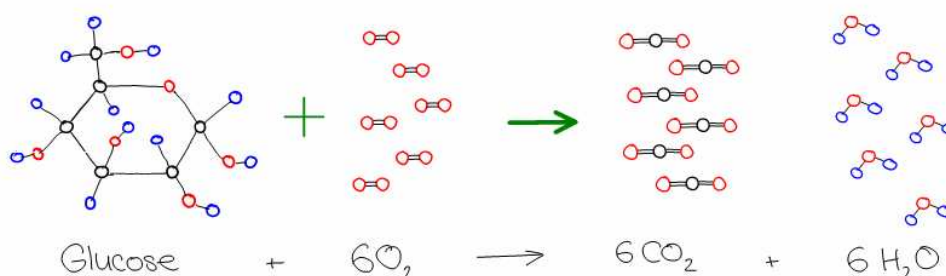


8.1 – Cell Respiration

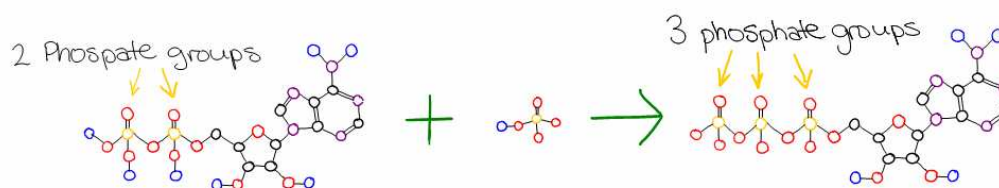
8.1.1 - State that oxidation involves the loss of electrons from an element, whereas reduction involves a gain of electrons; and that oxidation frequently involves gaining oxygen or losing hydrogen, whereas reduction frequently involves losing oxygen or gaining hydrogen

Oxidation	Reduction
Lose electrons	Gain electrons
Gain oxygen	Lose oxygen
Lose hydrogen	Gain hydrogen

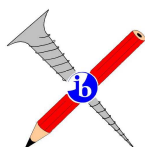


In the equation above, the glucose molecule is **oxidised** into CO₂. The hydrogen atoms in the molecule are removed, and some of the oxygen atoms from the O₂ are added.

The oxygen molecules are **reduced** to form the H₂O molecules. Oxygen atoms are removed [separated], and then hydrogen atoms from the glucose molecule are added.



The reaction above shows ADP + Pi being converted into ATP. The ADP molecule is oxidised. In the reverse, when ATP is converted back into ADP, the ATP is reduced.

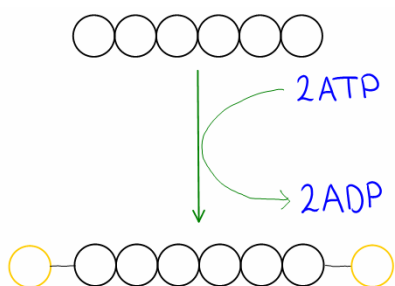


8.1.2 - Outline the process of glycolysis, including phosphorylation, lysis, oxidation and ATP formation

Glycolysis takes place in the **cytoplasm**. It takes place in a series of steps, breaking down the glucose molecule into the pyruvate ions.

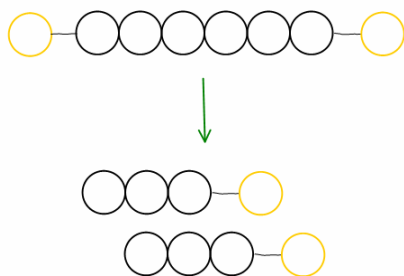
Phosphorylation

This is the first step, where the glucose molecule reacts with ATP to form **glucose phosphate**. It is then converted into **fructose biphosphate**, which reacts with another ATP molecule. In total, two ATP molecules are converted into 2ADP.



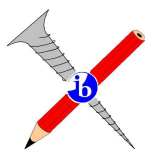
Lysis

In this stage, the fructose biphosphate is split into two molecules of **triose phosphate**, a three-carbon molecule.



