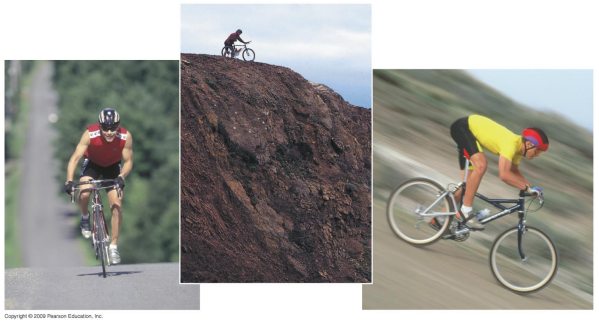
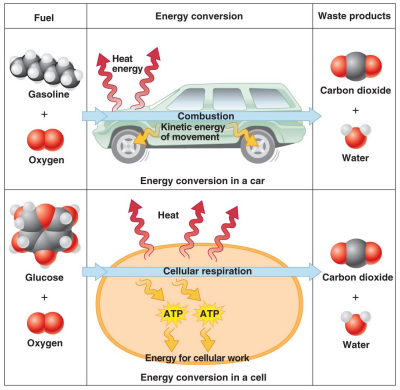
Biology – Chapters 8 & 9
Cellular Energetics

Honors Biology – Chapters 5b - 7
Cellular Energetics

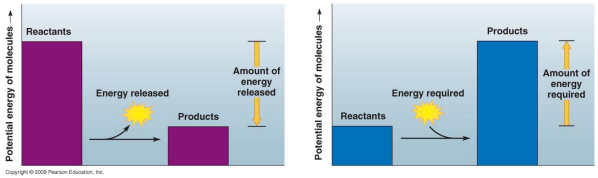
Ridgefield Memorial High School



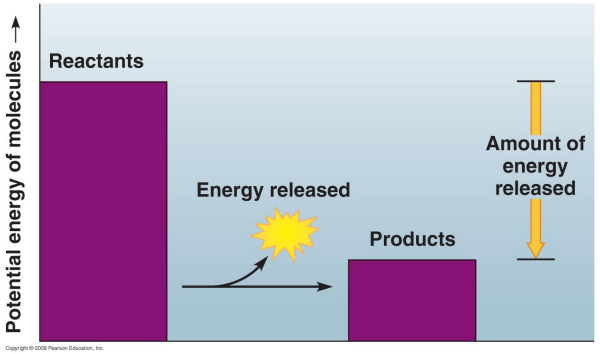
Potential energy is the ability to do something, as shown in the middle picture. In this case, the potential energy was converted into kinetic energy (the energy of motion).



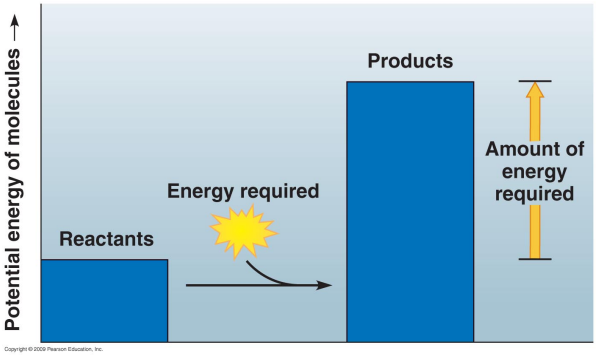
The burning of gasoline in a car is similar to the "burning" of glucose in a cell. There is "potential" chemical energy stored in the bonds of organic molecules.



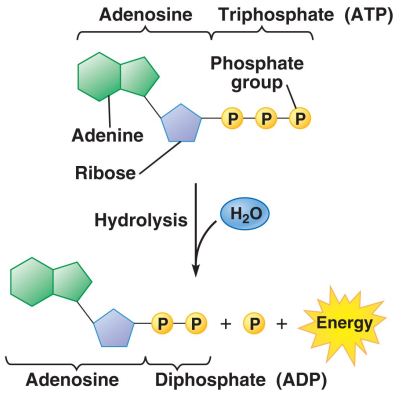
Some chemical reactions are exergonic, meaning they produce (release) energy.
Some chemical reactions are endergonic, meaning they absorb (require) energy.



