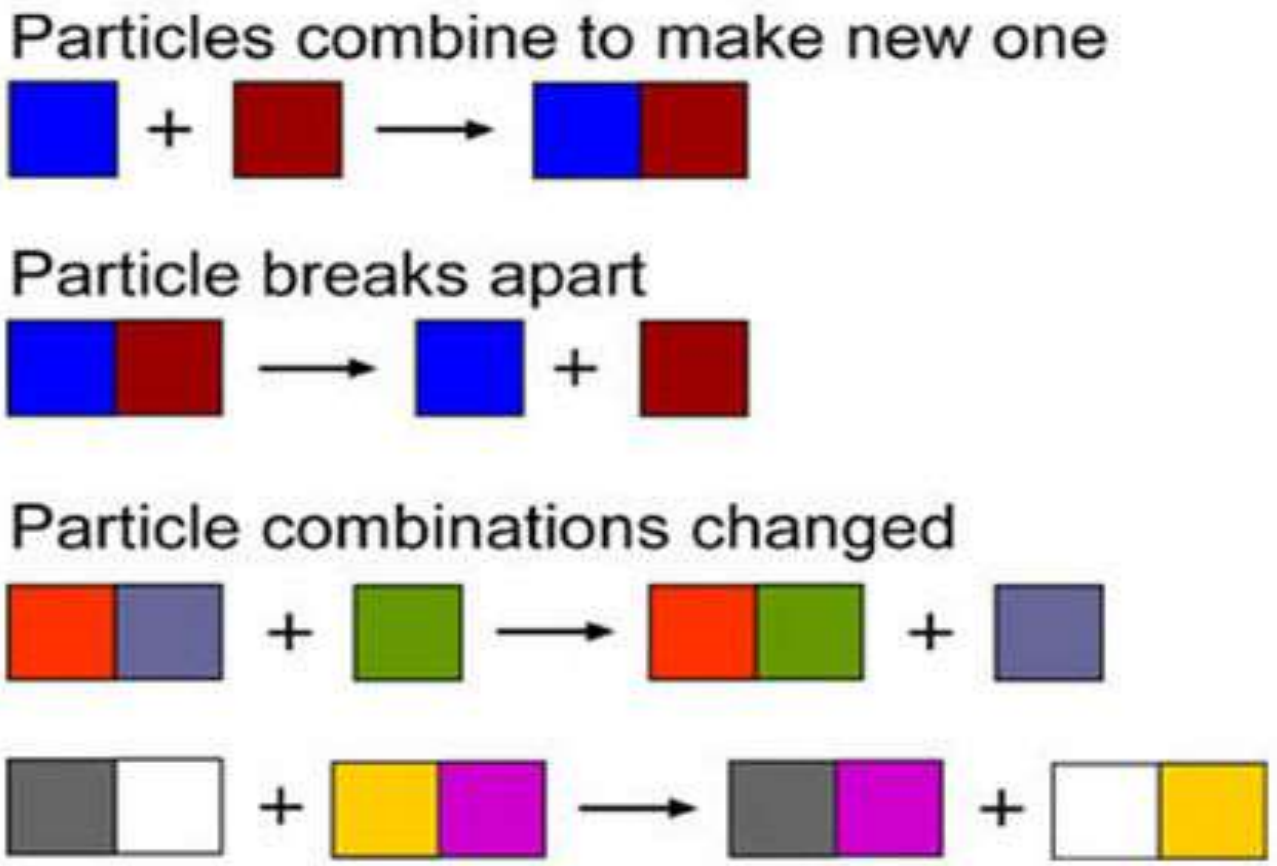
<u>Physical Activities</u>

- Running
- Playing sports
- Pumping our hearts

<u>Cellular Activities</u>

- Sending messages to our brain
- Transporting molecules in and out of our cells

Cellular Respiration is a **chemical reaction**!



During chemical reactions, molecules break apart and rearrange to make new molecules.

Like photosynthesis, cellular respiration has a *specific chemical reaction* that happens *every time*.

REVERSE OF PHOTOSYNTHESIS

+

→

We breathe in oxygen and get glucose from our food

We breathe out carbon dioxide

$$O_2 + C_6H_{12}O_6 \rightarrow CO_2 + H_2O + \text{Energy (ATP)}$$

(reactants)

(products)

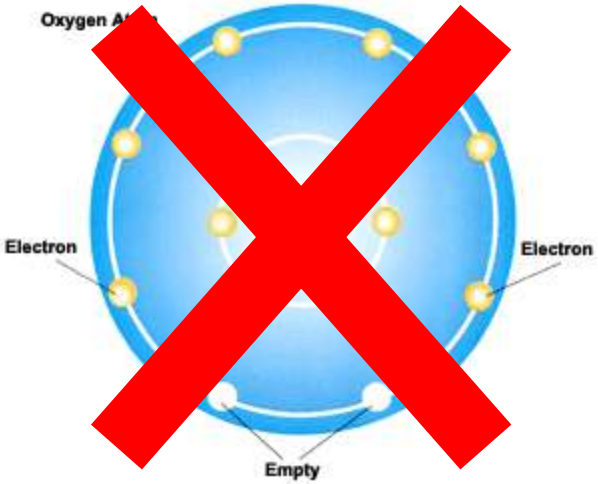
Cellular respiration can be divided into 2 main parts.

1. Anaerobic respiration

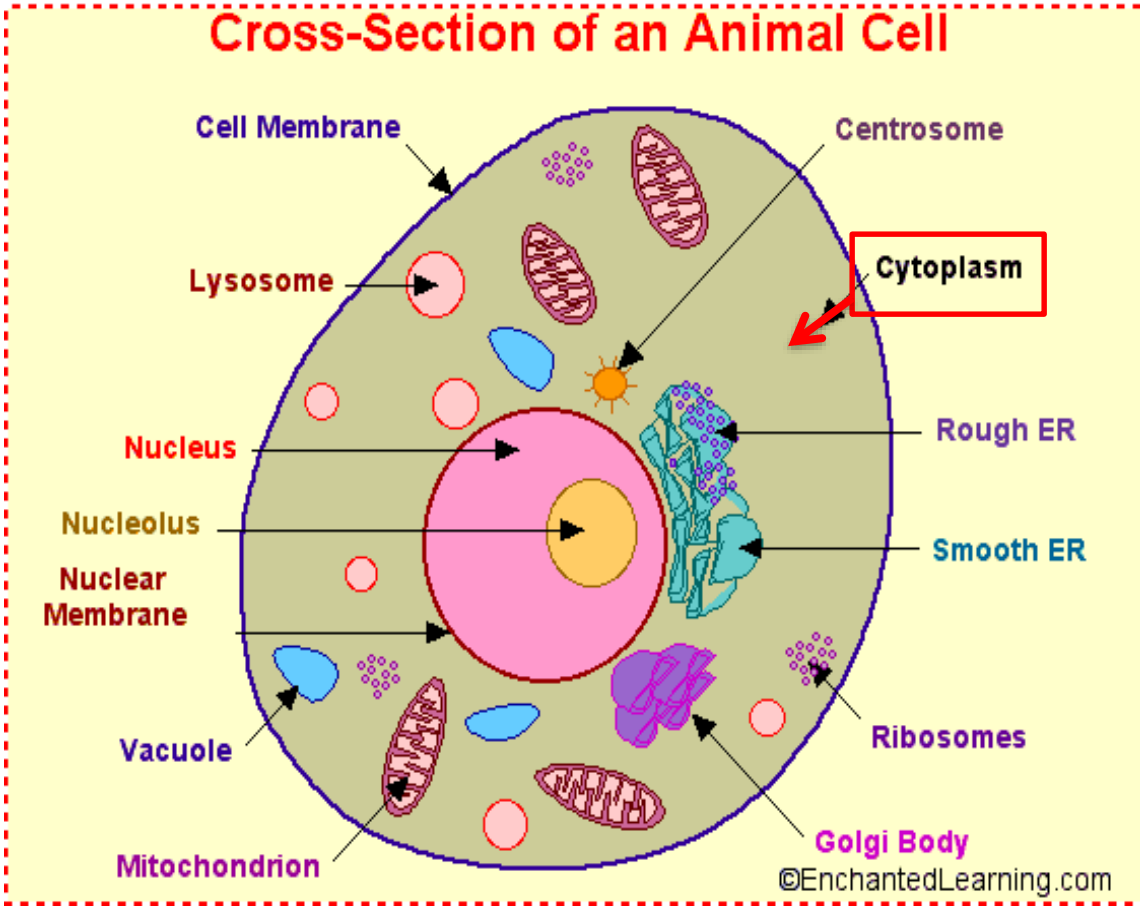
2. Aerobic respiration

Anaerobic Respiration

Does NOT need oxygen!

