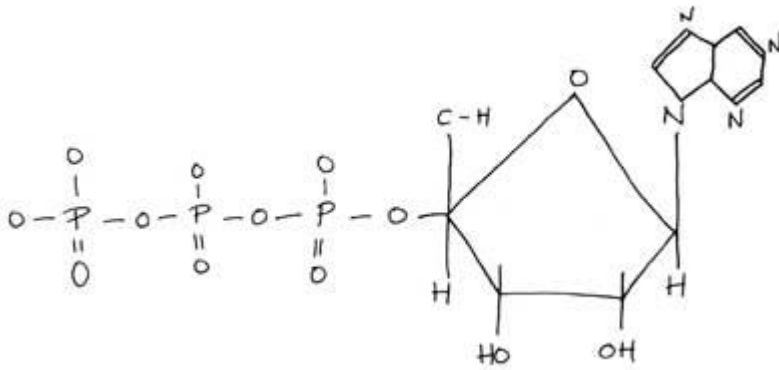


Respiration

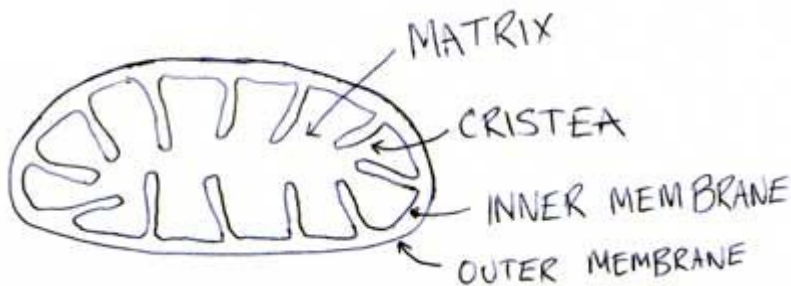
Respiration is a set of metabolic reactions and processes that take place within the cells of organisms. It stores biochemical energy within adenosine triphosphate (ATP) molecules. There are two types of respiration, aerobic and anaerobic. Respiration is also the process of making ATP rather than breaking it down.

ATP (Adenosine triphosphate)



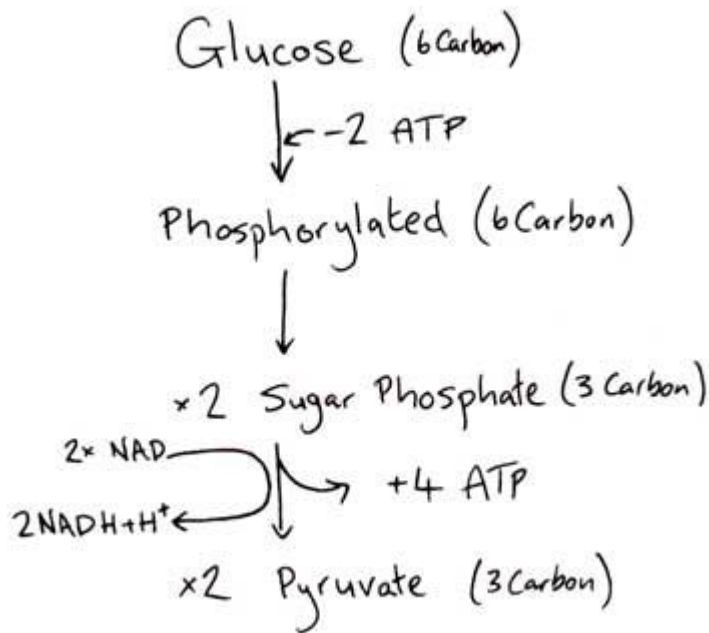
- ATP is the main energy storage and transfer molecule in the cell. It's a **nucleic acid** similar to RNA.
- It's formed from ADP (Adenosine diphosphate) + P_i and consists of a ribose sugar, a nitrogenous base (adenine) and three phosphate groups each carrying a negative charge.
- $ATP + H_2O = ADP + P_i + H^+ = 30.6Kj$
- This reaction is catalysed by the enzyme ATPase

Mitochondria



The diagram above shows the usual mitochondria which would be found in a eukaryotic cell. As seen, it contains an outer and inner membrane along with folds in the inner membrane called cristea. The center of the mitochondria is called the matrix. This is the site of action where the Krebs cycle and the ETC (electron transport chain) occur.

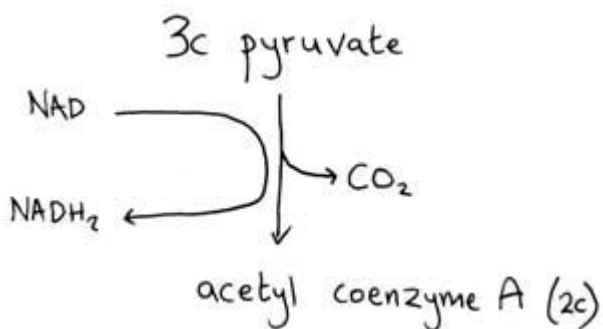
1. Glycolysis



The conversion to phosphorylated is simply to make it more reactive and the conversion to sugar phosphate easier.