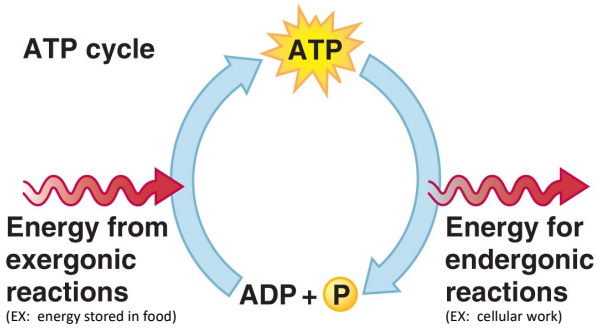
Some chemical reactions are exergonic, meaning they produce (release) energy.



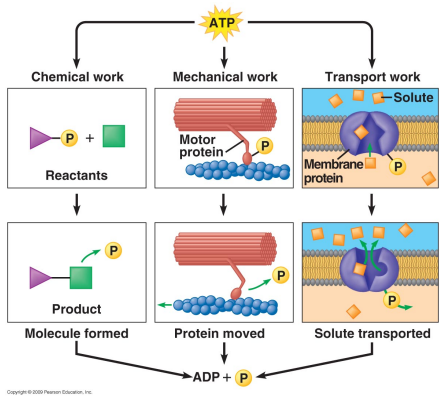
Some chemical reactions are endergonic, meaning they absorb (require) energy.



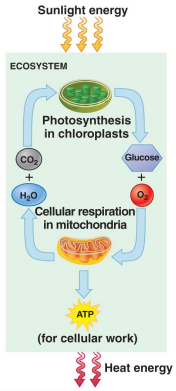
ATP is made of 1 adenosine and 3 phosphates. ADP is made of 1 adenosine and 2 phosphates. ATP contains a "high energy bond" in between the ADP and the third phosphate group.



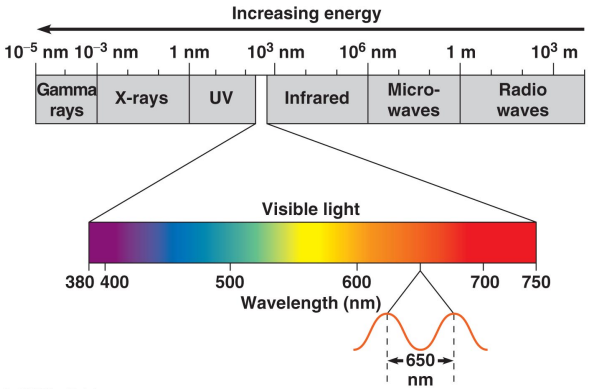
The energy from food (glucose) reattaches the phosphate back onto the ADP, forming ATP. This is the basic concept of cellular respiration.



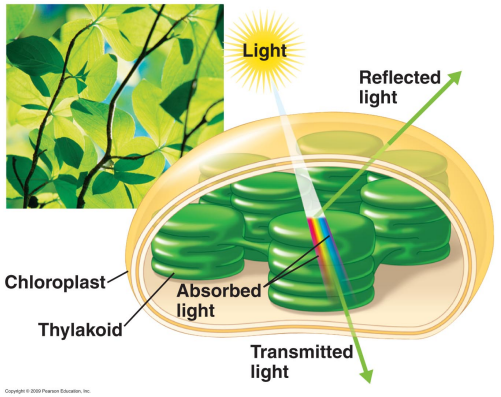
ATP is primarily used for chemical, mechanical, and transport work in cells.