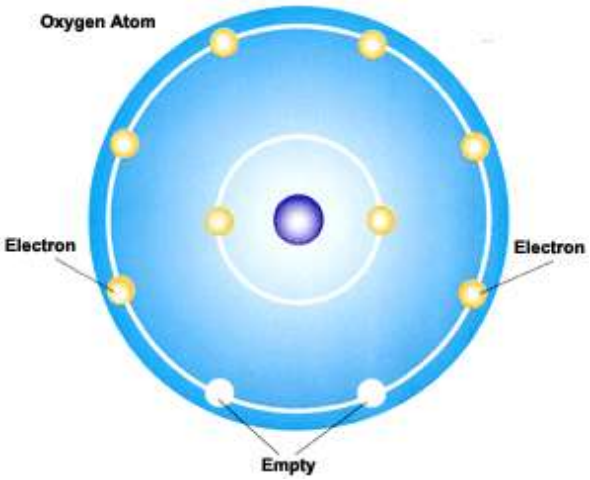


Happens in the <u>cytoplasm</u> of a cell

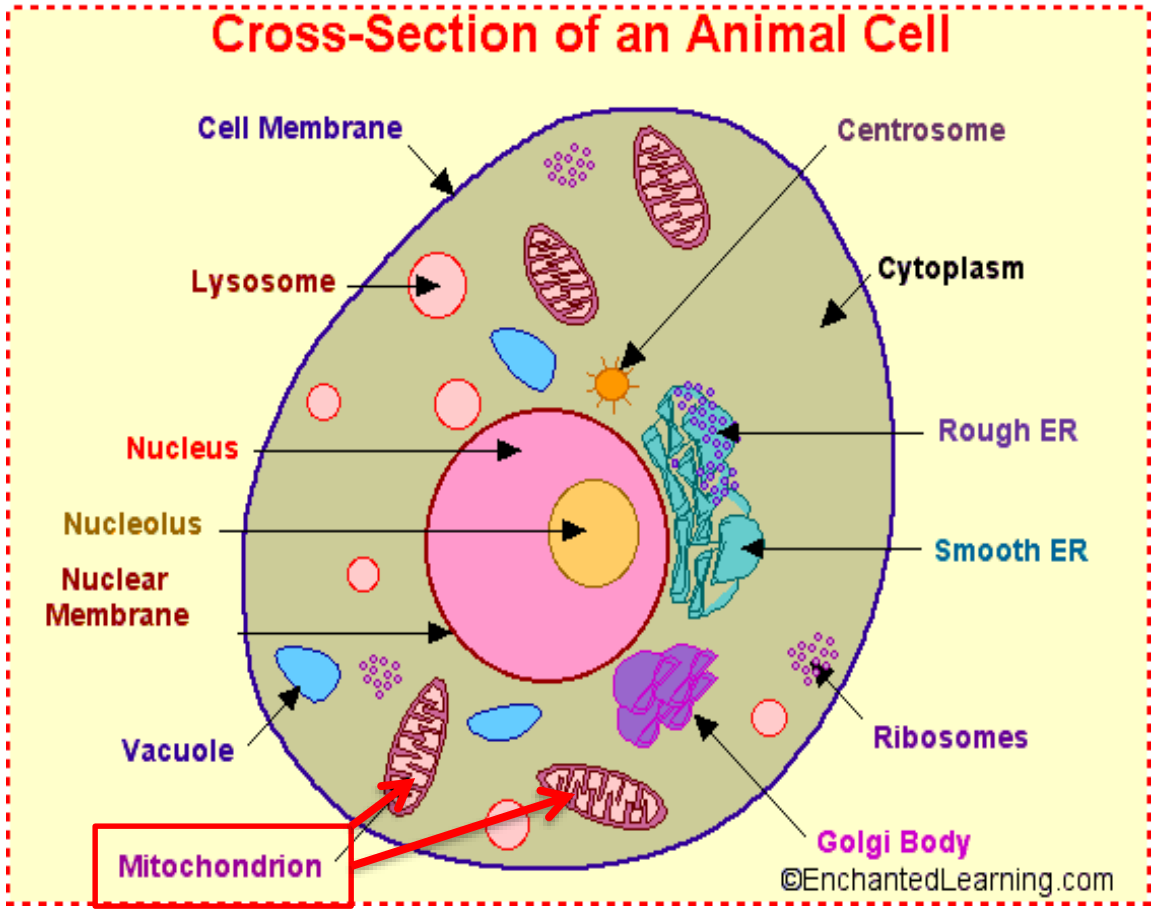


Aerobic Respiration

Requires oxygen



Happens in the <u>mitochondria</u> of a cell

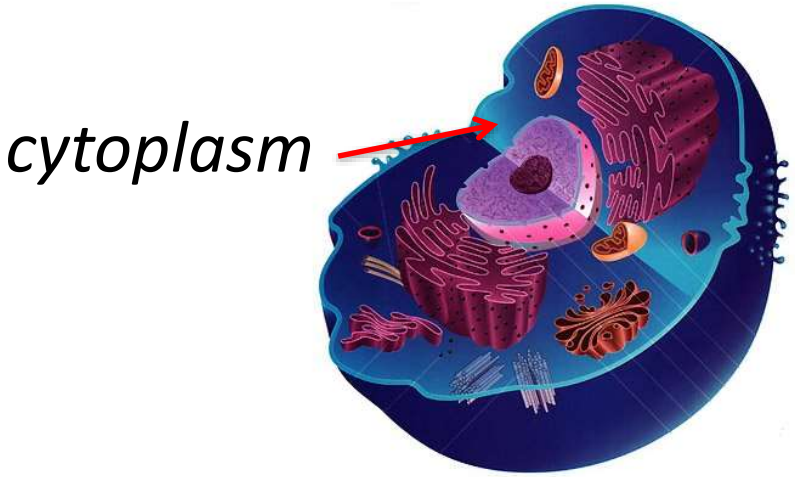


The steps in cellular respiration…

Step 1: **Glycolysis**

Glycolysis