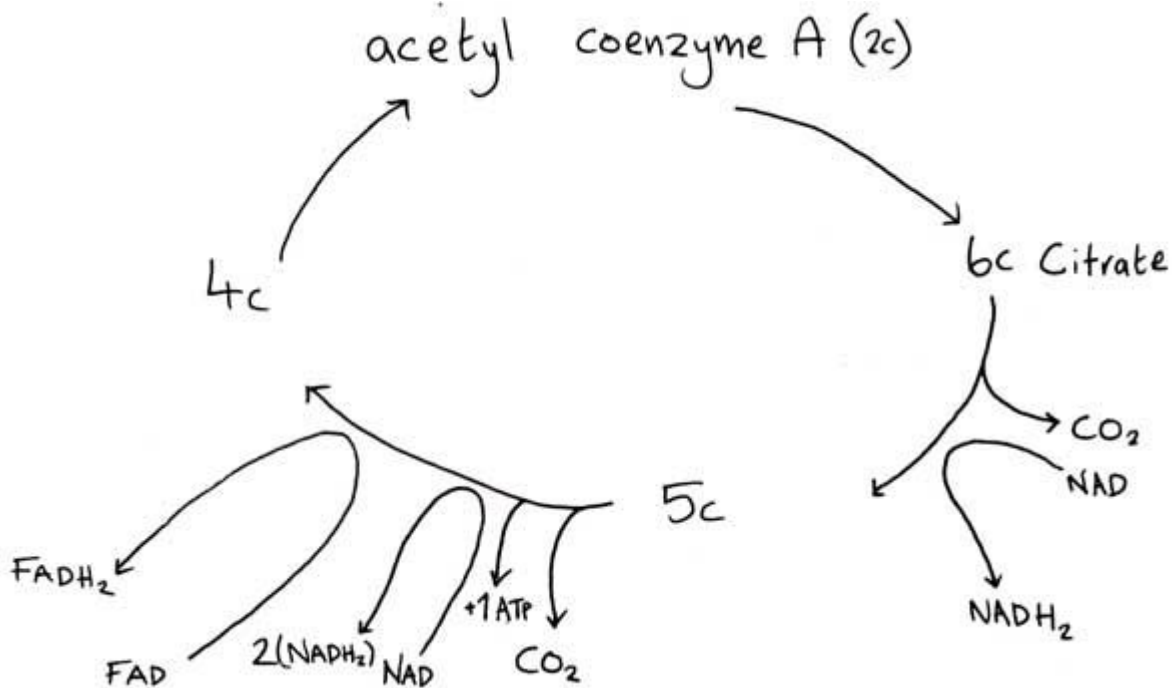
- This is the first stage of three in respiration and takes place within the cytoplasm of the cell.
- Glycolysis is the same process for aerobic and anaerobic respiration.
- In this process the cell gains a net of 2 ATP molecules.

2. The Link Reaction



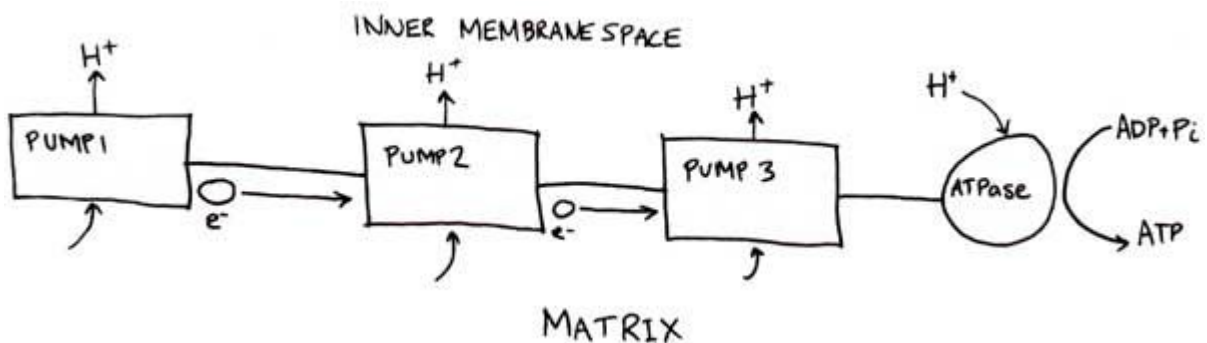
Pyruvate or Pyruvic acid then diffuses from the cytoplasm into the matrix of the mitochondria. Here it gets converted into acetyl coenzyme A, which is a two carbon structure. A carbon was lost through the release of CO₂.

3. The Krebs Cycle



- The function of the Krebs Cycle is a way to liberate energy from carbon bonds to provide ATP and reduced NAD with the release of carbon dioxide.
- NADH_2 and FADH_2 produced by the Krebs cycle are used under aerobic conditions to supply electrons for the electron transport chain but also to supply protons for the proton pumps, across the inner membrane.
- At the end of this process you are left with 6 CO_2 compounds, 4 ATP molecules, 10 NADH_2 and 2 FADH_2 .
- The Krebs cycle happens twice as much as glycolysis because at the end of glycolysis two, three carbon pyruvates are formed and only one is used during each turn of the krebs cycle.