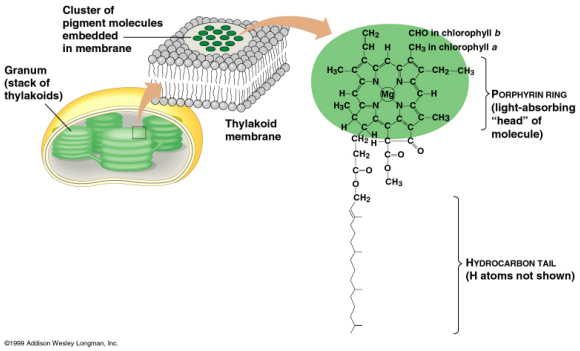
Plants perform photosynthesis, but animals AND PLANTS perform cellular respiration.



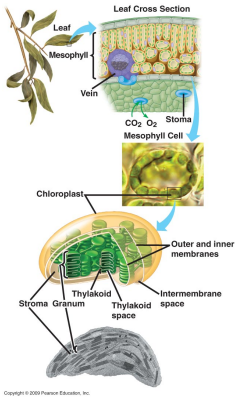
Red visible light has less energy than purple visible light.
There is an inverse (opposite) relationship between wavelength and energy.



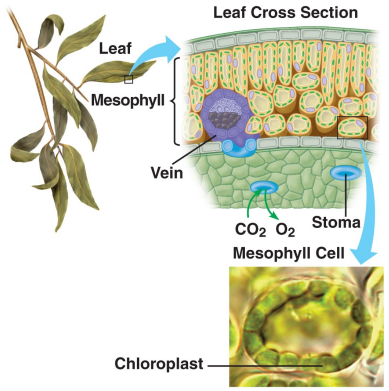
On a typical plant, green is reflected and all other colors are absorbed.



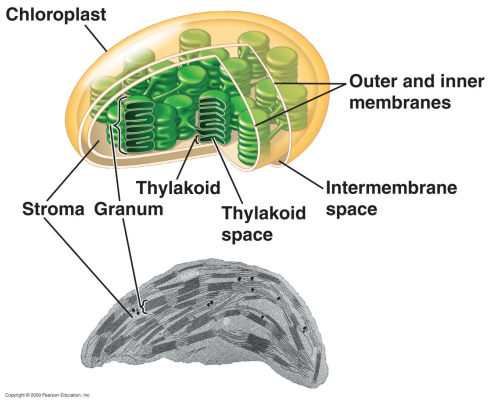
This is a chlorophyll molecule.
The magnesium (Mg) atom in the middle helps absorb sunlight.



Here are some of the levels of organization just within a leaf.

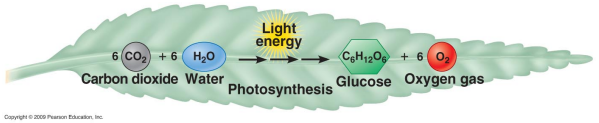


Leaves contain two adaptations to prevent water loss: a waxy cuticle
on the top side of the leaf and stomata (microscopic pores) on the bottom side.



The chloroplast has so many thylakoids to maximize surface area for photosynthesis.

These oxygen bubbles on an aquatic plant prove that it is doing photosynthesis.



In photosynthesis, carbon dioxide and water produce glucose
and oxygen gas (a waste product).

Reactants: 6 CO_2 12 H_2O

Products: $C_6H_{12}O_6$ 6 H_2O 6 O_2

The oxygen gas comes ONLY from the splitting of the water molecule.
Plants NEVER, EVER, EVER convert carbon dioxide into oxygen. THAT IS IMPOSSIBLE!!!

Photosynthesis

CO_2 (carbon dioxide) (from the air) + H_2O (water) (from the roots) → reactants (starts with this)

$C_6H_{12}O_6$ (glucose) + O_2 (oxygen gas) products (ends with this)

2 stages of photosynthesis:
1. Light Reactions
2. Dark Reactions

Light Reactions
$H_2O \rightarrow O_2$ } Where did the hydrogens go?