Oxidation

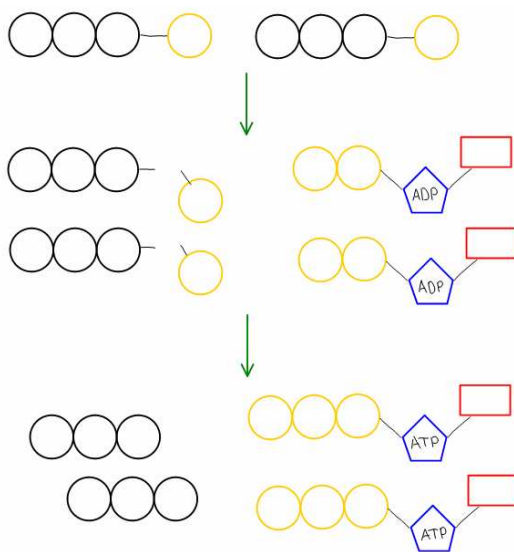
Hydrogen is removed from the triose phosphate molecules. An enzyme and a coenzyme allow for the reaction to take place. The coenzyme is called **NAD** [nicotinamide adenine dinucleotide], and it is a hydrogen and electron acceptor. During the oxidation of triose phosphate, NAD is reduced to form **NADH + H⁺**



ATP Formation

When the triose phosphate is converted into **pyruvate**, ATP is released. This type of ATP formation is different, as it occurs **at substrate level**. Four molecules of ATP are produced when two molecules of pyruvate are formed. Coupled with the loss of two ATP molecules in phosphorylation, the net gain of ATP in glycolysis is two.

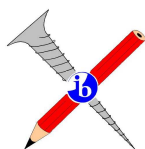
The triose phosphate is oxidised to form **pyruvic acid**. The phosphate is donated to ADP to form the ATP. Pyruvic acid is also a three -carbon molecule. Under the conditions of the cytoplasm, the pyruvic acid immediately ionises to form the ion pyruvate.

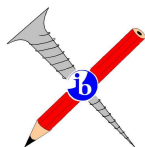
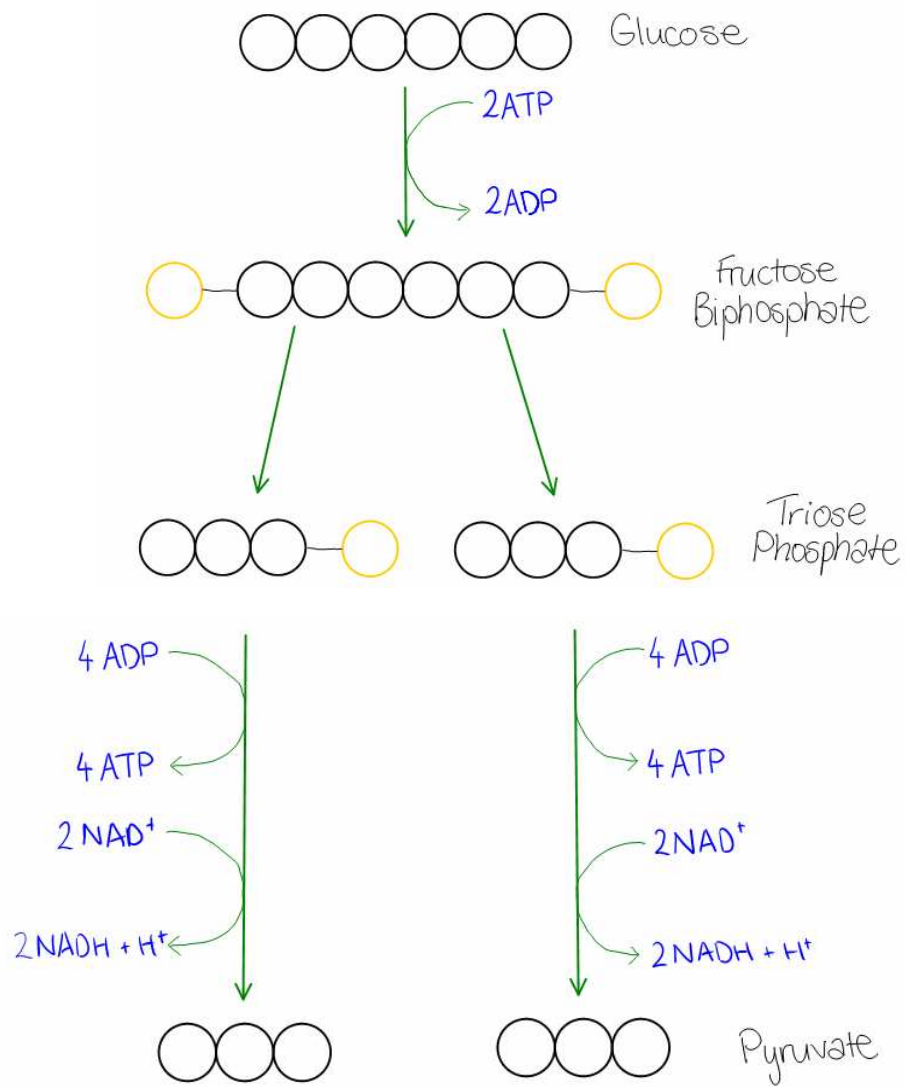