3. Electron Transport Chain



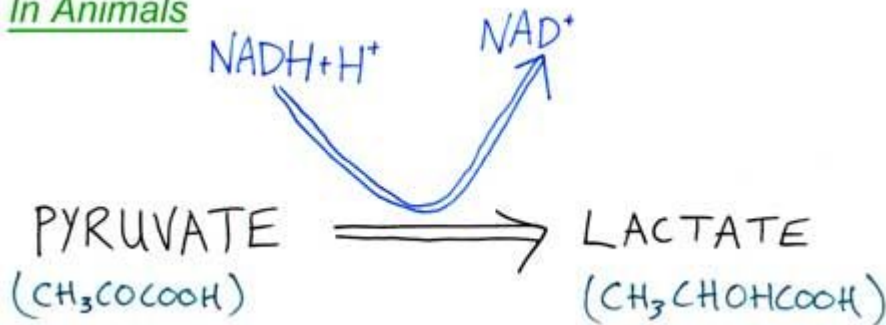
- The third stage consists mainly of the movement of H^+ , carried by NADH_2 , from the matrix into the intermembrane space via proton pumps in the mitochondria. Then once the H^+ molecules are in the intermembrane space they can then pass back through the ATPase into the matrix forming ATP. As you can see from the diagram below ADP is used in this reaction along with P_i (organic phosphate molecule) to form ATP.
- There is a higher H^+ concentration in the inter-membrane space which is why the proton pumps are required.

- The NADH₂ from the Krebs cycle when beginning the electron transport cycle get converted into two electrons (e⁻) and two hydrogen's (H⁺).
- Once the electrons lose their energy they can be used in the formation of H₂O

Anaerobic Respiration

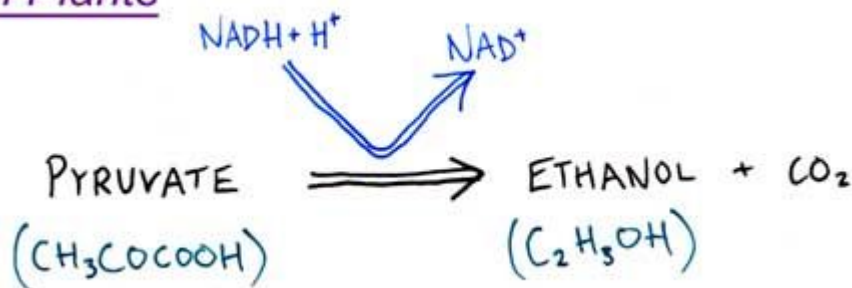
- The process of anaerobic respiration is similar to the aerobic respiration. The first stage, glycolysis, is the same because it doesn't require oxygen but it does require NAD⁺.

In Animals



- In aerobic respiration the electron transport chain turns NADH back into NAD with the aid of oxygen and thus recycles the NAD. With anaerobic respiration the shortage of oxygen in the cells means that they must find another way to convert NADH back into NAD, this process is called fermentation.
- Lactate fermentation occurs in mammals when there is a deficiency of oxygen. It has many advantages including strenuous exercise and oxygen demand under water. It works by each pyruvate molecule produced taking up two hydrogen molecules (from glycolysis) to form lactate. This then leaves the NAD⁺ to be recycled.
- The lactate produced can cause problems in itself, it's a toxic chemical and can form cramp in muscles. This lactate can be taken away from the cells by the blood to the liver to be converted into glycogen.

In Plants



- In plants fermentation occurs but not in the form of lactate but instead producing ethanol and CO₂.

The Respiring of Fats and Proteins



How Fats and Proteins get respired without oxygen.

- Fats and proteins can also be used to respire. When fats are about to be respired they are broken down into fatty acids and glycerol. The glycerol is converted into triose phosphate and enters the glycolysis stage. The fatty acids are broken down into two carbon fragments and entered into the Krebs cycle via acetyl co-enzyme A.
- Proteins cannot be stored by mammals so have to either be used or excreted.

- The respiration of proteins only occurs when there is an excess of them in the diet. To begin their process the amino group is removed (called deamination). The amino group then combines with CO₂ forming urea, later to be excreted. The remains of the amino acid, now without an amino group, are called organic acids and are fed back into the Krebs cycle.

Respiratory Quotient

Respiratory Quotient, or RQ for short, is a number used in estimating carbon dioxide production. The equation to find the RQ is:

$$\text{RQ} = \text{CO}_2 \text{ Released} / \text{O}_2 \text{ Used}$$

For example the question might ask: The equation to calculate the oxidation of a lipid is



Use the equation to calculate the respiratory quotient of this lipid. Show your workings.

And the answer? Using the RQ equation you can see we need to know the amount of CO₂ Released and the amount of O₂ Used. This will be 57 for CO₂ and 80 for O₂. $57 / 80 = 0.71$

An easier question would be: what's the RQ for this equation, $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 = 6\text{CO}_2 + 6\text{H}_2\text{O}$ Try it!