Section 4.4 & 4.5 Cellular Respiration

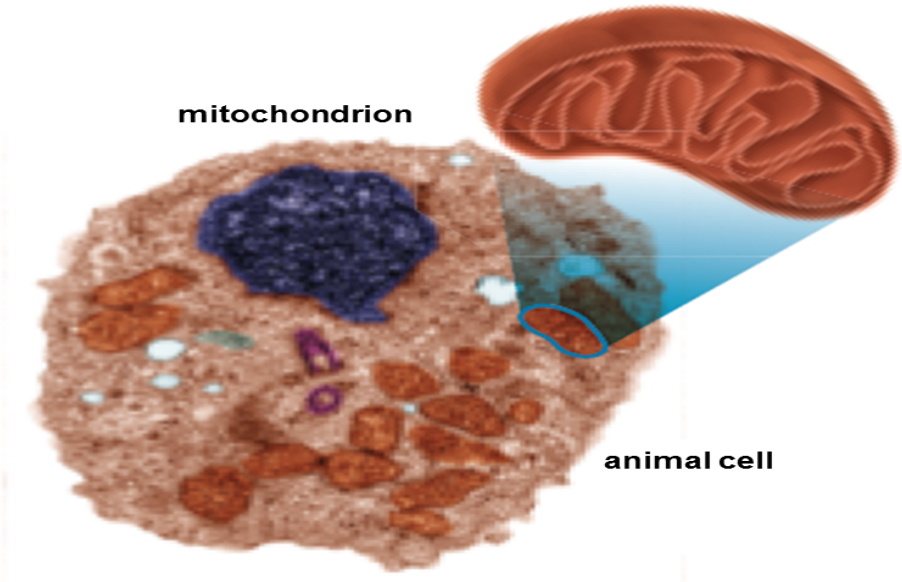
I. Oxidative Respiration

1. ***Plants*** and ***animals*** both do the process of cellular respiration.

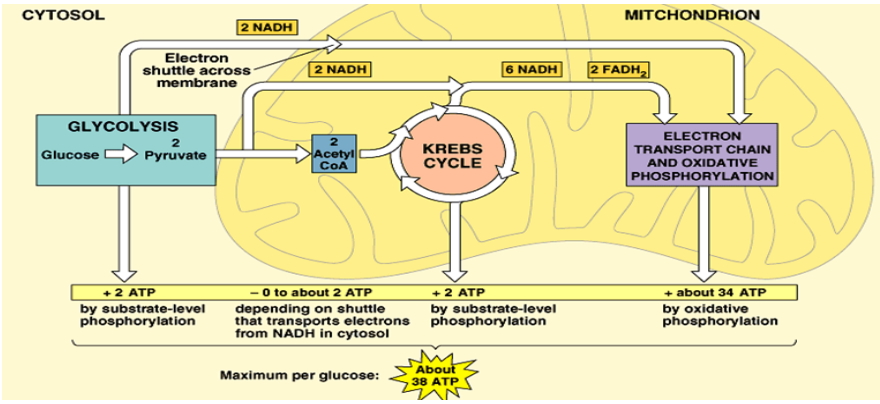
2. Cellular Respiration = **process by which the mitochondria *breaks down food molecules to produce ATP*** .

3. Cellular Respiration equation:

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O + 36\,ATP$$



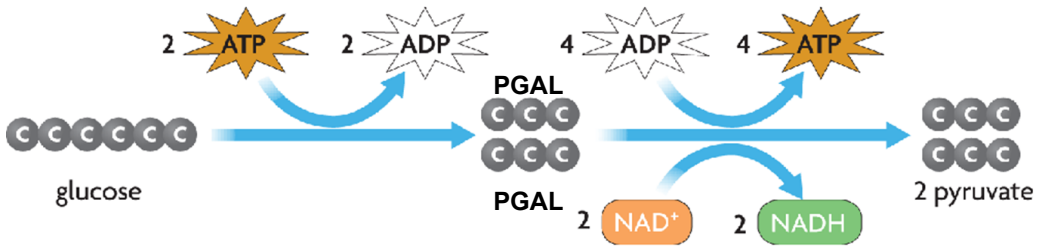
4. There are three stages of oxidative respiration:
   a. ***Glycolysis***
   b. ***Citric Acid Cycle*** or Krebs Cycle
   c. ***Electron Transport Chain***



A. Glycolysis

1. Glycolysis = series of chemical reactions in the ***cytoplasm*** of a cell that breaks down glucose into two molecules of ***pyruvic acid***.

2. As glucose is broken down, ***4 ATP*** molecules will have been created (which the cell ***uses 2*** molecules immediately) and also an additional ***energy carrier*** as well ***(NAD^+ to NADH)***, which will move on to the ***electron transport chain*** to be used later on to make additional ***ATP*** molecules.