glucose to break apart



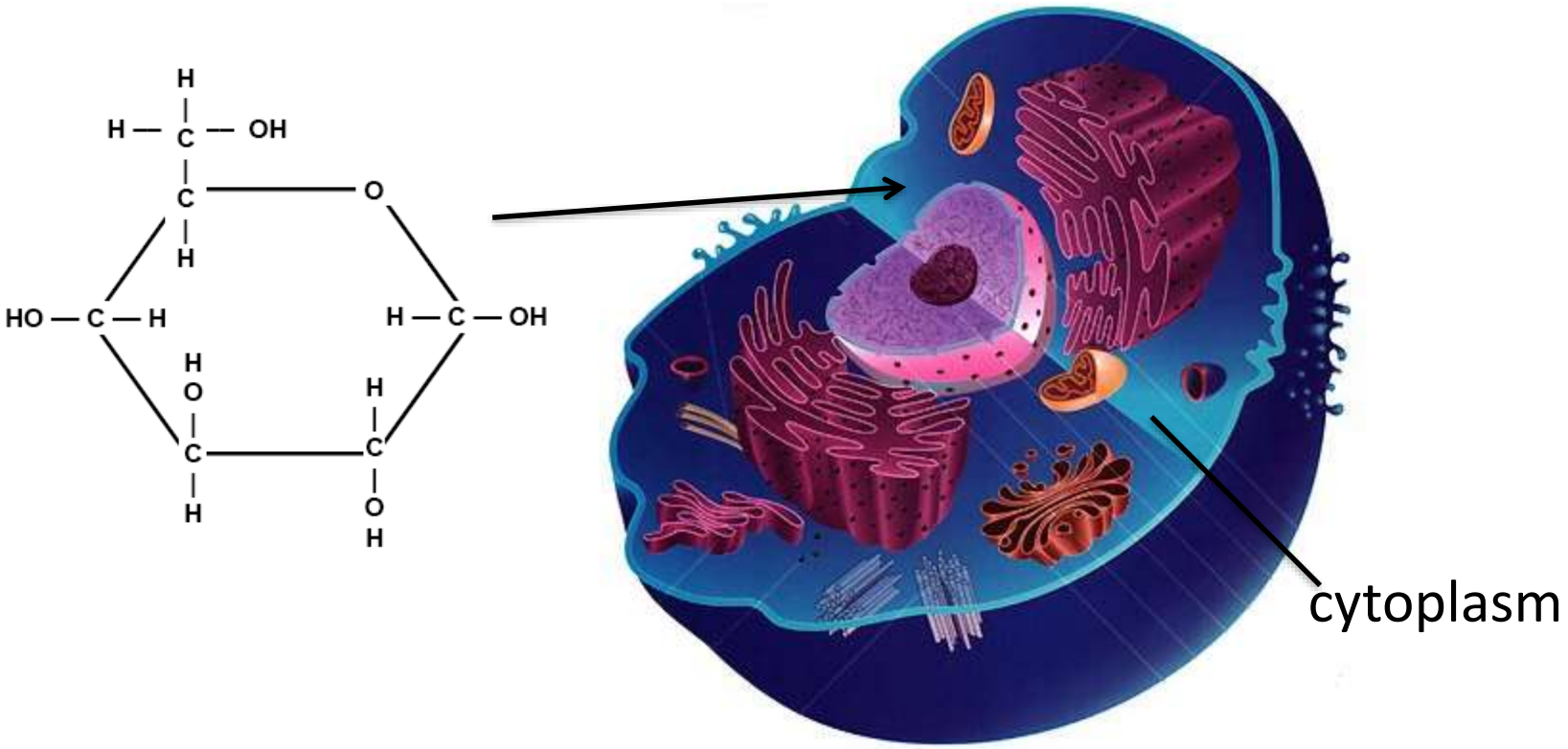
Glycolysis is an *anaerobic respiration* process…

Therefore, glycolysis happens in the cytoplasm and does NOT require oxygen.

Glycolysis

(breaking apart glucose)

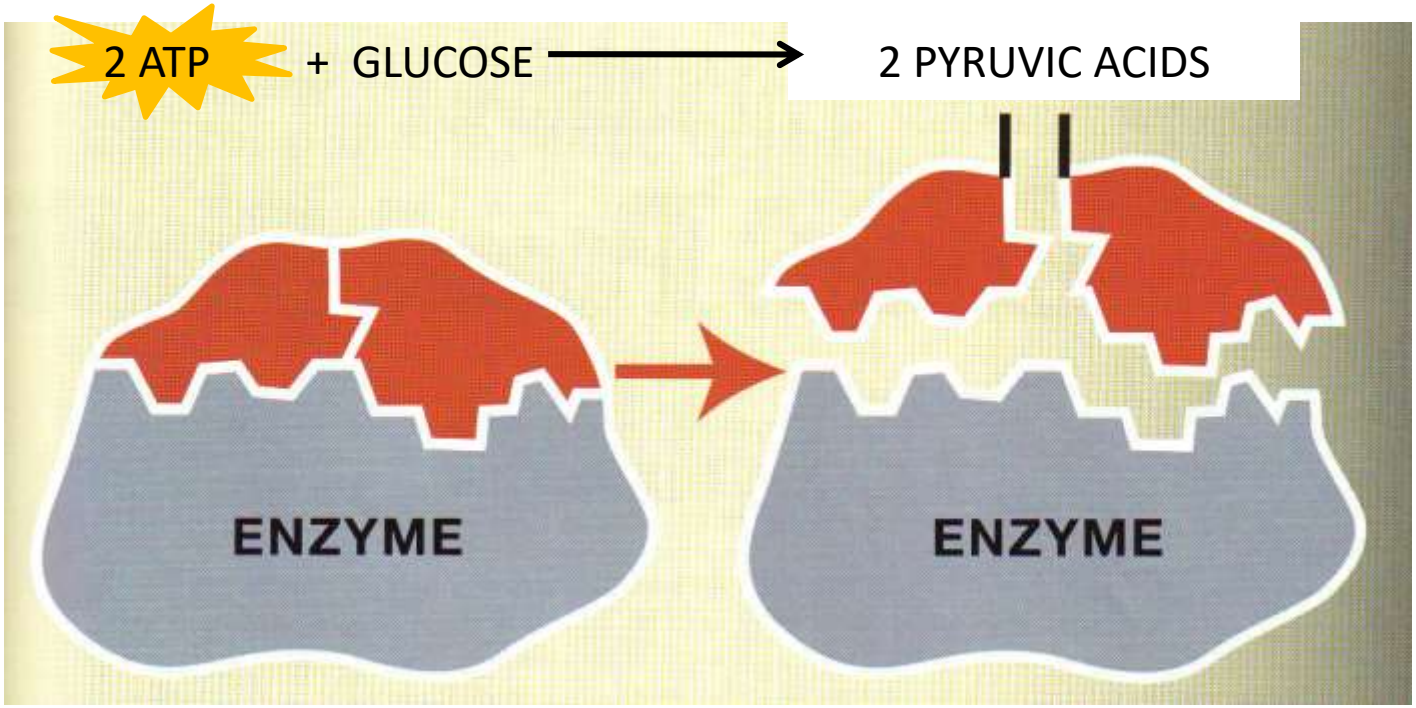
1. Food (glucose) enters the cytoplasm of the cell.



