**Cellular Respiration**

(production of ATP by the oxidation of food molecules)

**Glycolysis** (1st step of all respiratory pathways)

occurs in the _______ of the cell; has ___ steps catalyzed by ___ enzymes

(produces a lot of ATP in the absence of oxygen; similar to aerobic respiration but uses an inorganic molecule other than oxygen as a final electron acceptor; found in a few bacteria)

(produces a lot of ATP using oxygen as the final electron acceptor; main form of respiration in most organisms)

(produces a very small amount of ATP in the absence of oxygen; uses an organic molecule as a final electron acceptor)

(each with much potential energy available in its bonds)

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**Lactic Acid Fermentation**
(skeletal muscle fibers, some bacteria)

**Fermentation**

**Alcohol Fermentation**
(yeast)

Fermentation occurs in normally aerobic organisms in the absence of _____. Without oxygen, the prep steps, citric acid cycle and electron transport chain cannot proceed. The purpose of fermentation is to regenerate the coenzyme ______ for use in glycolysis. (There is only a limited number of NAD⁺ molecules that must be continually recycled in order for the oxidation of glucose to continue. Since fermentation pathways involve only glycolysis, they generate only _____ net ATP's per molecule of glucose.)
Aerobic respiration
(follows glycolysis in most cells)

“prep steps”
(occur in the ________
of the ________)

Acetyl group

CH\(_2\)O

NAD\(^+\)

CoA

Acetyl coA

(from glycolysis)

citric acid cycle (Krebs cycle)
(occurs in the ________
of the ________)

\(\text{\facilitates NAD}^+\) and FADH

Ketoglutaric acid

(5 carbons)

Succinic acid

(4 carbons)

Maleic acid

(4 carbons)

NAD\(^+\)

ADP

FAD

H\(^+\)

NADH (x2) = ________ NADH

FADH\(_2\) (x2) = ________ FADH\(_2\)

Record what is yielded by the prep steps and citric acid cycle. The left column shows the products for one pyruvic acid. Double these numbers to fill in the second column – the yield for a molecule of glucose.

\(\text{\facilitates NAD}^+\) and FADH

Energy from the flow of ________

down the electron transport chain is used to actively transport pairs of ________'s from the matrix to the intermembrane space. These flow back into the matrix through a channel associated with the enzyme _________. For each pair of H\(^+\)'s that flow through, the enzyme can catalyze the formation of one ATP. Since the electrons carried by NADH allow 3 pairs of H\(^+\)'s to be pumped, ________ ATP's can be made. The electrons carried by FADH\(_2\) enter the chain later so only 2 pairs of H\(^+\)'s are pumped. These electrons allow ________ ATP's to be made.

Summary of Maximum Energy Yield from the Oxidation of One Molecule of Glucose

<table>
<thead>
<tr>
<th></th>
<th>In the Cytoplasm</th>
<th>In the Mitochondria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycolysis:</td>
<td>(\text{--ATP})</td>
<td>(\text{--ATP}^*)</td>
</tr>
<tr>
<td>From glycolysis:</td>
<td>(\text{NADH} \rightarrow \text{--ATP}) (x2)</td>
<td>(\text{NADH} \rightarrow \text{--ATP}) (x2)</td>
</tr>
<tr>
<td>From respiration:</td>
<td>(\text{Acetyl CoA: NADH} \rightarrow \text{--ATP})</td>
<td>(\text{NADH} \rightarrow \text{--ATP}) (x2)</td>
</tr>
<tr>
<td>Krebs cycle:</td>
<td>(\text{FADH}_2)</td>
<td>(\text{--ATP})</td>
</tr>
<tr>
<td>Total:</td>
<td>(\text{--ATP})</td>
<td>(\text{--ATP})</td>
</tr>
</tbody>
</table>

* In some cells, the energy cost of transporting the electrons from the NADH molecules formed in glycolysis across the inner mitochondrial membrane lowers the net yield from these 2 NADH to 4 ATP; thus the total maximum yield in these cells is 36 ATP.