Dark Reactions
$CO_2 \rightarrow C_6H_{12}O_6$ } Where did the hydrogens come from?

Light Reactions

- called a "hydrolysis" reaction (water cutting or splitting)
- requires energy from the sun

H_2O (water splits into 3 parts using sunlight as energy)
1. H^+ = hydrogen ions } go to the dark reactions with the help of a chemical called NADPH
2. e^- = electrons
3. O_2 = oxygen gas → goes into the air (atmosphere)

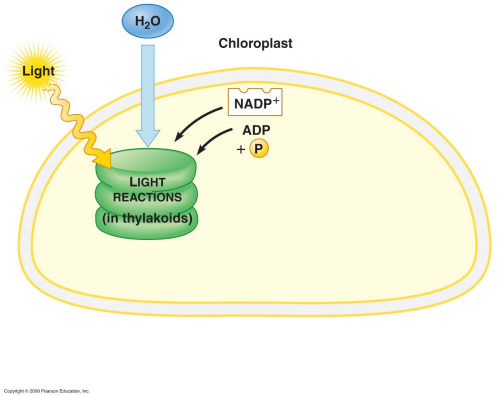
NADPH = nicotinamide adenine dinucleotide Phosphate hydrogen
NADPH is an "electron carrier" - it brings the hydrogens from the light reactions to the dark reactions
NADPH is like a taxi!
The energy from sunlight is saved in the form of ATP!

Dark Reactions

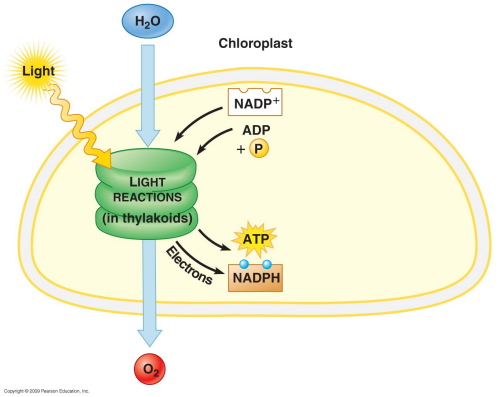
- called the "Calvin Cycle"

6 CO_2 + hydrogens from NADPH → $C_6H_{12}O_6$ glucose

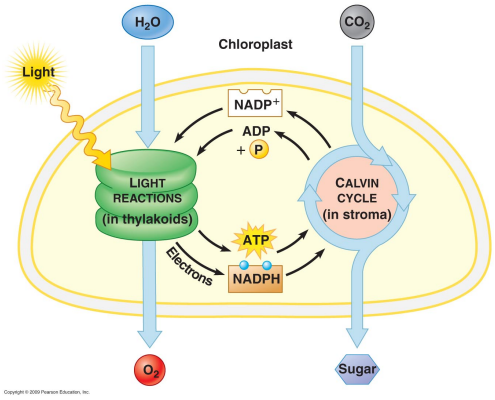
3 key players in the Dark Reactions
1. ATP = gives energy to build sugars
2. Rubisco = the main enzyme for the dark reactions
3. NADPH = brings the hydrogens and electrons from the light reactions to the dark reactions



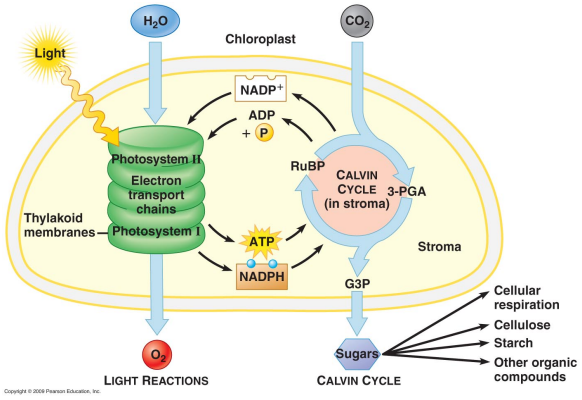
The ATP and NADPH made by the light reactions are used by the dark reactions.