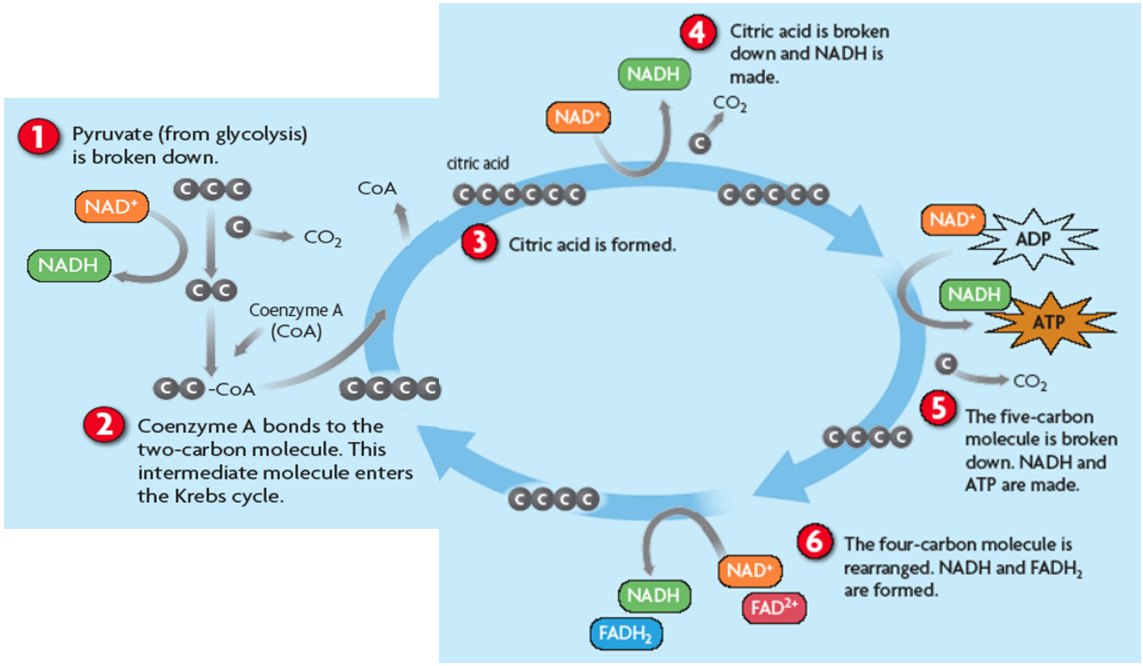
3. The **two pyruvic acid** molecules now move into the ***mitochondrion*** and enter the ***citric acid*** cycle to be further broken down and to release more energy.

B. The Citric Acid Cycle (Krebs Cycle)

1. This cycle take place in the ***matrix*** of the mitochondria.

2. This cycle **produces** ***two*** ATP molecules, ***four*** CO_2 molecules, and some additional ***energy carriers*****,** NAD^+ and FAD^+ ***to NADH and*** $FADH_2$.

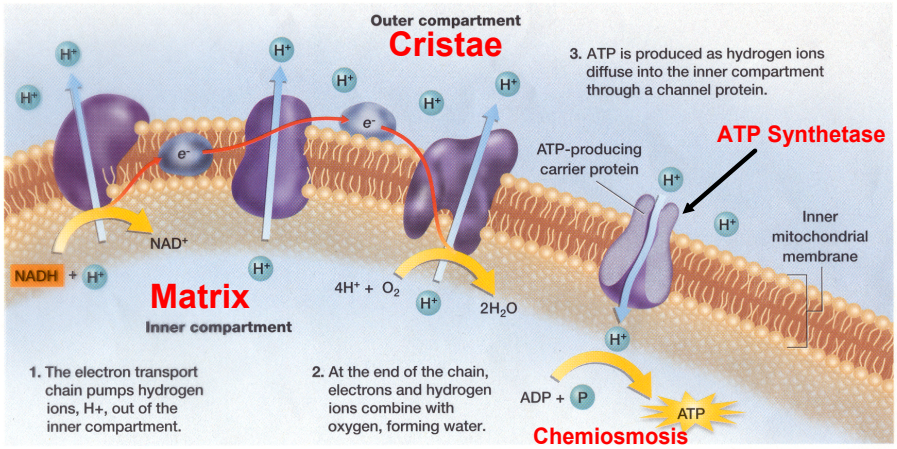
3. The CO_2 is ***released out*** of the cell, the ATP is ready to be ***used***, and the energy carriers **move on to the electron transport chain** to create more ***ATP*** molecules.



C. The Electron Transport Chain (System)

1. This process takes place in the ***inner*** membrane of the mitochondrion.
2. It uses ***oxygen*** and the energy carriers produced by ***glycolysis*** and the ***citric acid*** cycle to produce ***32*** ATPs.