The result of this entire process is:

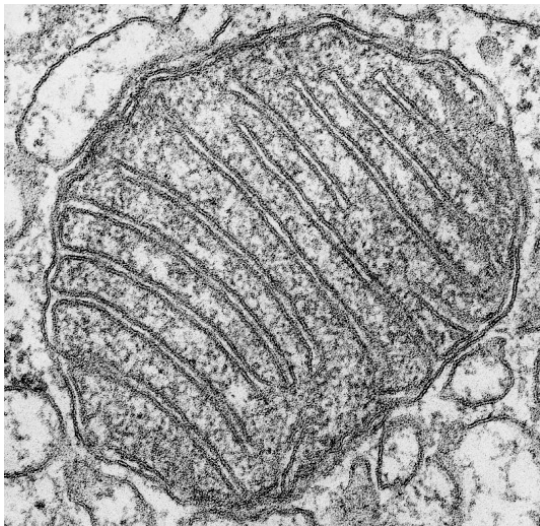
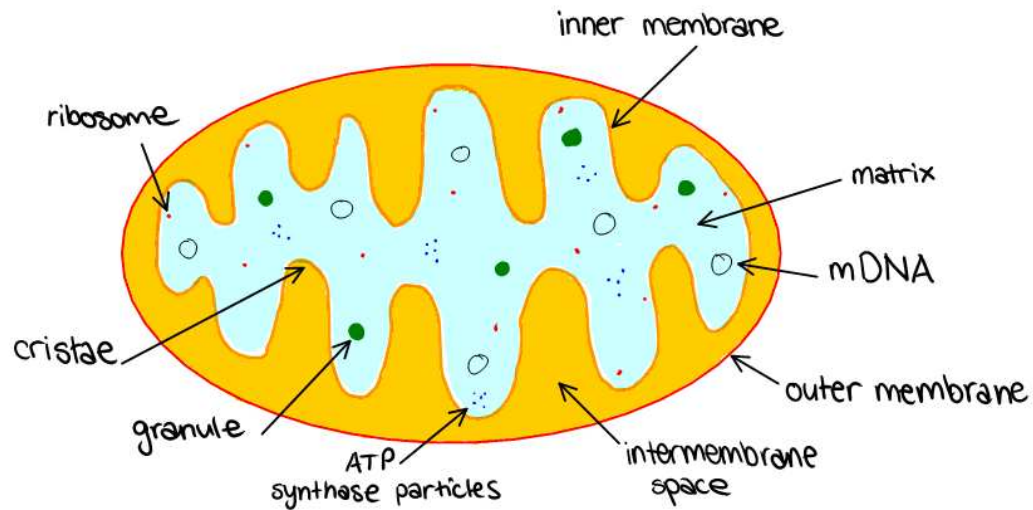


The $\text{NADH} + \text{H}^+$ will produce more ATP later. No oxygen is required for this process.