Glycolysis *(breaking apart glucose)*

2. a. Enzymes (cytopl.) break glucose into 2 molecules.
b. Transition phase: pyruvate binds to coenzyme in the mitochondria c. -2 ATP

This part uses 2 ATP



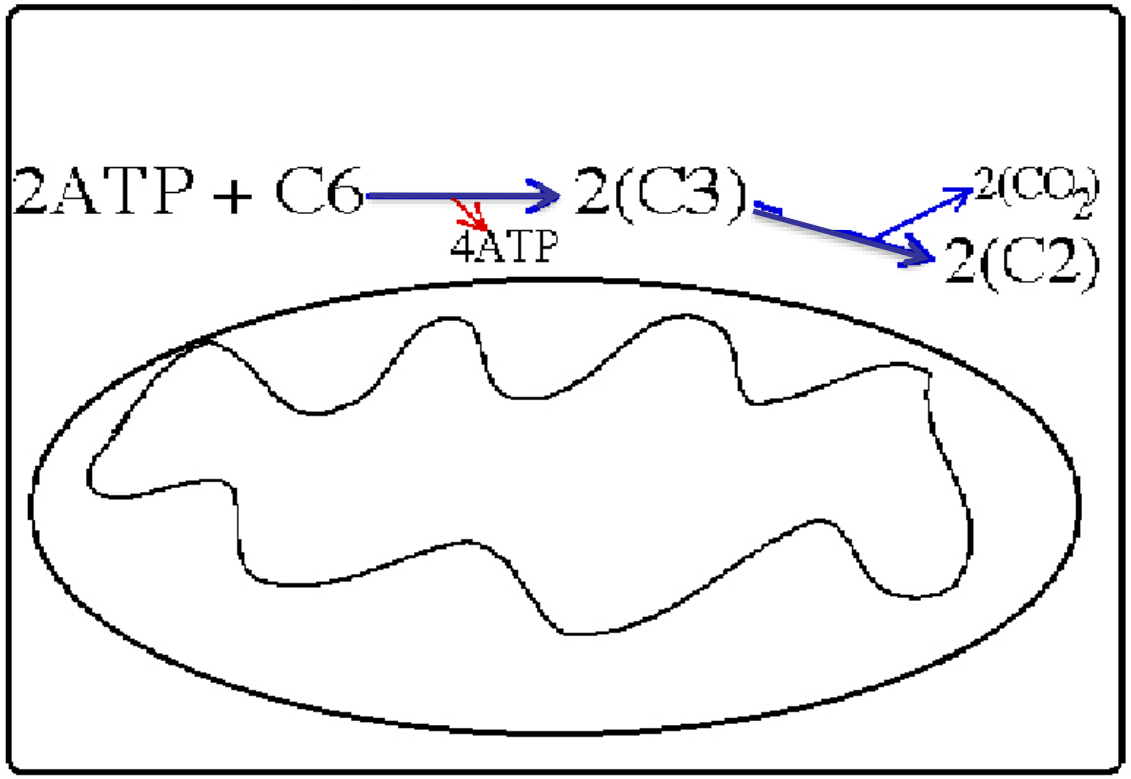
Glycolysis

(breaking apart glucose)

3. When the bonds in glucose break, *energy is released and stored in 4 ATP!!*

Glycolysis *makes* 4 ATP and *uses* 2 ATP

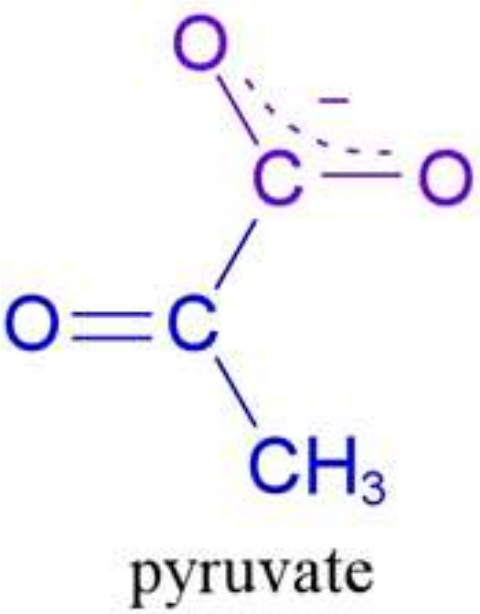
***** The *net gain* of glycolysis is 2 ATP*****



Recap!

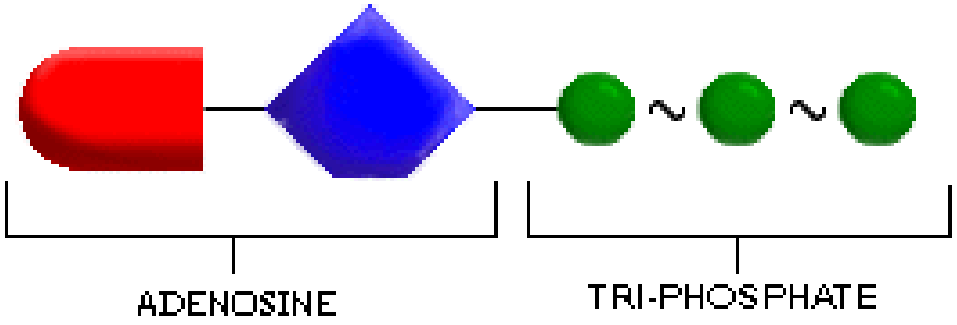
The products of glycolysis are…

Pyruvate

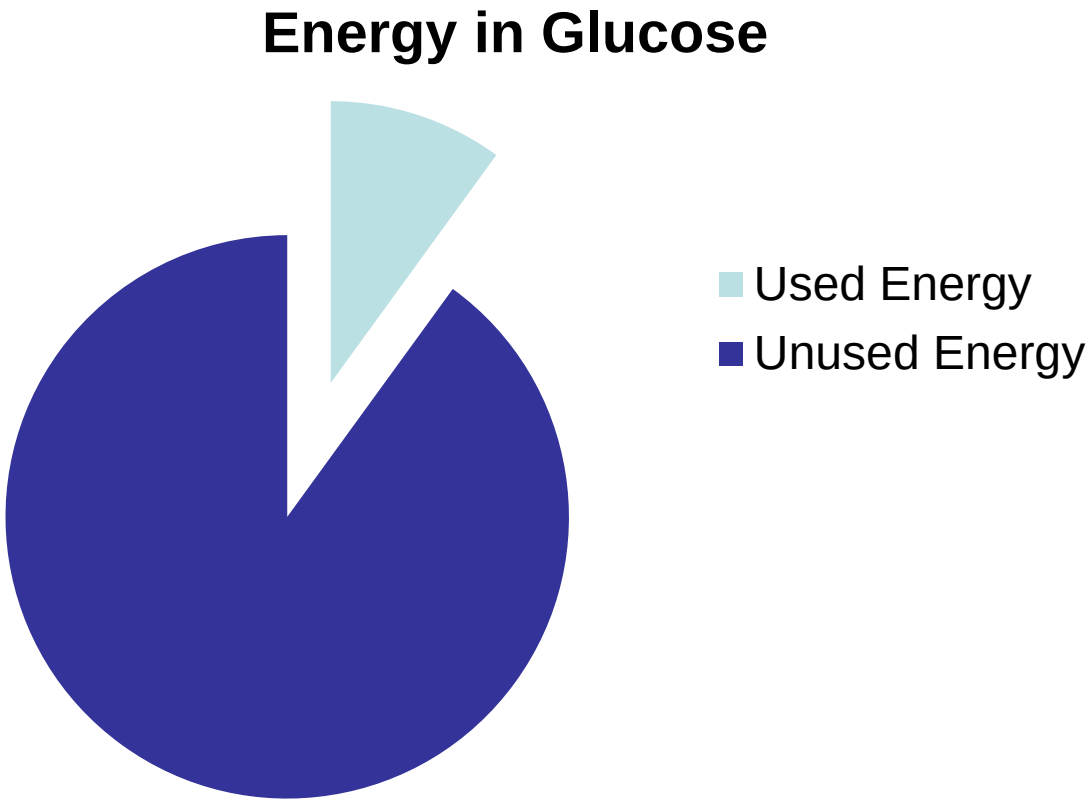


pyruvate

2 ATP's



After finishing glycolysis the cell has only taken out 10% of one glucose molecule!



Therefore, the process must continue!!!

The steps in cellular respiration…

Step 1: **<u>Glycolysis</u>**

Step 2: ????????????

The next step depends on what the conditions of the cell are.

Is there is oxygen available to the cell?