** From the breakdown of just ***one*** glucose molecule, your cell gains ***36 to 38*** ATP molecules!**

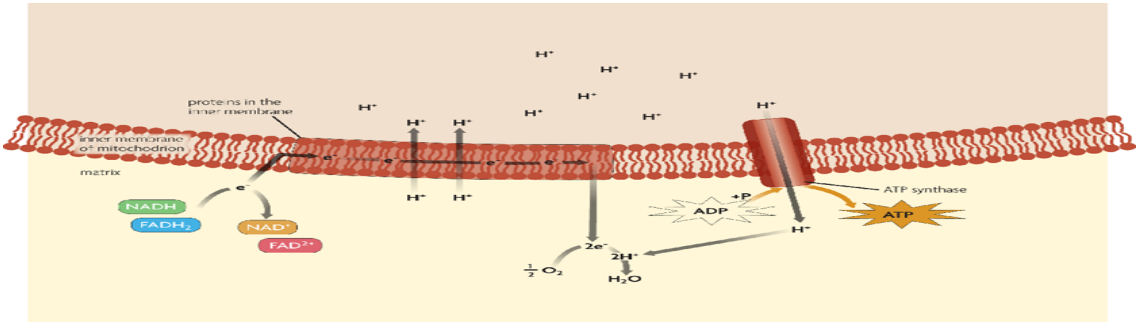


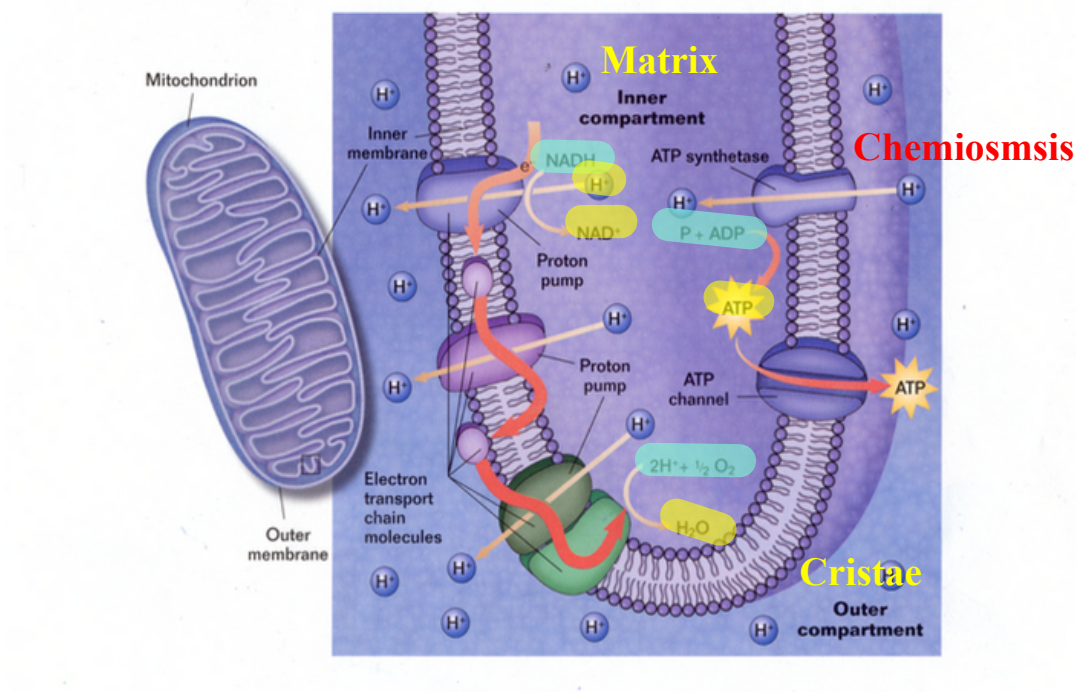
The electron transport chain in the mitochondrion is the site of ***oxidative phosphorylation*** in eukaryotes.

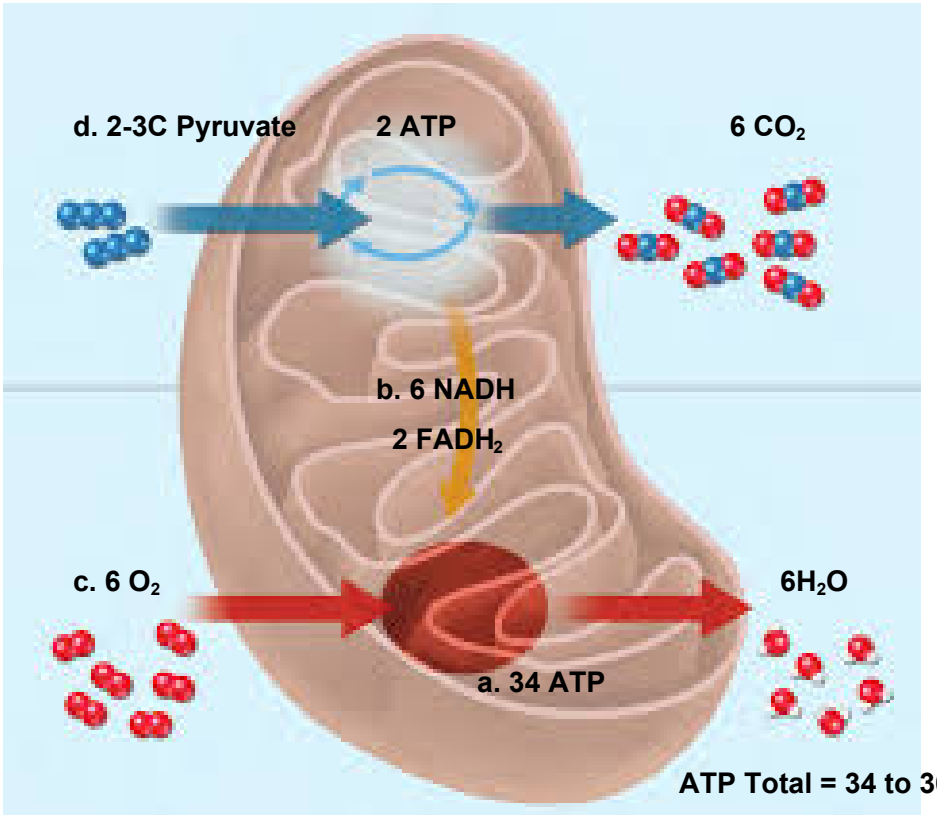
Chemiosomosis - the active transport of hydrogen (H^+) to make ATP.

