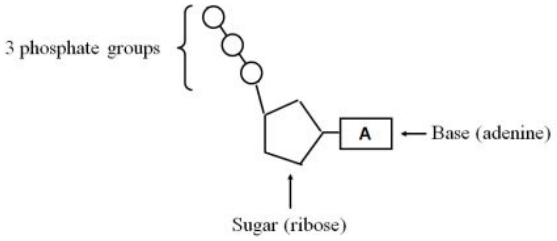
CAIE Biology A-level

Topic 12: Energy and respiration

Notes

ATP

Adenosine triphosphate is a nucleotide derivative and consists of **ribose, adenine and three phosphate groups**.



- **Energy is released when ATP is hydrolysed** to form **ADP and a phosphate molecule**. This process is catalysed by **ATP hydrolase**.
- The **inorganic phosphate can be used to phosphorylate other compounds**, as a result making them more reactive.
- **Condensation of ADP and inorganic phosphate catalysed by ATP synthase produces ATP** during photosynthesis and respiration.

Respiration

Respiration is the breakdown of a **respiratory substrate** such as glucose to **produce energy** in the form of ATP. There are two types of respiration:

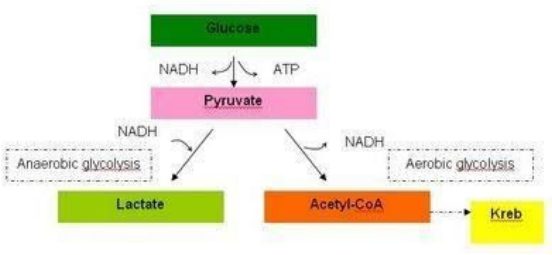
- **Aerobic**- occurs in the presence of oxygen. Produces large amounts of ATP.
- **Anaerobic**- occurs in the absence of oxygen. Produces less ATP and is less efficient.

Some organisms and tissues are able to respire in both aerobic and anaerobic conditions. When yeast and plants respire under anaerobic conditions, they produce ethanol and carbon dioxide as end-products; mammalian muscle tissue produces lactate when oxygen is in low supply, which causes fatigue.

Respiration is a multi-step process with each step catalysed by a specific intracellular enzyme.

Glycolysis:

Glycolysis is the first process of both aerobic and anaerobic respiration. In aerobic respiration which occurs in cytoplasm of cells.



In this process glucose is **phosphorylated** to produce 2 molecules of **pyruvate**, 2 molecules of ATP and 2 molecules of **NADH**.

In **anaerobic respiration** the pyruvate is further converted into lactate with the help of

NADH. **Lactate** is then converted back to pyruvate in the liver.

The link reaction:

The next step of aerobic reaction is **the link reaction** where pyruvate is converted to **acetyl coenzyme A** with the help of **NADH.**

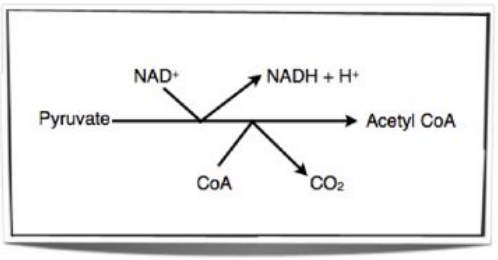
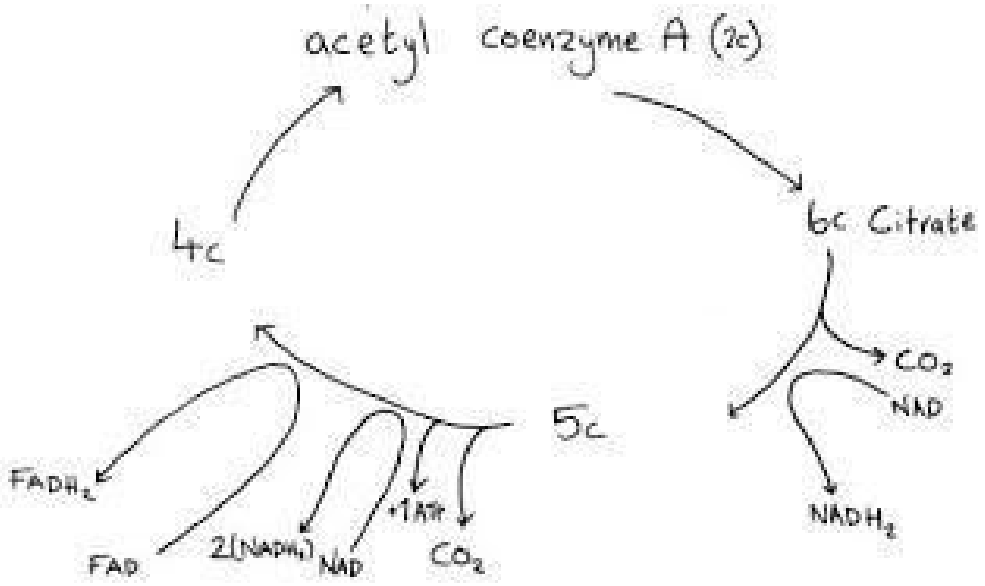