Glycolysis

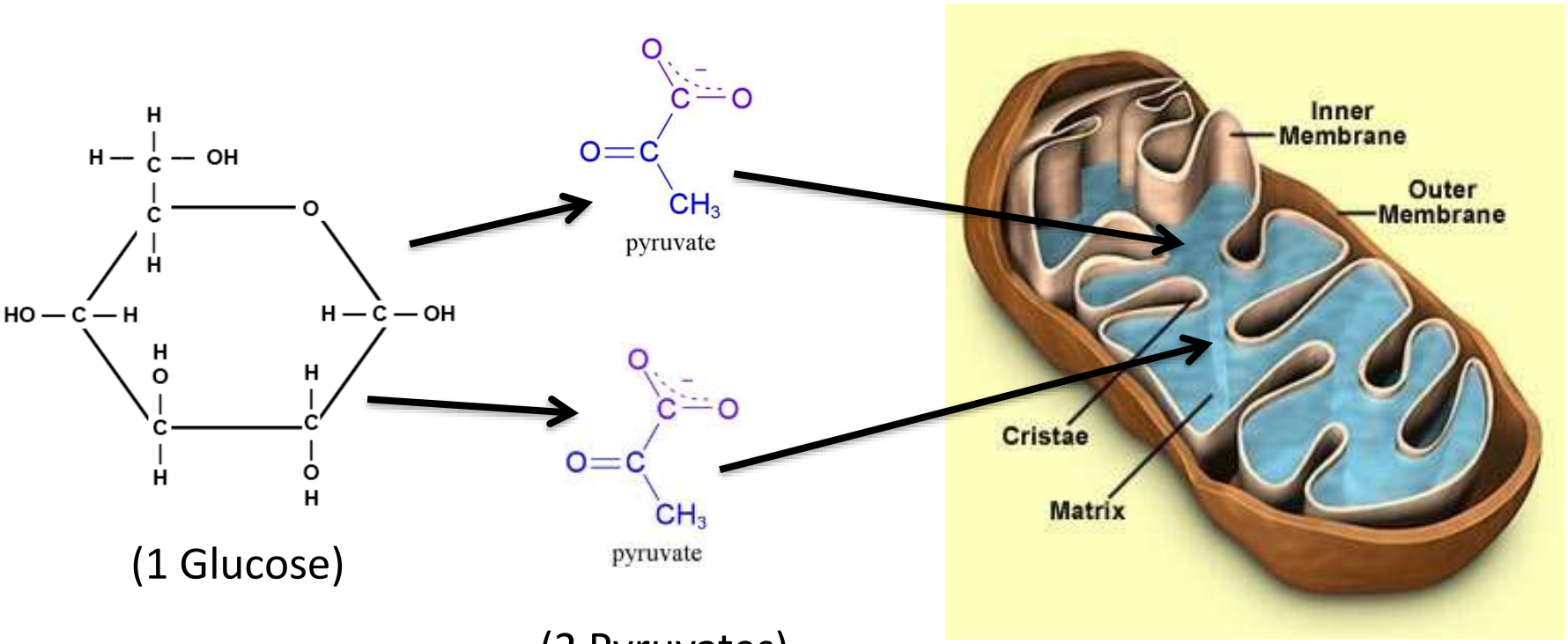
YES!

NO!

Aerobic Respiration

Anaerobic Respiration

Aerobic Respiration



(1 Glucose)

(2 Pyruvates)

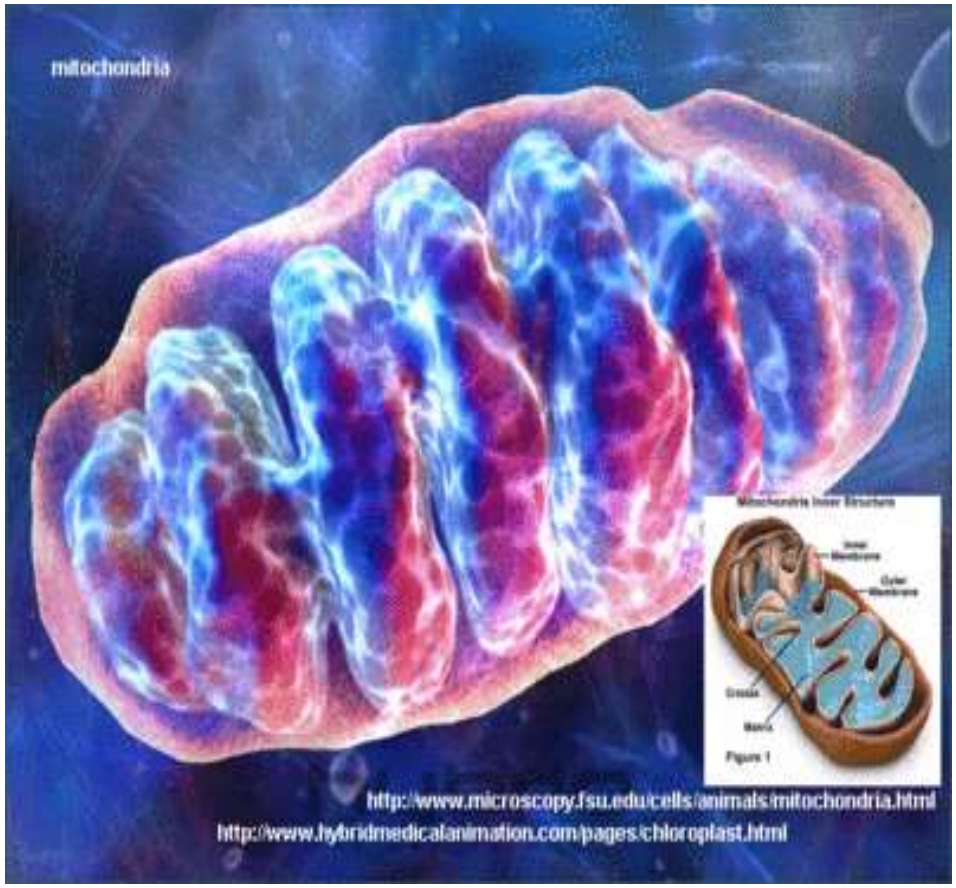
The products of glycolysis move into the mitochondria where they are used for aerobic respiration.

Aerobic Respiration

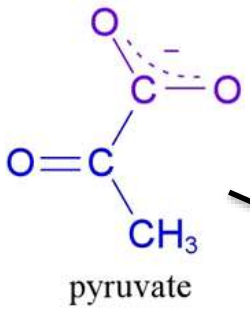
During aerobic respiration, 2 processes take place in the mitochondria.