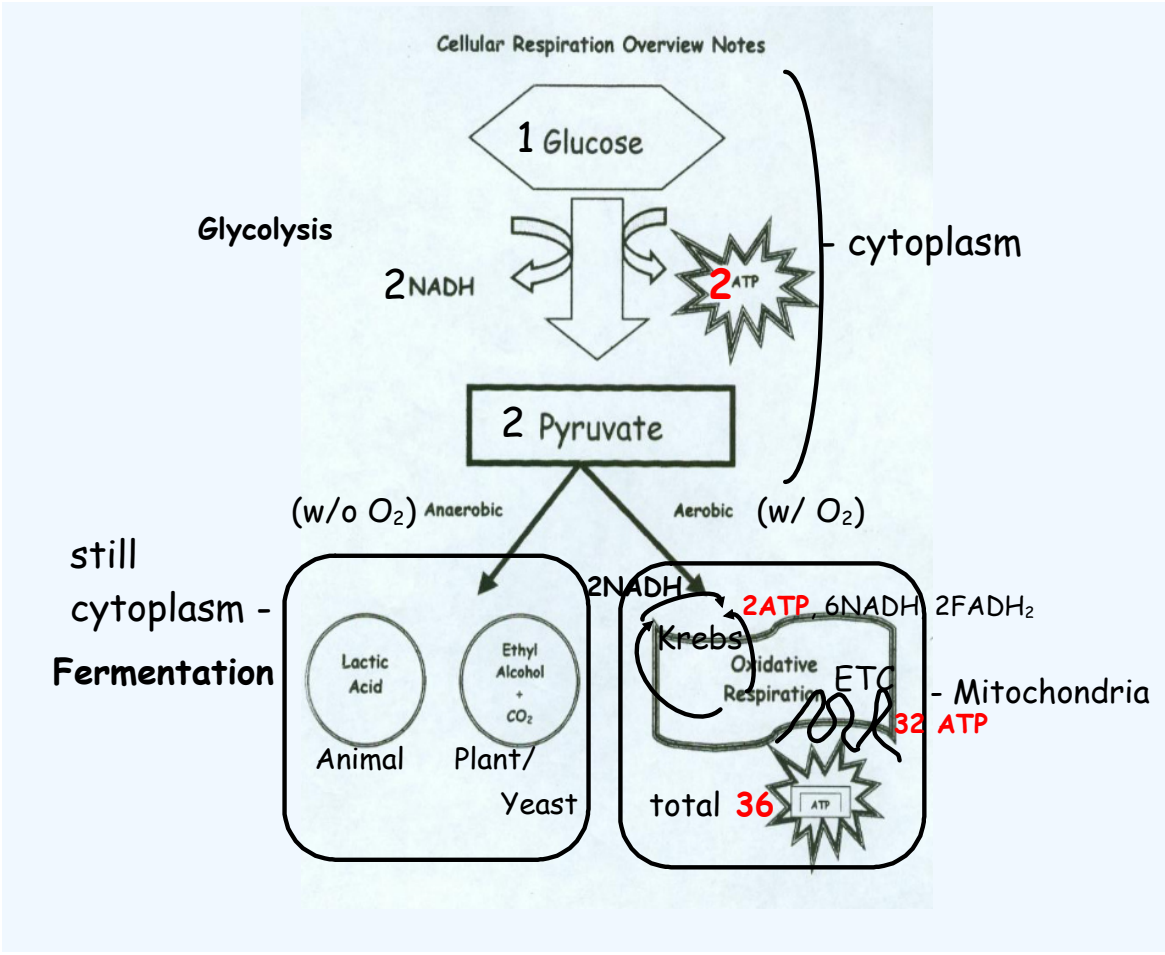
Phosphorylation - (oxidative) is a metabolic pathway that uses electrons transferred from ***electron donors*** (***$NADH$ & $FADH_2$*** generated in the Krebs Cycle) ***to electron acceptors*** (***O_2*** coming in from outside the mitochondion).