8.1.3 - Draw and label a diagram showing the structure of a mitochondrion as seen in electron micrographs

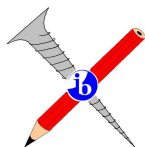


The **mitochondrion** is the organelle in which the rest of cellular respiration occurs.

All the enzymes necessary for these reactions are located here.

The **matrix** contains enzymes and metabolites.

The **inner membrane** folds in to form **cristae**, maximising the surface area.

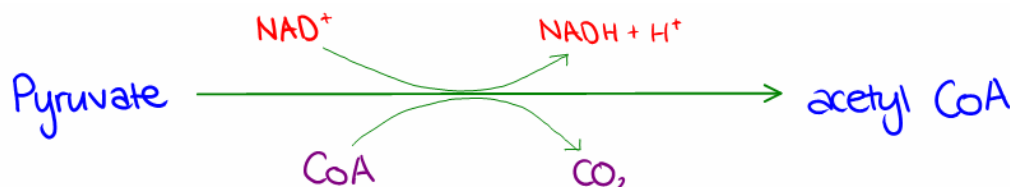


8.1.4 - Explain aerobic respiration, including the link reaction, the Krebs cycle, the role $\text{NADH} + \text{H}^+$, the electron transport chain and the role of oxygen

Link Reaction

Once the pyruvate has diffused through the membrane of the mitochondrion, it is metabolised. The reaction occurs in the matrix. The pyruvate has one carbon atom removed to form CO_2 through **decarboxylation**. It is also oxidised through the removal of oxygen. Combined, this is referred to as **oxidative decarboxylation**. One of the products is an acetyl group, which joins to the coenzyme A [**CoA**] in the link reaction to form **acetyl CoA**.

It is called the link reaction because it essentially 'connects' glycolysis to the Krebs cycle.

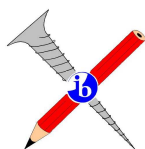


Krebs Cycle

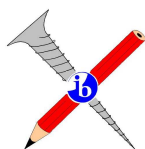
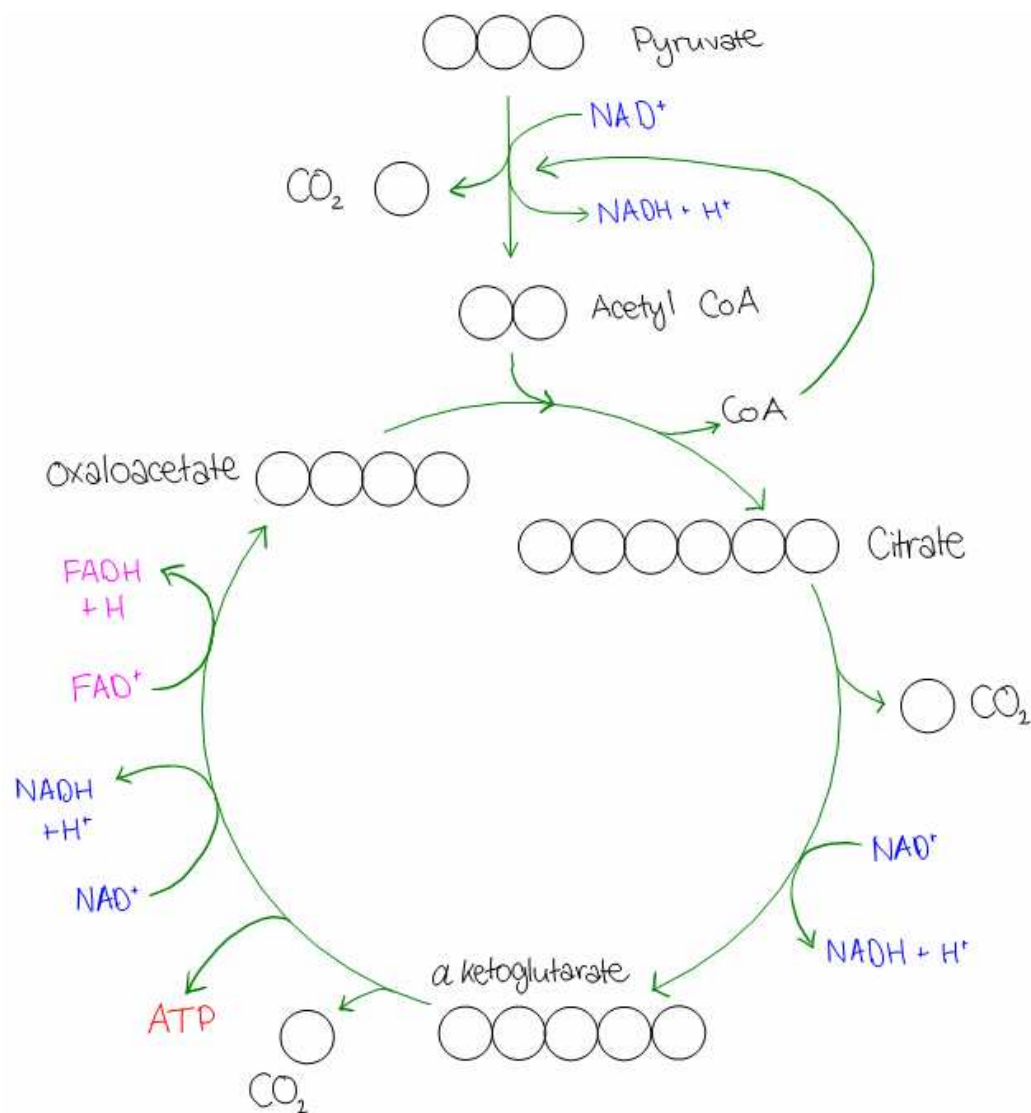
This is also called the **citric acid cycle**. After the link reaction, the **acetyl CoA** reacts with oxaloacetate [**OAA**], with the result of **CoA** and **citrate**.

