MEGA LECTURE

Edexcel (B) Biology A-level

Topic 5: Energy for Biological Processes

Notes

MEGA LECTURE

Aerobic Respiration

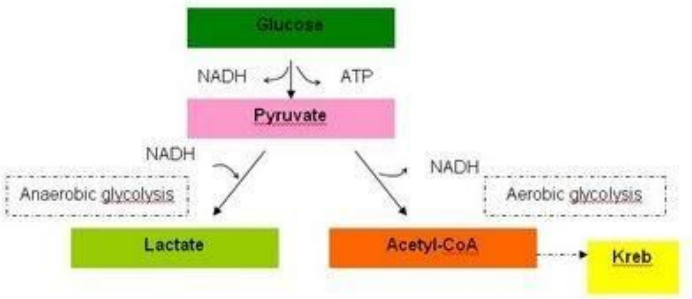
Aerobic respiration is the process by which **glucose** is converted into energy. It involves the splitting of glucose to produce **carbon dioxide and water** in the presence of oxygen. **Anaerobic respiration** occurs in the absence of oxygen and produces lactic acid in the body. Respiration is a multi-step process, with each step controlled and catalysed by a specific intracellular enzyme. Both aerobic and anaerobic respiration yield **ATP**, which is used for metabolic reactions and generating heat.

It has four stages:

- Glycolysis
- Link Reaction
- Krebs Cycle
- Oxidative Phosphorylation

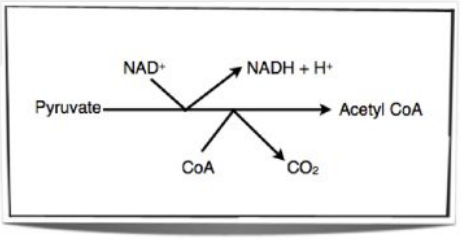
Glycolysis

Glycolysis is the first process of both aerobic and anaerobic respiration. It occurs in the 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. Lactate **decreases blood pH** which affects the Central Nervous System. Reduced stimulation from the CNS affects muscle contraction.