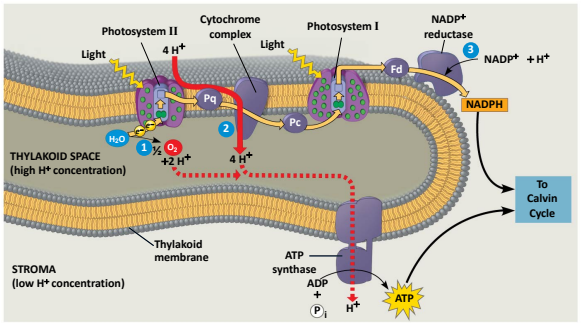
The ATP and NADPH made by the light reactions are used by the dark reactions.



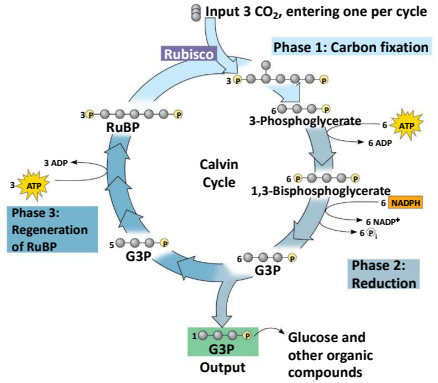
The ATP and NADPH made by the light reactions are used by the dark reactions.



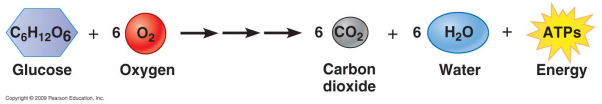
The ATP and NADPH made by the light reactions are used by the dark reactions.



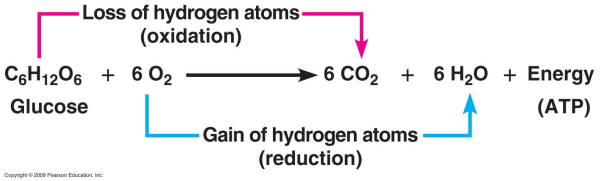
This is a much more detailed look at the light reactions of photosynthesis.
The light reactions are technically called the "light dependent reactions".



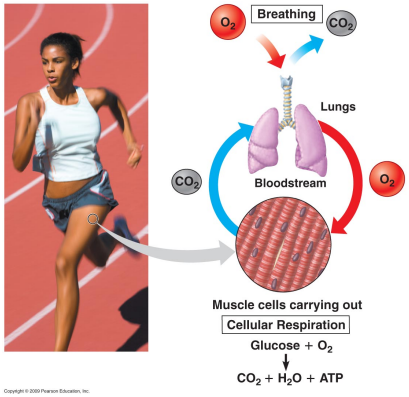
This is a much more detailed look at the dark reactions of photosynthesis. The dark reactions are technically called the "light independent reactions" or the Calvin Cycle.



In cellular respiration, glucose and oxygen gas produce carbon dioxide, water, and ATP.



Like photosynthesis, cellular respiration involves electron carriers to move hydrogens.



Cellular respiration is different (but related to) respiration, which means breathing.

TABLE 6.4 ENERGY CONSUMED BY VARIOUS ACTIVITIES (IN KCAL)

Activity	Kcal Consumed per Hour by a 67.5-kg (150-lb) Person*
Running (7 min/mi)	979
Dancing (fast)	510
Bicycling (10 mph)	490
Swimming (2 mph)	408
Walking (3 mph)	245
Dancing (slow)	204
Sitting (writing)	28

*Not including kcal needed for body maintenance

Your body "burns calories" by doing cellular respiration.

Cellular Respiration

Mitochondrion #3 is the best – it has the most surface area!

