2.9 Carriage of Carbon Dioxide

How haemoglobin is involved in the transport of carbon dioxide

All respiring tissues release carbon dioxide as they respire. There are three ways in which this can be removed:

- it can dissolve directly into the blood plasma
- it can combine with haemoglobin to form a compound known as **carbaminohaemoglobin**
- it can form hydrogen carbonate ions

The majority of carbon dioxide (around 85%) is transported in the latter way. This is a fairly complicated process:

Carbon dioxide diffuses into the blood and enters red blood cells, where it combines with water to form **carbonic acid** – this reaction is catalysed by the enzyme catalyst **carbonic anhydrase**.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

The carbonic acid (H_2CO_3) is very unstable, and so it easily dissociates to release **hydrogen ions** (protons) and **hydrogen carbonate ions**.

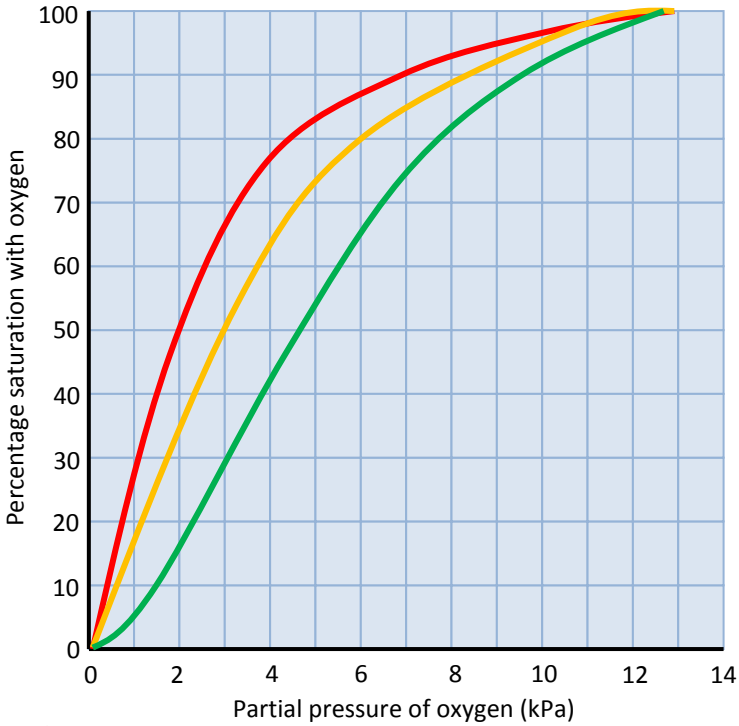
$$H_2CO_3 \rightarrow H^+ + HCO_3^-$$

The hydrogen carbonate ions (HCO_3^-) diffuse out of the red blood cells. As these ions have a *negative charge*, this means that there is a *positive charge* inside the cell as a result. Therefore, **chloride ions** (Cl^-) which also have a negative charge move into the blood cell to balance out the charges, returning it to neutral. This is called the **chloride shift**.

To prevent the hydrogen ions (which are protons) causing the blood cell to become very acidic, hydrogen ions are taken up by haemoglobin to produce **haemoglobinic acid** (HHb^+).

Oxyhaemoglobin

Haemoglobin carries oxygen in the form of **oxyhaemoglobin**. When this molecule dissociates, oxygen is released. The hydrogen ions which are released from the dissociation of carbonic acid compete for the space oxygen takes up on the haemoglobin molecule. So when carbon dioxide is present, hydrogen ions displace oxygen molecules on the haemoglobin. As a result, the higher the potential pressure of carbon dioxide, the more oxygen is released from the oxyhaemoglobin, because there is a lower affinity for *oxygen*.



Where there are heavily respiring tissues, such as the muscles, there will be more carbon dioxide present. Therefore, there will be more hydrogen ions produced in the red blood cells, making the oxyhaemoglobin release more oxygen. This shift as shown in the graph is called the **Bohr effect**.

At *any* oxygen partial pressure, oxyhaemoglobin releases more oxygen when the carbon dioxide is of a higher concentration. So when more carbon dioxide is present, haemoglobin is less oxygen saturated, causing the oxyhaemoglobin dissociation curve shift downwards and to the right – the **Bohr shift**.

The Bohr effect results in oxygen being more readily released where more carbon dioxide is produced from respiration: what muscles need for respiration to continue.