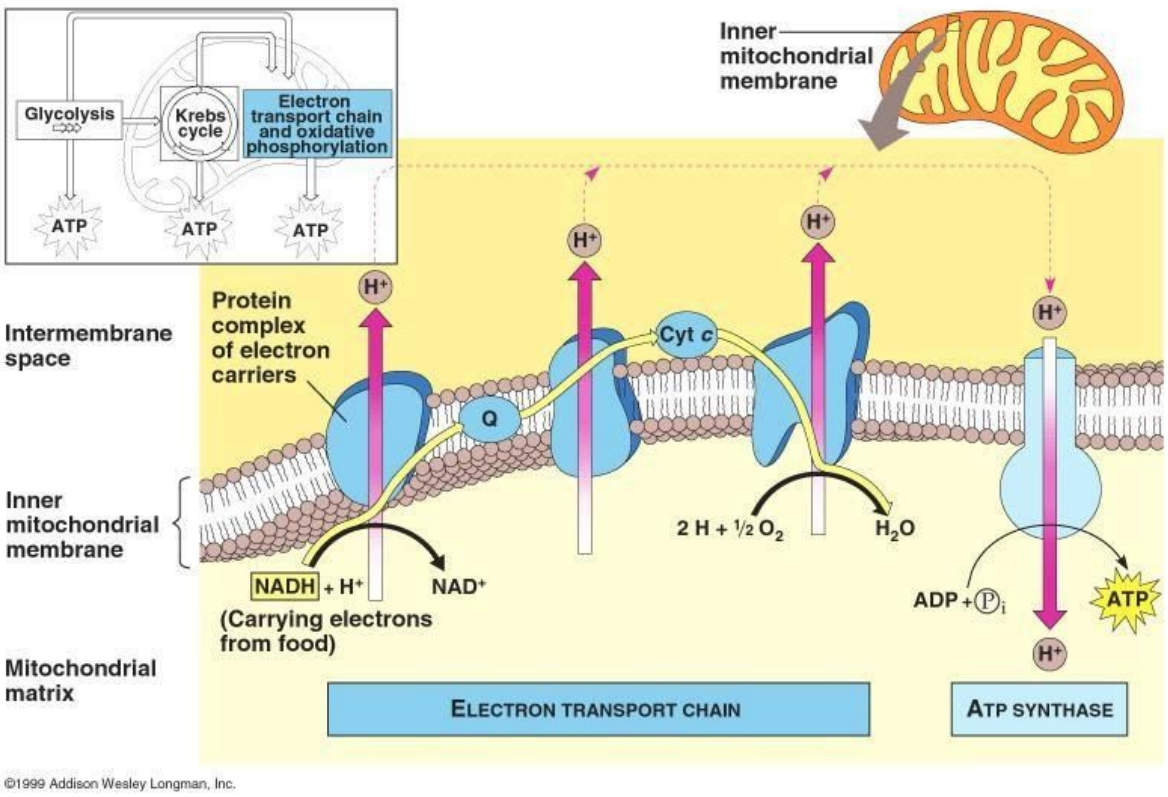
Figure: IB guides

Krebs Cycle

Acetyl-CoA then enters the **Krebs cycle** where glucose is oxidised and carbon dioxide, ATP, **reduced NAD and reduced FAD** are produced. The Krebs cycle also includes **decarboxylation** (removal of carbon dioxide) and **dehydrogenation** (removal of hydrogen) to convert 6-carbon citrate to 4-carbon oxaloacetate.



Oxidative phosphorylation



Oxidative phosphorylation is the process in which ATP is synthesised in the **electron transport chain** in mitochondria. This process generates the majority of ATP in aerobic respiration and it occurs as following:

- Reduced coenzymes carry **hydrogen ions** and electrons to the electron transport chain which occurs on the **inner mitochondrial membrane**
- Electrons are carried from one electron carrier to another in a series of **redox reactions: the electron carrier** which passes the electron on is oxidised whereas the electron carrier which receives it is reduced
- **Hydrogen ions** move across the membrane into the **intermembrane space** – as a result of this, the concentration of the hydrogen ions in the intermembrane space is high
- Hydrogen ions diffuse through ATP synthase into the **mitochondrial matrix** down the **electrochemical gradient**
- ATP is produced using ATP synthase, a **stalked granule**. Approximately 4 hydrogen ions produce one ATP molecule.
- Hydrogen atoms are produced from hydrogen ions and electrons. The **hydrogen atoms are then combined with oxygen to produce water**

Respiratory substrates include **carbohydrates, lipids and proteins** which release varying amounts of energy, depending on the number of hydrogens in the structure which are oxidised to water. For instance, the number of hydrogens is greater in fatty acids than carbohydrates.

The **respiratory quotient (RQ)** can be measured to determine which respiratory substrate is being used and to determine if the organism is undergoing anaerobic respiration.

RQ = carbon dioxide produced / oxygen consumed

Different respiratory substrates have different RQ values e.g. carbohydrates have a value of 1.0, lipids – 0.8 and proteins 0.9.