1. Kreb's Cycle (CITRIC ACID CYCLE)

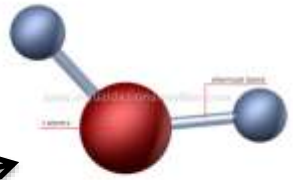
2. Electron Transport Chain



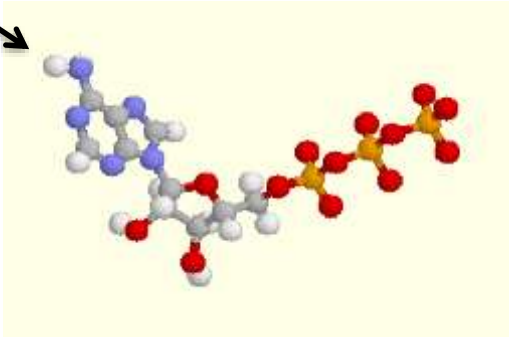
The Krebs Cycle



pyruvate

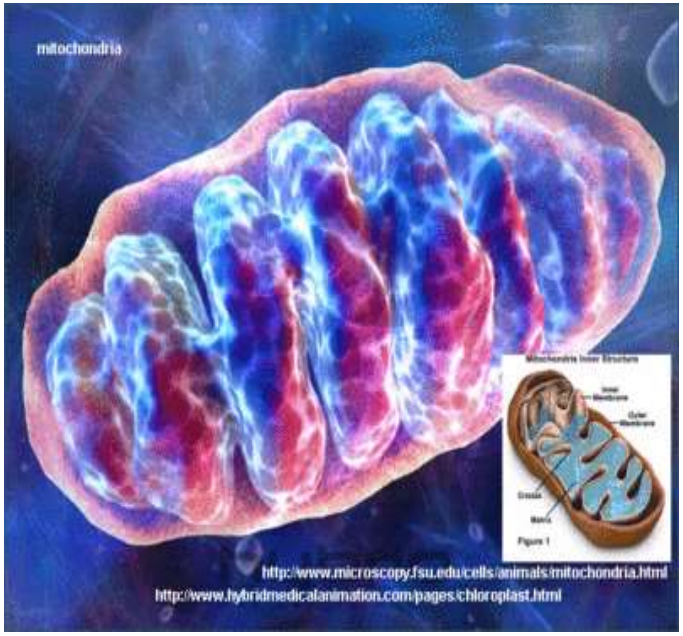


KREBS CYCLE!



KREBS OR CITRIC ACID CYCLE

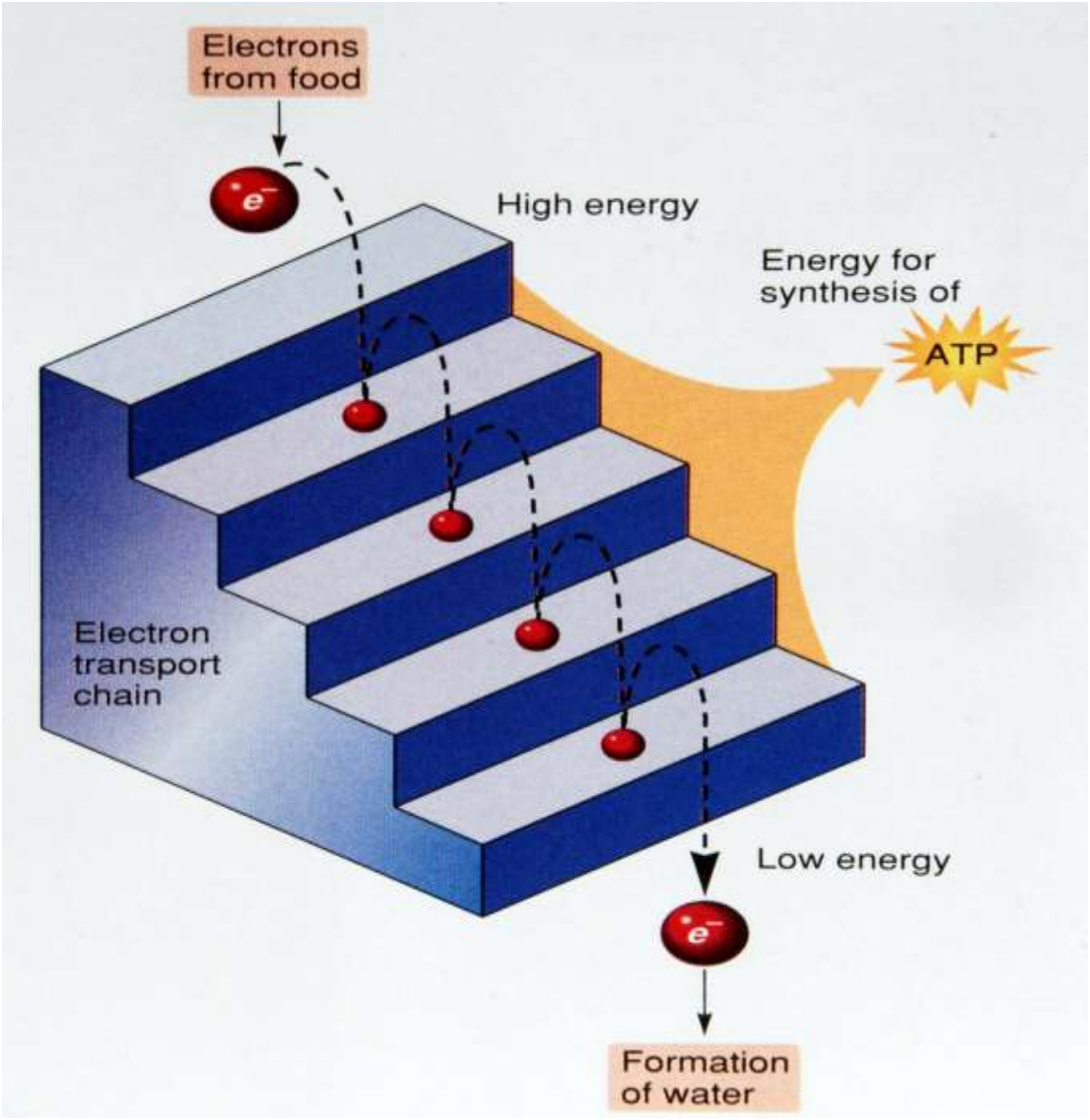
a. acetyl co-A molecule enters cycle
b. combines w oxaloacetate ->citrates -> CO_2
c. occurs in the matrix
d. +2 ATP…
e. <u>PRODUCES: 3 Carbon dioxide, 1 ATP, 1 FADH2, 4 NADH</u>



Electron Transport Chain

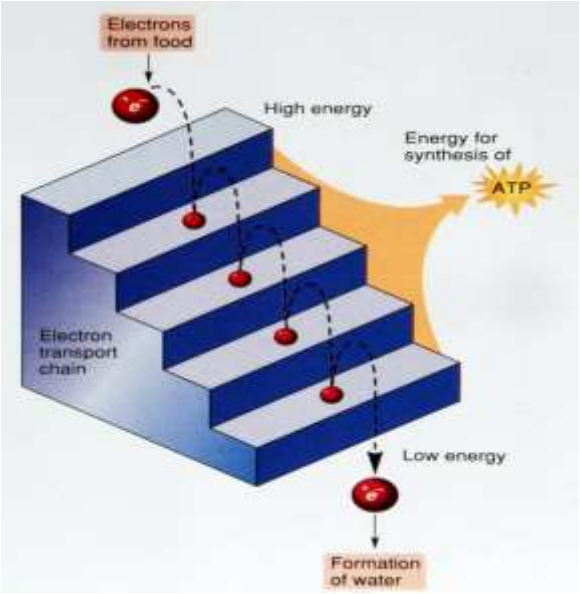
Uses high energy electrons to convert ADP to ATP.

Also forms water!

