

WJEC Biology A-level

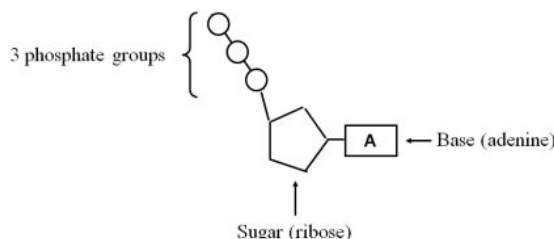
Topic 3.1-3.3: Importance of ATP, Photosynthesis and Respiration

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.

Photosynthesis

Photosynthesis is a reaction in which **light energy** is used to split apart the strong bonds in water molecules in a process of **photolysis** in order to combine **hydrogen with carbon dioxide** to produce a fuel in the form of **glucose**. **Oxygen** is a waste product of this reaction and is released into the atmosphere. The rate of photosynthesis is determined by carbon dioxide concentration, light intensity and well as temperature.

Chloroplast is the site of photosynthesis and it is adapted to photosynthesis in the following ways:

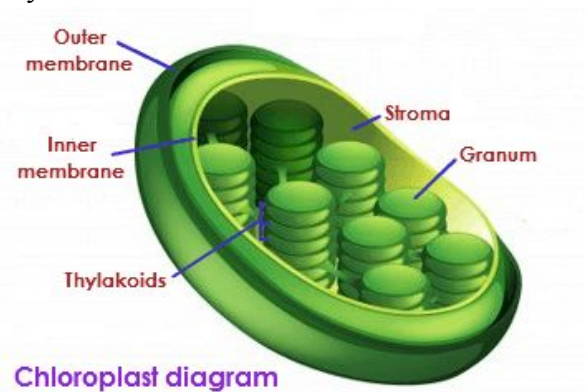


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- It contains **stacks of thylakoid membranes called grana** which contain the photosynthetic pigments such as **chlorophyll arranged as photosystems**
 - It contains **stroma** which is the fluid surrounding the grana, stroma contains all the **enzymes** required for the light independent stage of photosynthesis.

There are two stages of photosynthesis:

- **Light-dependent reaction** in which **electrons are excited** to a higher energy level by the energy trapped by **chlorophyll** molecules in the **thylakoid membranes**. Electrons are then passed down the **electron transport chain** from one electron carrier to the next and this process generates **ATP**



from ADP and inorganic phosphate in a process called **photophosphorylation**.

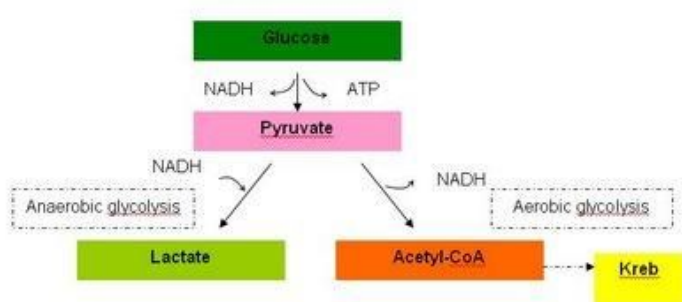
Reduced NADP is also generated in the light-dependent stage as the electrons are transferred to NADP along with a proton. Both ATP and reduced NADP are used in the light-independent stage of photosynthesis.

- **Light-independent reaction** also known as the **Calvin cycle** is the final stage of photosynthesis which uses ATP (source of energy) and reduced NADP (reducing power) to produce glucose. The light independent reaction occurs as follows:
 - 1) **RuBP** is combined with **carbon dioxide** in a reaction called **carbon fixation catalysed by RUBISCO**.
 - 2) **RuBP** is converted into **two glycerate 3-phosphate (GP)** molecules
 - 3) Reduced NADP and ATP are used to convert **GP to glyceraldehyde 3-phosphate (TP)**
 - 4) Some of TP molecules are used to make **glucose** which is then converted to essential organic compounds such as **polysaccharides, lipids, amino acids and nucleic acids**.
 - 5) Remaining TP molecules are used to **reform RuBP with the help of ATP**.

Respiration

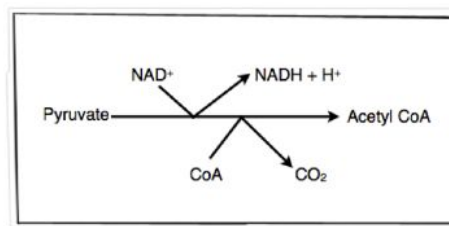
Aerobic respiration as splitting of the **respiratory substrate**, to release carbon dioxide as a waste product and reuniting of hydrogen with atmospheric oxygen with the release of a large amount of energy, whereas **anaerobic respiration** occurs in the absence of air. Respiration is a multi-step process with each step controlled and catalysed by a specific intracellular enzyme.