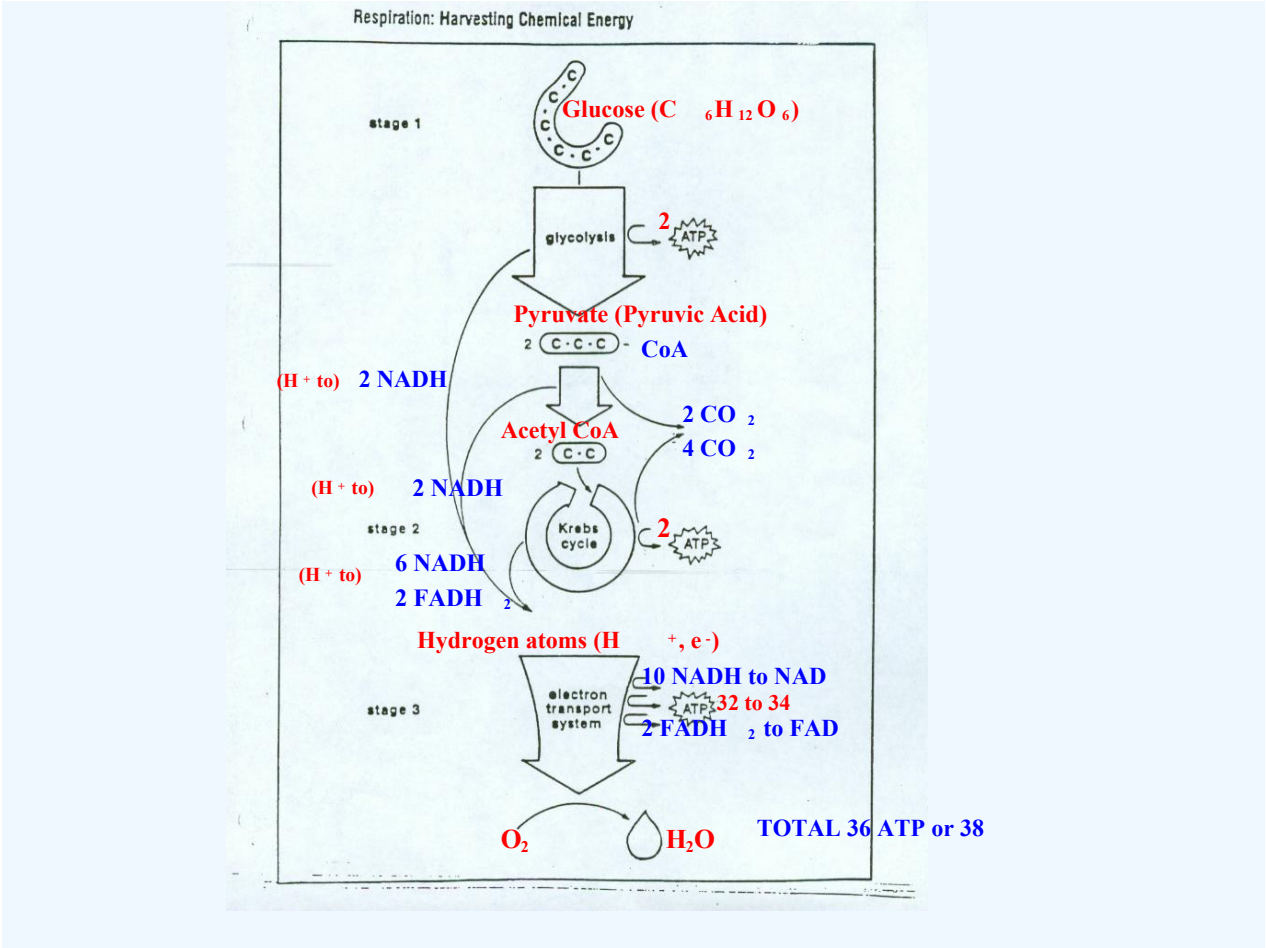
These ***redox*** reactions release energy, which is used to power ATP Synthase to form ***ATP*** & sending ***H^+*** thru to become **H_2O.**




Mitochondrion
Inner membrane
Outer membrane
Matrix
Inner compartment
NADH
NAD+
ATP synthetase
P + ADP
ATP
Proton pump
Proton pump
ATP channel
ATP
2H+ + ½ O2
H2O
Electron transport chain molecules
Cristae
Outer compartment
Chemiosmsis


d. 2-3C Pyruvate
2 ATP
6 CO2
b. 6 NADH
2 FADH2
c. 6 O2
6H2O
a. 34 ATP
ATP Total = 34 to 36