Citrate then gives off two molecules of CO_2 in separate decarboxylation reactions. A molecule of ATP is formed at substrate level. Three molecules of reduced NAD are produced along with one molecule of another hydrogen acceptor. This acceptor is called flavin adenine dinucleotide [**FAD**].

Two cycles of the Krebs cycle take place for each molecule of glucose, as there are two molecules of pyruvate formed.



Step	Product			
	CO ₂	ATP	Reduced NAD	Reduced FAD
glycolysis		2	2	
link reaction	2		2	
Krebs cycle	4	2	6	2
TOTAL	6	4	10	2

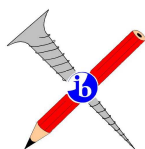
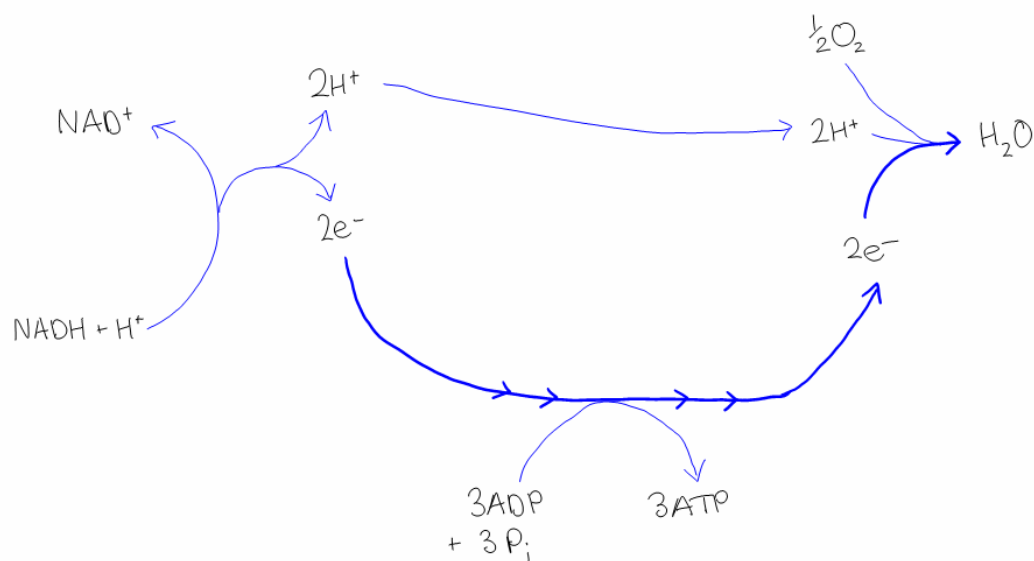


