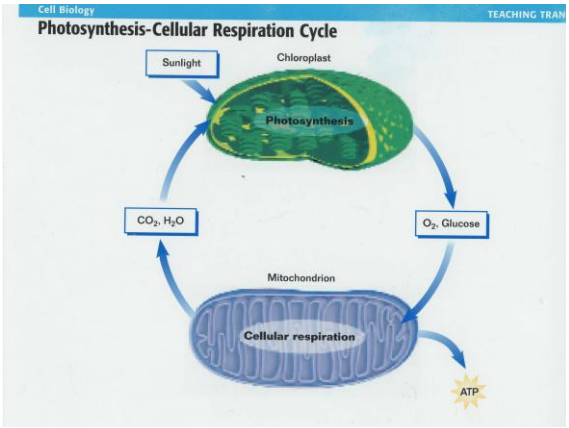
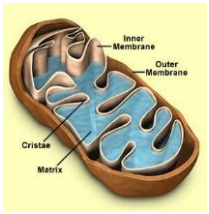
CELLULAR RESPIRATION

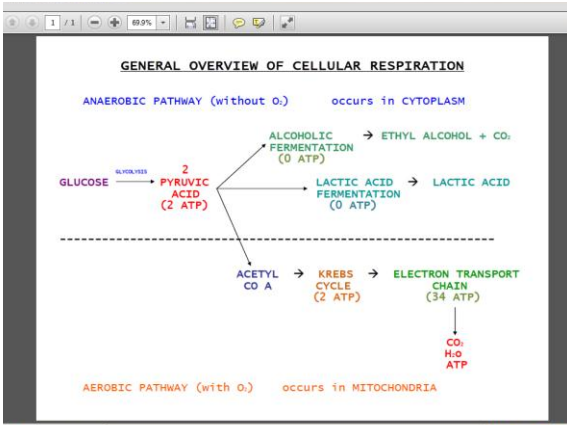


Cellular Respiration

complex process whereby cells make ATP by breaking down organic compounds

location: mitochondrial cristae





Glycolysis
(Glucose/breaking)

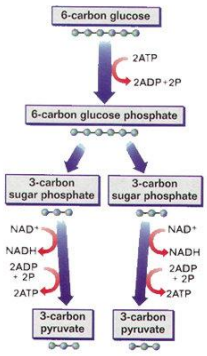
Process where one molecule of GLUCOSE (6 C) is broken down into 2 molecules of PYRUVIC ACID (3 C)

- occurs in cytoplasm
- occurs before respiration or fermentation

Glycolysis: 4 Major Steps

1. Unstable 6C glucose is formed
   ***** uses 2 ATP *****
2. This molecule breaks down into 2 3C compounds
3. phosphate group is added to each 3C molecule
4. **PYRUVIC ACID and 4 ATP** is formed

End products
2 pyruvic acid + 2 ATP



2 Possible Pathways for 2 Pyruvic Acid

If O2 present	If no O2 present
respiration	fermentation
(aerobic)	(anaerobic respiration)
mitochondria	cytosol

If no oxygen is present the 2 pyruvic acid will go into anaerobic respiration (fermentation)

FERMENTATION

1. **Lactic Acid Fermentation** (animals)
   - A. As O2 is consumed in aerobic respiration, it becomes scarce
   - B. NADH is broken down and donates its H to pyruvic acid
   - C. resultant NAD returns to glycolysis where it is converted to NADH (cyclical- happens over and over again)
   - D. lactic acid forms from pyruvic acid

   causes muscle pain and soreness

2. **Alcoholic Fermentation** (yeasts, plant cells, microorganisms)
   - converts pyruvic acid to ethyl alcohol
   - A. CO2 molecule is removed from Pyruvic acid (3C) leaving a 2 C compound
   - B. 2 H (from NADH + H ion) are added to 2C compound to form ethyl alcohol
   - C. NAD+ is formed (back to glycolysis)

   causes alcohol in beer and wine, air bubbles in bread, beer, and wine**

NO ATP FORMED IN FERMENTATION

PURPOSE OF FERMENTATION:
TO REGENERATE NAD+ FOR GLYCOLYSIS

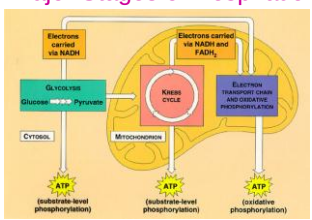
RESPIRATION (aerobic)

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

Process of breakdown of pyruvic acid in the presence of oxygen

- prokaryotic cells: occurs in cytosol
- eukaryotic cells: occurs in mitochondria
- much more efficient than anaerobic respiration