Cellular Respiration Overview Notes
1 Glucose
Glycolysis
2NADH
2 ATP
- cytoplasm
2 Pyruvate
(w/o O_2) Anaerobic
Aerobic (w/ O_2)
still
cytoplasm -
Fermentation
Lactic Acid
Animal
Ethyl Alcohol + CO_2
Plant/ Yeast
2NADH
2ATP, 6NADH 2$FADH_2$
Krebs
Oxidative Respiration
ETC
- Mitochondria
32 ATP
total 36
ATP


Respiration: Harvesting Chemical Energy
stage 1
Glucose ($C_6H_{12}O_6$)
glycolysis
2 ATP
Pyruvate (Pyruvic Acid)
2 C·C·C - CoA
(H+ to) 2 NADH
Acetyl CoA
2 C·C
2 CO_2
4 CO_2
(H+ to) 2 NADH
stage 2
Krebs cycle
2 ATP
(H+ to) 6 NADH
2 $FADH_2$
Hydrogen atoms (H^+, e^-)
stage 3
electron transport system
10 NADH to NAD
ATP 32 to 34
2 $FADH_2$ to FAD
O_2
H_2O
TOTAL 36 ATP or 38

II. Comparing Photosynthesis and Cellular Respiration

What do you notice?

Photosynthesis:

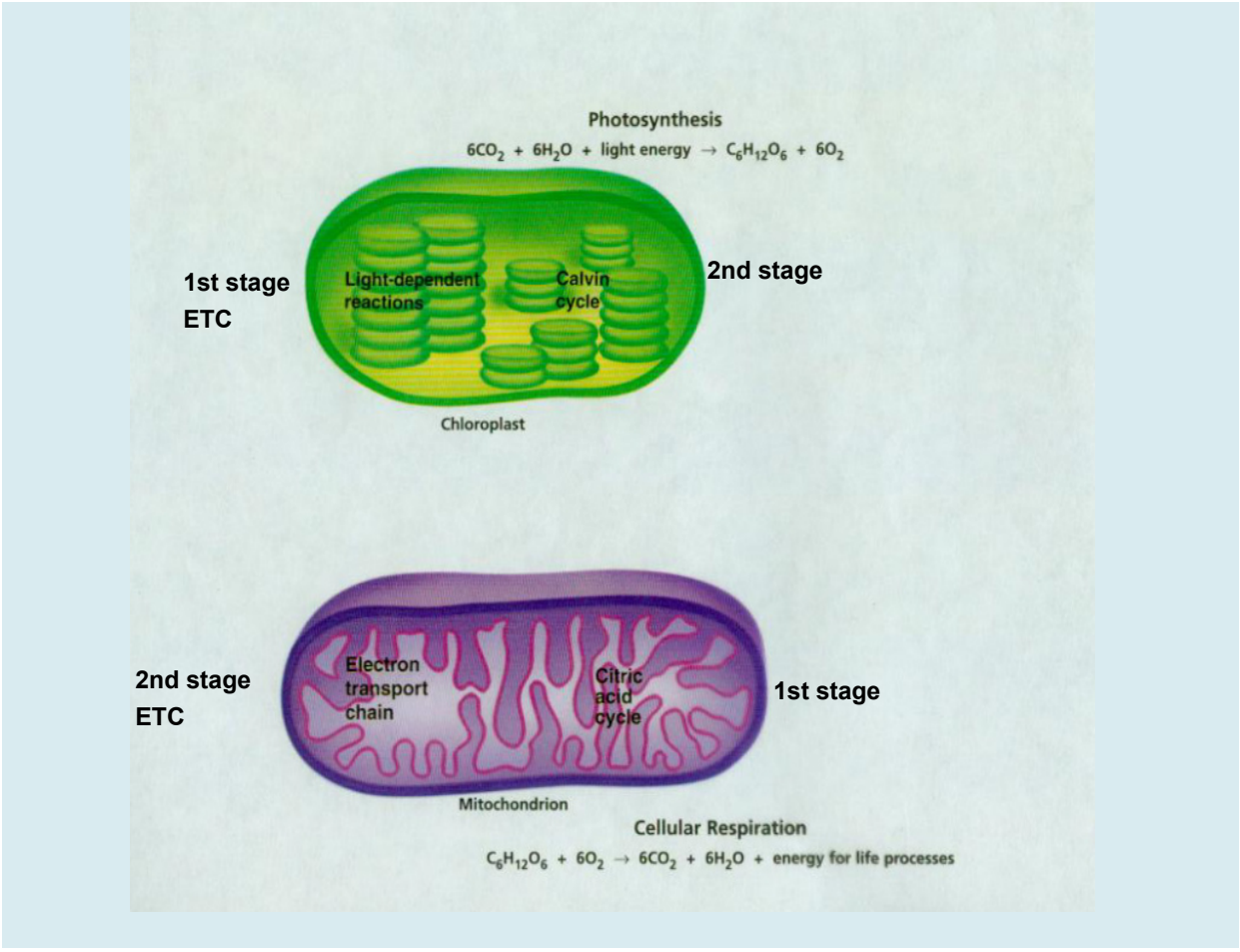
$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6\,O_2$$