Goal of respiration: 32 ATP

$C_6H_{12}O_6$ + O_2 → CO_2 + H_2O

glucose — oxygen gas — carbon dioxide — water

reactants (starts with) — products (ends with)

opposite formula of photosynthesis

3 stages:
1. Glycolysis
2. Krebs Cycle
3. Electron Transport Chain (ETC)

3 stages:
1. Glycolysis
2. Krebs Cycle
3. Electron Transport Chain (ETC)

1. Glycolysis

Glucose splitting/cutting

C-C-C-C-C-C glucose

Splits here

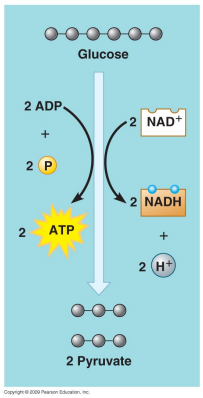
C-C-C C-C-C 2 pyruvates

pyruvate has 3 carbons (it is half of a glucose)

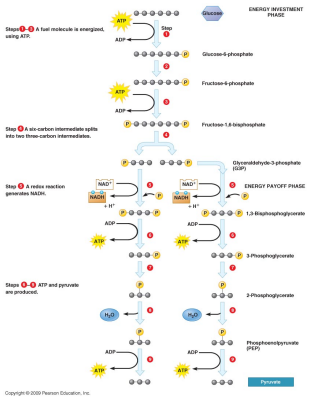
2 other things are made in glycolysis:

2 ATP and

VIP 2 NADH } carries hydrogens and electrons to the ETC



This is an overview of glycolysis...



...which is actually a complicated process that requires numerous steps and enzymes.

② Krebs Cycle

C-C-C C-C-C 2 pyruvates
(splits) (splits)

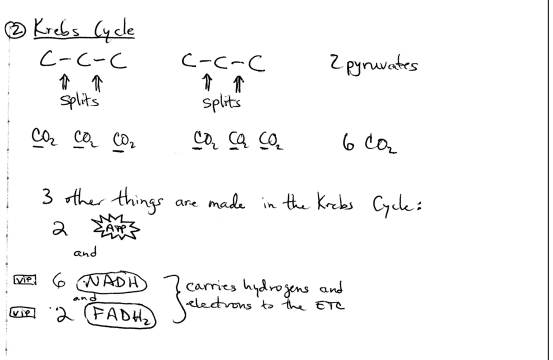
CO_2 CO_2 CO_2 CO_2 CO_2 CO_2 6 CO_2

3 other things are made in the Krebs Cycle:

2 ATP

and

6 NADH and 2 $FADH_2$ } carries hydrogens and electrons to the ETC



The Krebs cycle (also called the citric acid cycle) occurs next, and requires many more steps and enzymes.

③ ETC

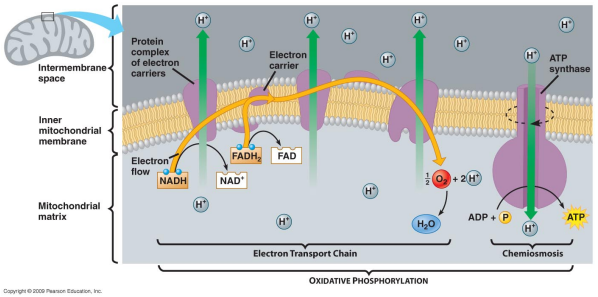
breathe in oxygen (O_2) and it combines with hydrogens to form H_2O

H's come from: 8 NADH and 2 $FADH_2$

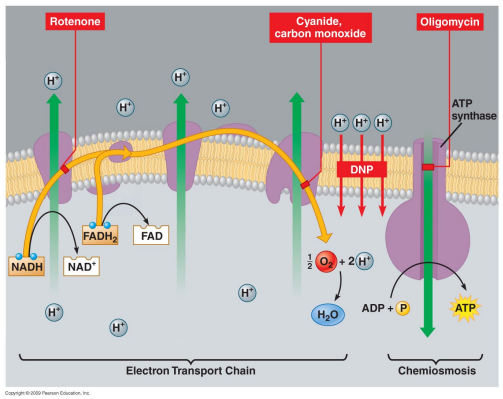
"Oxygen is the final electron acceptor." (oxygen receives the hydrogens and the electrons)