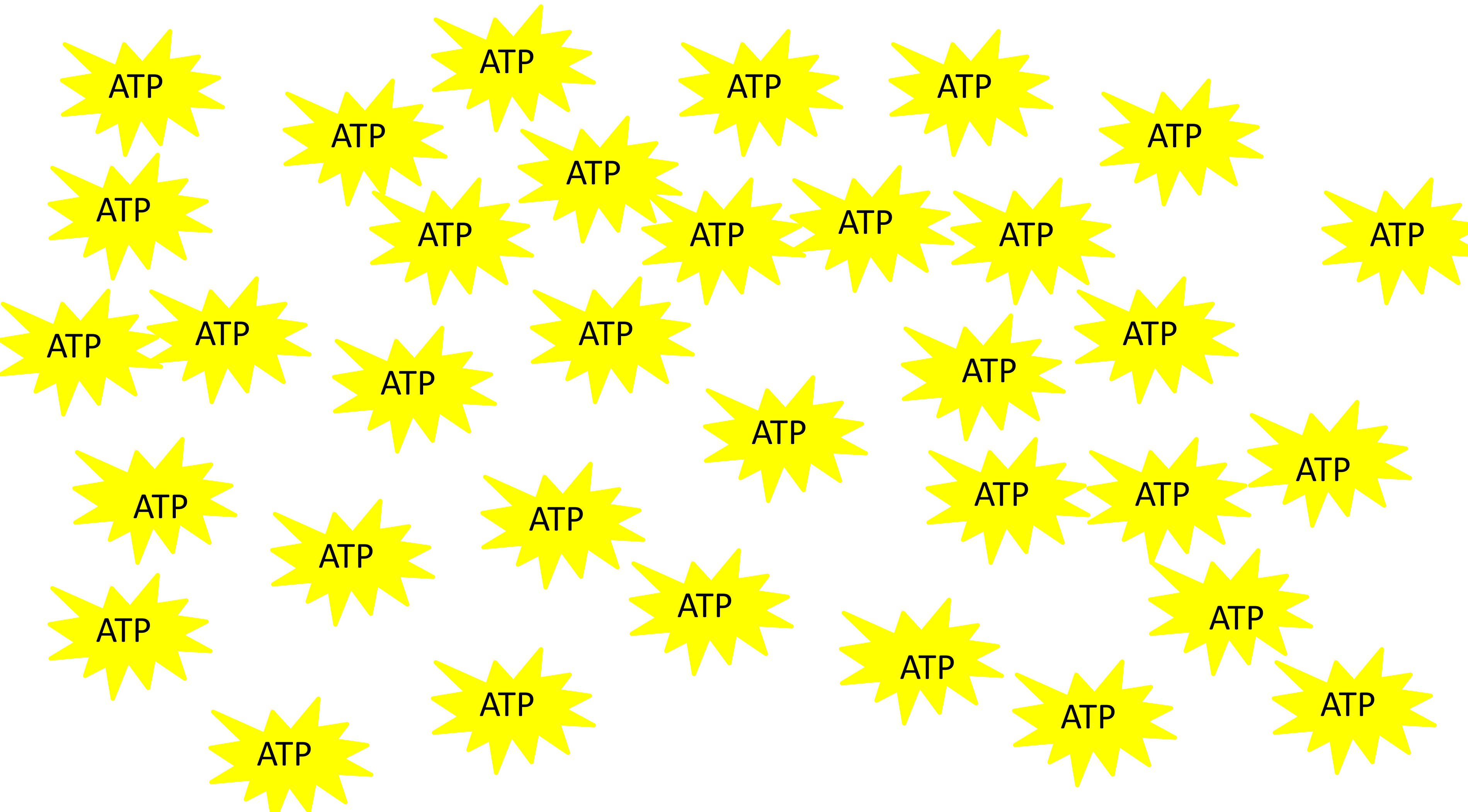


Electron Transport Chain

A. transfers e- from Kreb's cycle down a series of protein carriers
B. Energy given off is used to make ATP
C. terminal e- acceptor is oxygen TO H2O
D. occurs in the inner membrane
E. MAKES A WHOPPIN' +34 ATP…



Together the *Krebs Cycle* and the *Electron Transport Chain* make 34 ATP molecules!



Aerobic Respiration

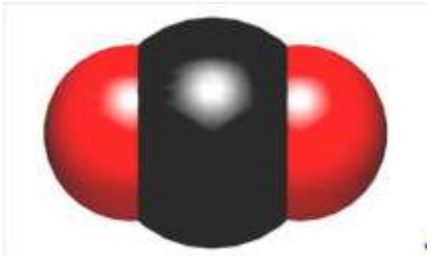
$O_2 + C_6H_{12}O_6 \rightarrow CO_2 + H_2O + Energy\ (ATP)$

Made in Krebs Cycle

Made in Electron Transport Chain

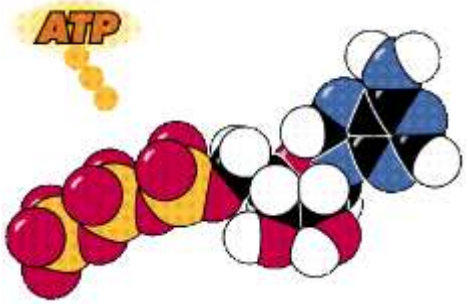
TOTAL PRODUCTS:

-CO_2



-H_2O

-ATP



Is there is oxygen available to the cell?

Glycolysis

YES!

NO!

Aerobic Respiration

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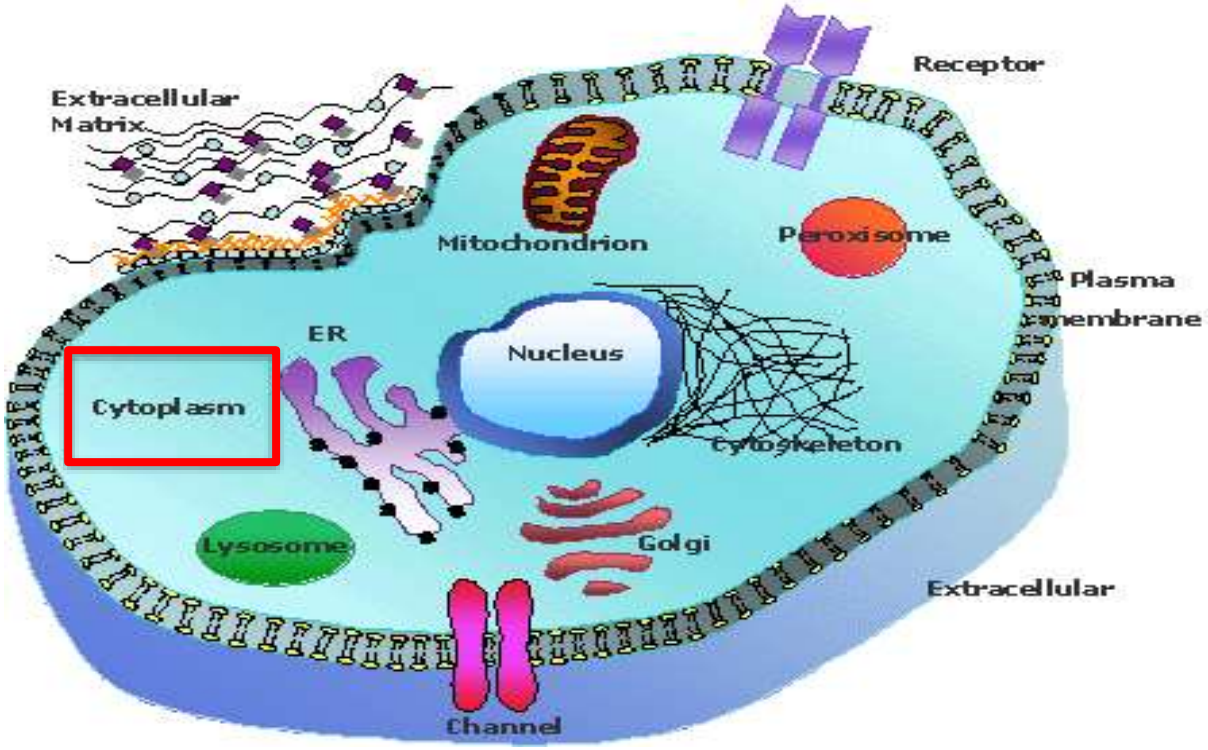
Anaerobic Respiration

Releasing energy from food molecules by producing ATP WITHOUT oxygen

Remember, anaerobic respiration happens in the _cytoplasm_.