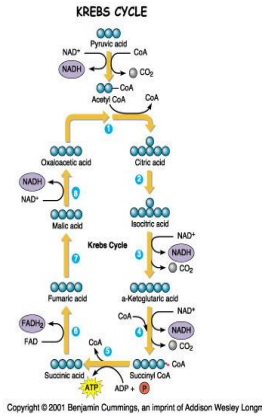
2 Major Stages of Respiration



1. **krebs cycle (2 ATP made)**
   - oxidation of glucose is completed
   - NAD+ is reduced to NADH
2. **electron transport chain (34 ATP made)**
   - NADH is used to make ATP
   - location where most ATP is made

2 pyruvate (from glycolysis)
↓
Acetyl Co A
goes into Krebs cycle
↓
Citric Acid
converted into → CO2 given off
↓
4 C compound
converted into → 1 ATP made, 2 NADH made
↓
another 4 C compound
converted into → FADH2 made
regenerated for first step
↓
Oxaloacetic Acid made for first step to combine with acetyl Co A
(cyclical process)

animation



IN SUMMARY

1 glucose → 2 pyruvate (glycolysis)
forms
2 acetyl co A
therefore
1 glucose causes 2 turns of the Krebs Cycle

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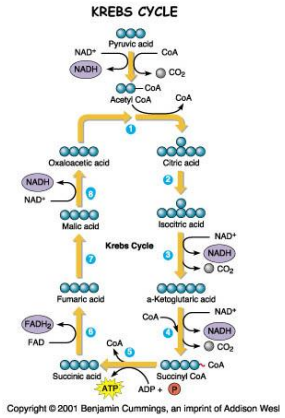
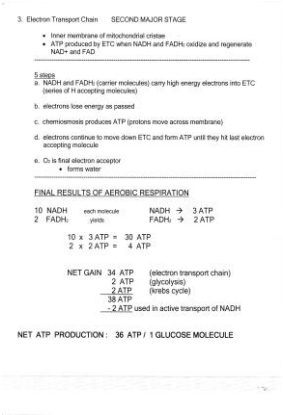
each molecule of Acetyl Co A produces:
3 NADH (carries H+)
1 FADH2 (carries H+)
1 ATP

END NET GAIN

3 NADH		6 NADH
1 FADH2	X 2 =	2 FADH2
1 ATP	mols	ATP
2 CO2		4 CO2 (waste)

***** NADH and FADH2 drive the electron transport chain *****




3. Electron Transport Chain SECOND MAJOR STAGE

- Inner membrane of mitochondrial cristae
- ATP produced by ETC when NADH and FADH2 oxidize and regenerate NAD+ and FAD

5 steps
a. NADH and FADH2 (carrier molecules) carry high energy electrons into ETC (series of H accepting molecules)

b. electrons lose energy as passed

c. chemiosmosis produces ATP (protons move across membrane)

d. electrons continue to move down ETC and form ATP until they hit last electron accepting molecule

e. O2 is final electron acceptor
- forms water

FINAL RESULTS OF AEROBIC RESPIRATION

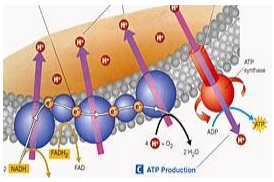
10 NADH each molecule yields NADH → 3 ATP
2 FADH2 yields FADH2 → 2 ATP

10 x 3 ATP = 30 ATP
2 x 2 ATP = 4 ATP

NET GAIN 34 ATP (electron transport chain)
2 ATP (glycolysis)
2 ATP (krebs cycle)
38 ATP
-2 ATP used in active transport of NADH

NET ATP PRODUCTION : 36 ATP / 1 GLUCOSE MOLECULE

- Process of extracting ATP from NADH and $FADH_2$



animation

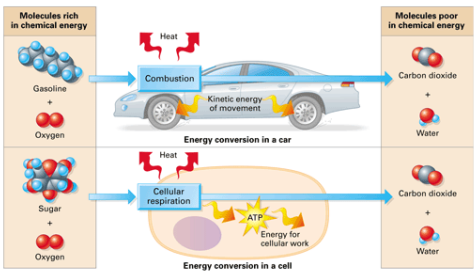
Remember...
photosynthesis and respiration are exact opposite processes.

Look at the general equations for both…….what do you notice?

$6\ CO_2 + 6\ H_2O + \text{light energy} \rightarrow C_6H_{12}O6 + 6\ O_2$

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

Both are needed for all of life's activities.



Both engines and cells use oxygen to convert the potential energy in complex molecules to energy that can be used for work.