Terminal Oxidation and Oxidative Phosphorylation

In the Krebs cycle and glycolysis, pairs of hydrogen atoms are removed from the respiratory substrates. Oxidised **NAD** is converted into reduced NAD, except in the Krebs cycle, where **FAD** is reduced instead.

Hydrogen atoms or their electrons are transported along a series of carriers in the final stage of respiration. They begin from reduced NAD or FAD, combine with oxygen and form water. Energy is released during the process, which is controlled and used by the cell in the form of ATP. For each molecules of NAD that is oxidised, 3 molecules of ATP are formed.

In total, aerobic respiration forms **38 molecules of ATP** for each molecule of glucose.

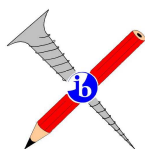
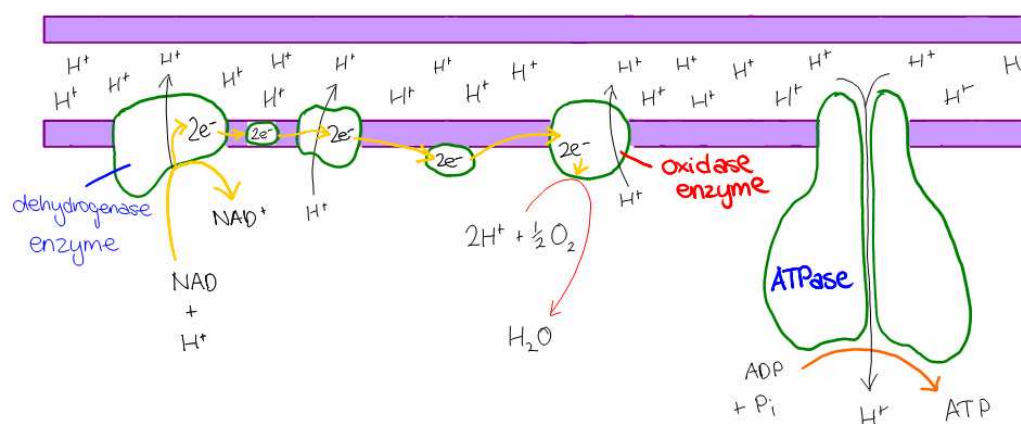


8.1.5 - Explain the oxidative phosphorylation in terms of chemiosmosis

Chemiosmosis is the process where ATP synthesis is coupled with electron transport via the movement of protons (H^+ ions).

Electron carrier proteins along the mitochondrial wall oxidise the reduced coenzymes. The energy from this is then used to pump the protons into the membrane space.

The protons accumulate in the space to form a **gradient in hydrogen ion concentration** and a lower pH. Potential energy is stored, and the ions will eventually flow back into the matrix through the channels in ATP synthase enzymes. The flow of protons causes ATP synthesis to occur.



8.1.6 - Explain the relationship between the structure of the mitochondrion and its function

Structure	Function
external double membrane matrix	the membrane is permanently permeable to pyruvate, O_2 , CO_2 and NAD^+ / $NADH + H^+$ creates an isolated space in which the enzymes of the link reaction and the Krebs cycle occur
inner membrane	this folds in to form the cristae, increasing the surface area for the electron transfer system. This increases the opportunity for ATP synthesis. the membrane is also impermeable to H^+ ions, creating a concentration gradient between the matrix and the inter-membrane space
inter-membrane space	this is a small space where H^+ ions can accumulate to facilitate phosphorylation