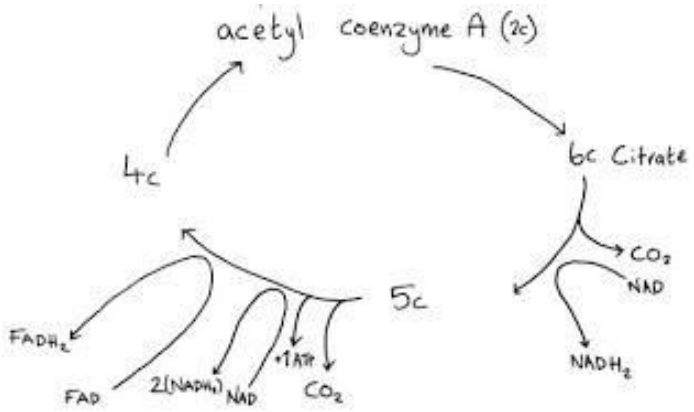
Link Reaction and Krebs Cycle

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

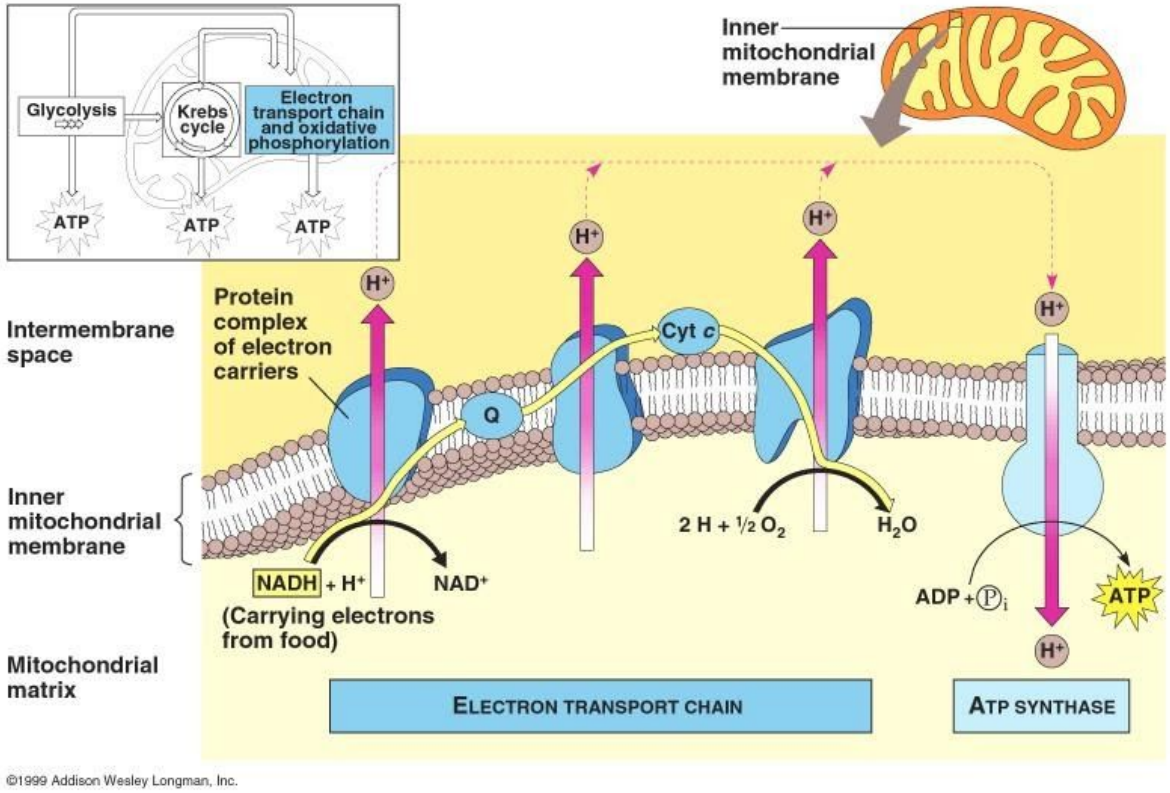


Acetyl-CoA then enters the **Krebs cycle,** where glucose is oxidised and carbon dioxide, ATP, **reduced NAD** and **reduced FAD** are produced.

Both the Link reaction and Krebs cycle occur in the **mitochondrial matrix**.



Oxidative Phosphorylation



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

- Reduced coenzymes NADH2 and FADH2 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 increases.
- Hydrogen ions diffuse back into the **mitochondrial matrix,** down their **electrochemical** and **concentration gradients.**
- ATP is produced on **stalked particles** using ATP synthase.
- Hydrogen atoms are produced from hydrogen ions and electrons. The **hydrogen atoms are then combined with oxygen** to produce water.

Photosynthetic Pigments

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 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 temperature.

Chloroplasts are the site of photosynthesis:

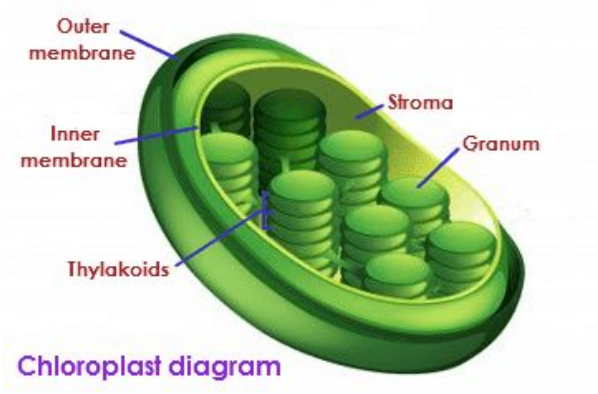


Figure 1 Tutorvista

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

Absorption Spectrum = the range of different wavelengths of light that a photosynthetic pigment absorbs

Action Spectrum = the rate of photosynthesis against the wavelength of light absorbed.

Chlorophyll is a mixture of **photosynthetic pigments** that absorb different wavelengths of light. Having more than one pigment means that more wavelengths of light and therefore more energy can be absorbed, making the process more **efficient.** Photosynthetic pigments **combine into photosystems I and II.**

The different photosynthetic pigments include:

- Chlorophyll a (blue-green)
- Chlorophyll b (yellow-green)
- Carotenoids:
  - Carotene (orange)
  - Xanthophyll (yellow)
- Phaeophytin (grey)

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.** Phosphorylation can be cyclic or non-cyclic. **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.

Cyclic Phosphorylation:

1. A photon of light hits a chlorophyll molecule.
2. Electrons are excited.
3. Electrons taken up by an electron acceptor.
4. Electrons passed along an electron transport chain. Energy is released, ATP is synthesised.
5. Electron returns to Photosystem I chlorophyll.

Non-Cyclic Phosphorylation:

1. Photon hits chlorophyll in Photosystem II.
2. Electrons are excited.
3. Electrons are taken up by an electron acceptor, passed along an electron transport chain to Photosystem I chlorophyll. Energy is released, ATP is synthesised.
4. Photon hits chlorophyll in Photosystem I.
5. **Photolysis**: water dissociates into hydrogen and hydroxide ions. Replaces lost electrons in Photosystem II chlorophyll.

6. Electrons are excited.
7. Electrons are taken up by an electron acceptor, passed along an electron transport chain to NADP.
8. NADP takes up an H+ ion from dissociated water and forms reduced NADP.
9. Hydroxide ions react together to form water and oxygen.

- **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 **GALP.**
4. Some GALP 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 GALP molecules are used to **reform RuBP** with the help of ATP.