2 types of **Anaerobic Respiration**

1. Lactic Acid Fermentation

2. Alcoholic Fermentation

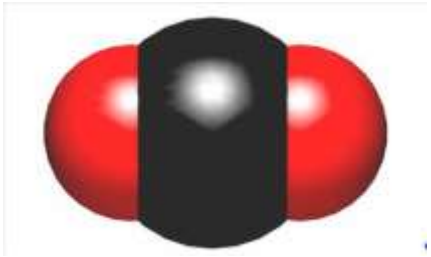
Anaerobic Respiration

$O_2 + C_6H_{12}O_6 \rightarrow CO_2 + H_2O + \text{Energy (ATP)}$

Even though anaerobic respiration is completed in a different way, the products are the same as in aerobic respiration!!!!!

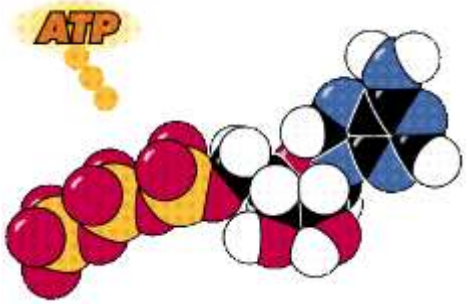
TOTAL PRODUCTS:

-CO_2



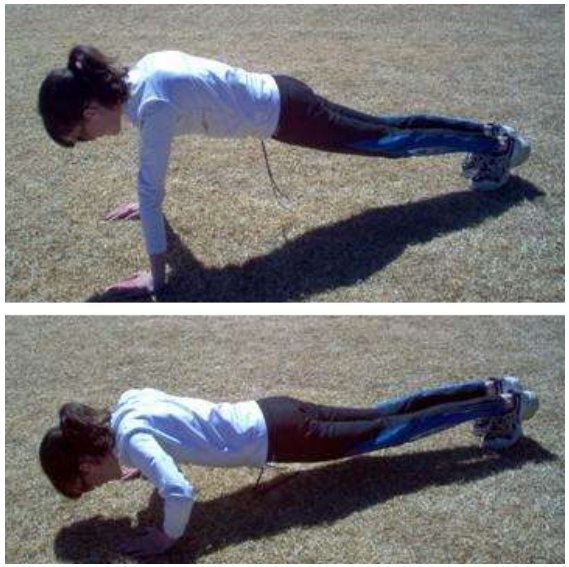
-H_2O

-ATP



Lactic Acid Fermentation: OUCH!

Occurs in ANIMAL cells when oxygen is ABSENT



# of mitochondria increase…

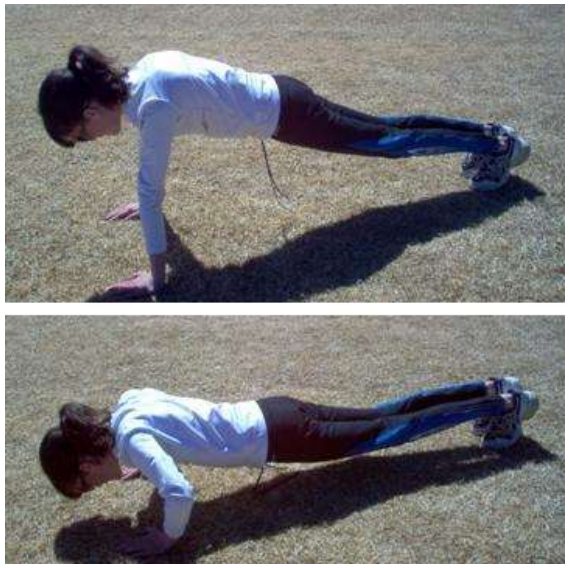
a. faster rise in O2 uptake at the onset of work to less O2 debt

2. Cramps & Charlie Horse

Occurs during rapid periods of exercise when the body cannot supply enough oxygen to the tissues/muscles

Lactic Acid Fermentation: OUCH!

Occurs in ANIMAL cells when oxygen is ABSENT



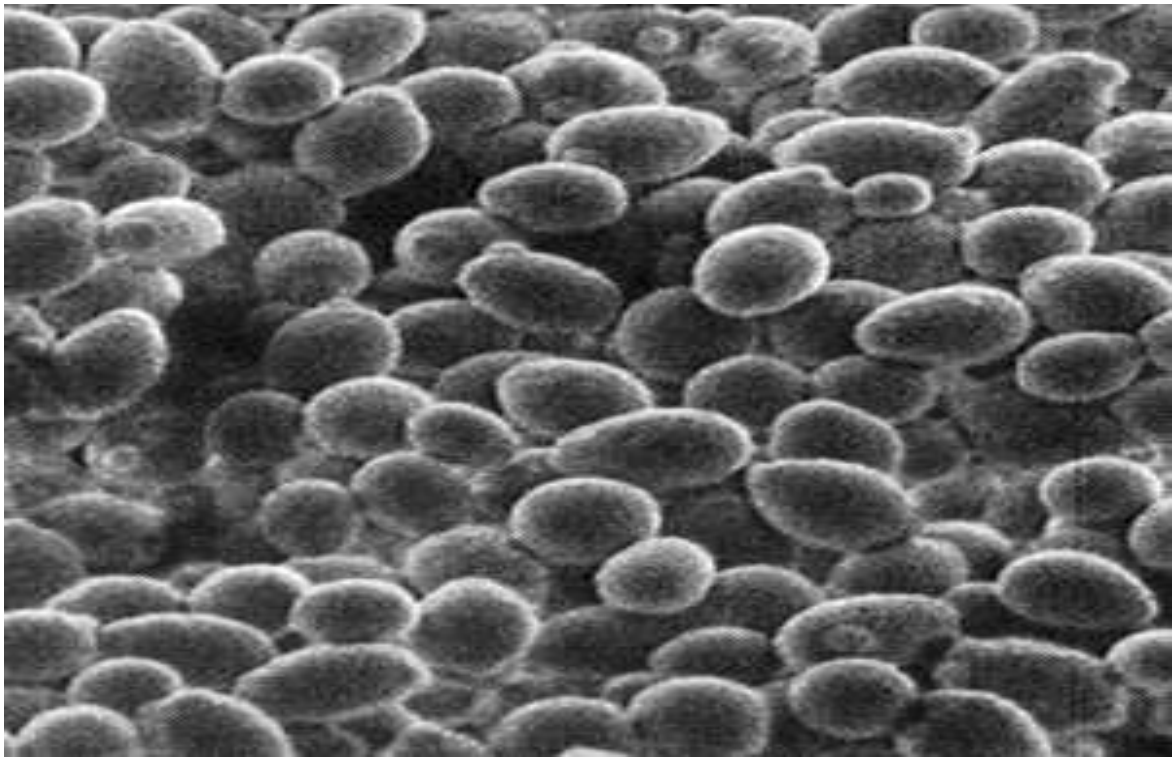
Animal cells store GLUCOSE as GLYCOGEN to use later. MUSCLES store glucose as GLYCOGEN which can be broken down into glucose to supply energy for 15-20 min of activity. THEN our body will start to burn fat after 20 min of aerobics!

Why do our muscles burn after we workout?

Lactic acid fermentation taking place in our muscles! $C_6H_{12}O_6$ -> CO_2 + Lactic + 2 ATP Acid a. occurs in muscles when body demands more E than can be supplied b. O_2 does not have enough time…

Alcoholic Fermentation

Occurs is PLANT cells and YEAST in the ABSENCE of oxygen



How does yeast make bread rise?

One of the products of alcoholic fermentation is carbon dioxide.

The carbon dioxide makes the little air pockets in bread and makes it rise. $C_6H_{12}O_6$ -> CO_2 + Ethanol + 2 ATP

a. performed by microorganisms; bacteria and yeast

b. CO_2 and bread rising