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

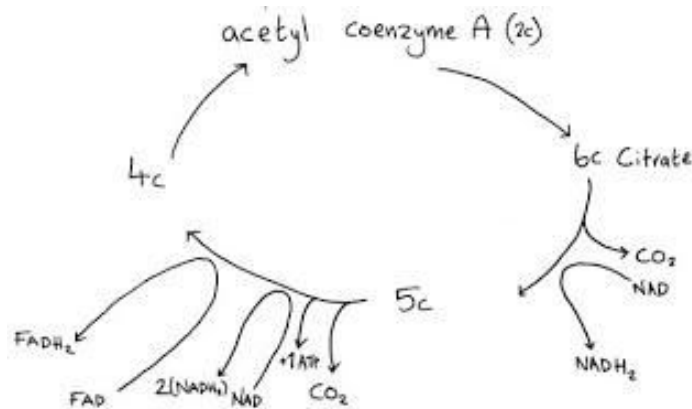


In this process glucose is **phosphorylated** to produce 2 molecules of **pyruvate**, 2 molecules of ATP and 2 molecules of NADH. In anaerobic respiration the pyruvate is further converted into lactate with the help of NADH. **Lactate** is then converted back to pyruvate in the liver.

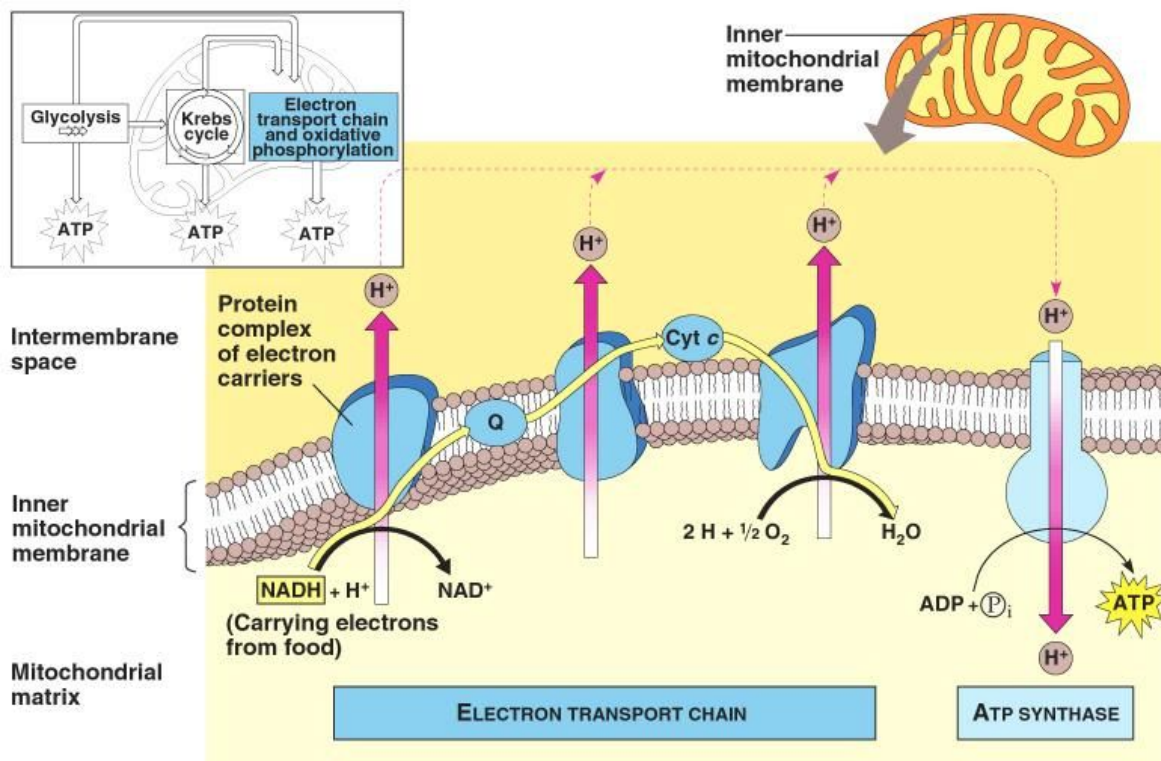
The next step of aerobic reaction is **the link reaction** where pyruvate is converted to **acetyl coenzyme A** with the help of **NADH**.



Acetyl-CoA then enters the **Krebs cycle** where glucose is oxidised and carbon dioxide, ATP, **reduced NAD** and **reduced FAD** are produced.



Oxidative phosphorylation



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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 that the concentration of the hydrogen ions in the intermembrane space is high.
- Hydrogen ions diffuse into the **mitochondrial matrix down the electrochemical gradient**.
- ATP is produced on **stalked particle** using ATP synthase.
- Hydrogen atoms are produced from hydrogen ions and electrons. The **hydrogen atoms are then combined with oxygen to produce water**.

Water and inorganic ions

- Water is required for **photosynthesis**, maintaining **structural rigidity, transport of substances and thermoregulation**.
- **Magnesium ions** are important as they are involved in **chlorophyll production**. They also activate some of the plant enzymes.
- **Nitrate ions** supply nitrogen for making **DNA, RNA, proteins as well as chlorophyll**.
- **Calcium ions** are **a component of plant cell wall** – they form **calcium pectate**. They're also **essential for plant growth**.