This process produces:

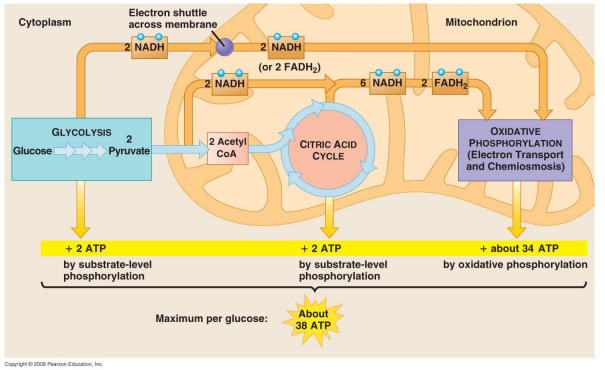
28 ATP



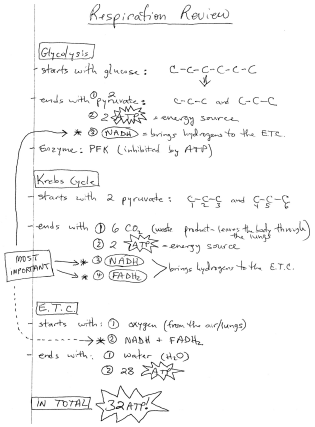
The third stage of cellular respiration is the electron transport chain (ETC).

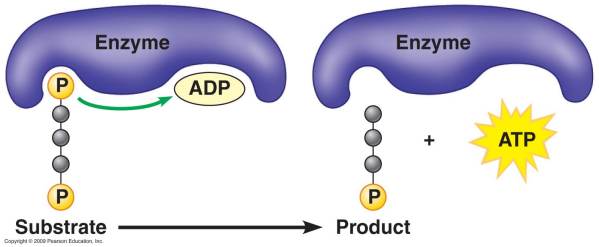


Various poisons can stop the ETC, which prevents a cell from producing 28-30 ATP.



The majority of the ATP is produced during stage 3, the electron transport chain.

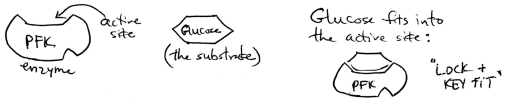




Enzymes are very much an important part of all 3 steps of cellular respiration.

Phosphofructokinase - "PFK"

PFK is the enzyme that controls glycolysis and all of cellular respiration



ATP can inhibit PFK and stop cellular respiration.

Yeast cells ferment the sugars in the grape juice, producing wine.

Fermentation

Aerobic → oxygen → Glycolysis = 2, Krebs Cycle = 2, ETC = 28 } 32 ATP

Anaerobic → no oxygen → Glycolysis = 2, Fermentation = 0 } 2 ATP

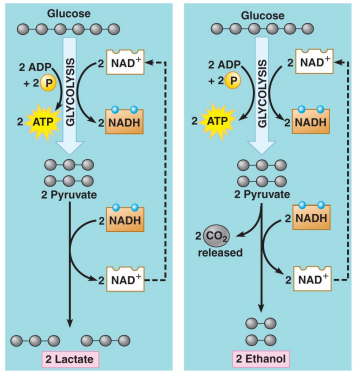
2 types of fermentation:

① Lactic Acid Fermentation:

- occurs in your muscles - produces the burning feeling
- starts with 2 pyruvates
- ends with lactic acids

② Alcohol Fermentation:

- occurs in yeast (EX: bread, beer)
- starts with 2 pyruvates
- ends with alcohols and CO_2
- CO_2 is what causes bubbles in beer and bread to rise



Fermentation occurs when a cell needs to make 2 ATP after all of the oxygen is used up. If fermentation occurs, it takes place immediately after glycolysis.