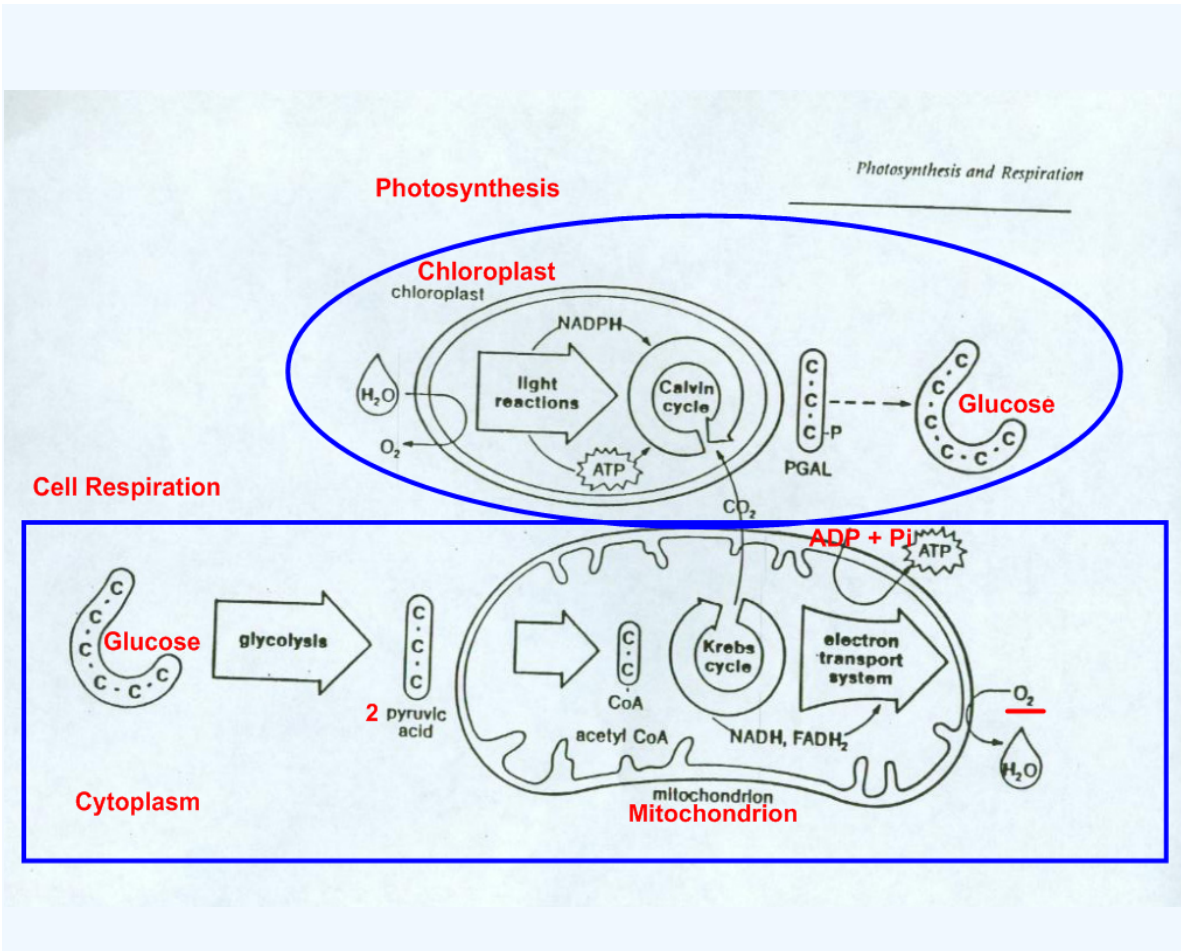
Cellular Respiration:

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O + 36\,ATP$$

The products of one process are the reactants of the other.

Photosynthesis	Cellular Respiration
1. Food *synthesized (made)*.	1. Food *broken down*.
2. Energy from sun *stored* in glucose.	2. Energy of glucose *released*.
3. CO2 taken *in*.	3. CO2 given *off*.
4. O2 given *off*.	4. O2 taken *in*.
5. Produces simple sugars.	5. Produces $CO_2 + H_2O$
6. *Requires* light.	6. Does *not* require light.


Photosynthesis
$6CO_2 + 6H_2O$ + light energy → $C_6H_{12}O_6 + 6O_2$
1st stage
ETC
Light-dependent reactions
Calvin cycle
2nd stage
Chloroplast
2nd stage
ETC
Electron transport chain
Citric acid cycle
1st stage
Mitochondrion
Cellular Respiration
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy for life processes


Photosynthesis and Respiration
Photosynthesis
Chloroplast
chloroplast
NADPH
H_2O
light reactions
Calvin cycle
O_2
ATP
PGAL
P
Glucose
Cell Respiration
CO_2
ADP + Pi
ATP
Glucose
glycolysis
2 pyruvic acid
CoA
acetyl CoA
Krebs cycle
NADH, $FADH_2$
electron transport system
O_2
H_2O
Cytoplasm
mitochondrion
Mitochondrion

Section 4.6 Fermentation

*There are times, such as heavy ***exercise***, when your cells are without ***oxygen*** for a short period of time.

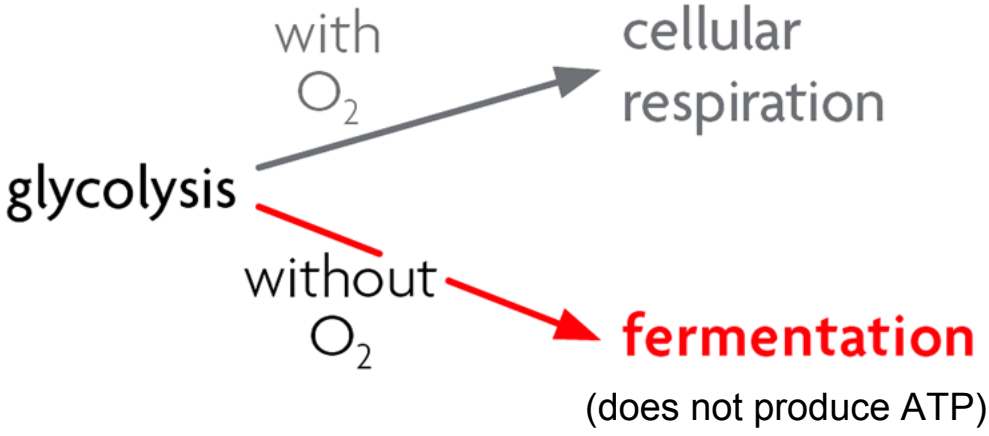
*When this happens, ***fermentation*** takes place instead of cellular respiration.

*There are two types of fermentation:

a. ***Lactic acid*** fermentation

b. ***Alcoholic*** fermentation

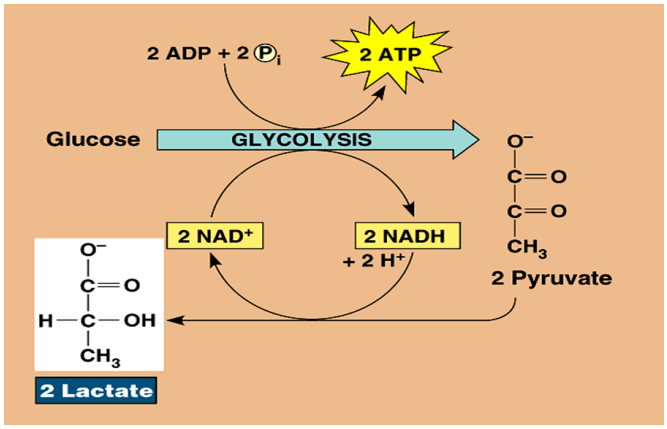
Fermentation is an anaerobic process that allows glycolysis to continue.



A. Lactic Acid Fermentation

1. This is an anaerobic process, which occurs in the ***cytoplasm*** of cells of ***animals***.
2. Process of what happens:

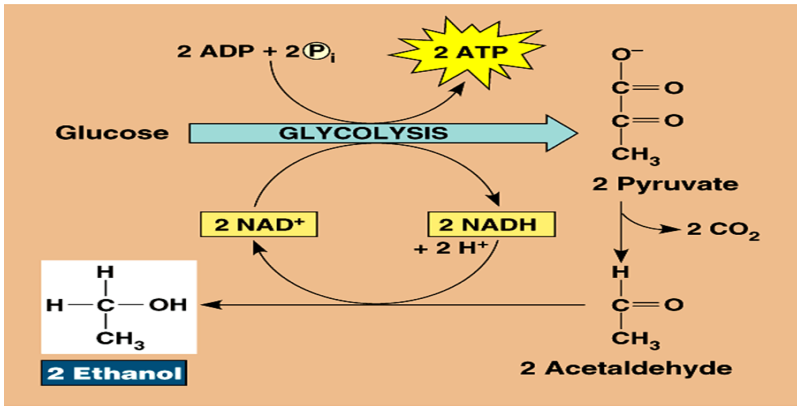
Glucose → Glycolysis (pyruvic acid) →
Lactic Acid **+** ***2*** **ATPs**
(from Glycolysis)



B. Alcoholic Fermentation

1. This is anaerobic process, which occurs in the ***cytoplasm*** of cells of ***plants, yeast*** cells, and some ***bacteria***.
2. Process of what happens:

Glucose →Glycolysis (pyruvic acid) →
CO_2 **+** ***Ethyl Alcohol*** **+** ***2*** **ATP** ***(from Glycolysis)***



- Fermentation is used in food production.
  - cheese
  - yogart
  - bread