C.5.2. Carbon Dioxide Transport

A. How is carbon dioxide transported?

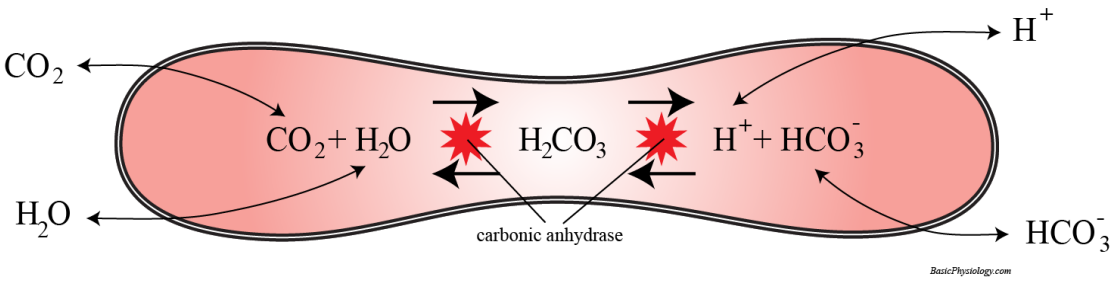
1. In all active tissues, metabolism generates, as a waste, carbon dioxide (=CO_2).	2. This CO_2 has to go back to the lungs to be exhaled. This transport is also performed by the blood flow.
3. There are **three** transport systems for CO_2: 1. Diffused in plasma (10%) 2. Bound to the hemoglobin molecule (20%) 3. Converted to bicarbonate ions (70%)	4. CO_2, just like O_2, is dissolved in the plasma of blood. But because CO_2 dissolves much better than oxygen (about 20 x), this amounts too much more CO_2 being transported by the plasma than O_2 (plasma only carries about 0.5% of the total oxygen).

B. CO_2 is bound to hemoglobin.

1. It is also possible for CO_2 to bind to the hemoglobin molecule.	2. In this case, the CO_2 is bound to the globin part of the hemoglobin and not to the heme part. So, it does not interfere with the oxygen transport!
3. In fact, it is slightly easier for hemoglobin to bind with CO_2 if there is less binding of that same hemoglobin with oxygen.	4. This is very nice! As erythrocytes flow towards active tissue, the oxygen content of the hemoglobin molecules decreases (as it gives oxygen to the tissue).
5. This 'release' of oxygen makes the hemoglobin molecule more sensitive to CO_2.	6. In some countries, this is called the **Haldane** effect.

C. CO_2 is transported as bicarbonate ions.

1. This is the main transport route for CO_2, which takes care of 70% of the total transport of CO_2.	2. This is a chemical reaction that binds CO_2 with water (H_2O) to create carbonic acid:
$CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$	

3. In principle, this reaction can take place anywhere in the body, as long as there is water. But the reaction is **very slow**.	4. There is however an **enzyme** that increases the speed of this reaction. This enzyme is **carbonic anhydrase** and, this is the important part, this enzyme is only available in the **erythrocytes**!
5. So, the CO_2 has to diffuse into the erythrocyte to be bound to water.	6. The next important thing is that carbonic acid (=H_2CO_3) is not stable but dissociates (= splits) into one hydrogen ion (=H^+) and one bicarbonate ion (=HCO_3^-).
	
7. So, in summary, the CO_2 molecule we started with, is converted into a bicarbonate ion.	8. The bicarbonate ions (together with the H^+ ions) can diffuse into the plasma (where they play an important role in the buffer system; see later).
9. Note that the reaction from CO_2 to bicarbonate is reversible. It may also go the other way.	10. This is of course what happens in the lungs; the bicarbonate ions are converted back, in the erythrocytes, to CO_2 to be exhaled in the air.

D. The chloride shift.

1. There is however one small problem. Both H^+ and HCO_3^- are ions and have a charge.	2. The H^+ ion is bound to hemoglobin molecule, thereby neutralizing its charge. This is actually the basis for the Bohr effect.

3. But the negative bicarbonate ions diffuse out of the erythrocytes into the plasma (concentration effect; there is more bicarbonate inside than outside the red blood cell).	4. But this would make the erythrocyte more **positive**. To compensate for this charge, other (negative) ions will **shift** to inside the cell; the most common negative ion is the **chloride ion** (=Cl^-).
5. Therefore, this compensation system is called the **Chloride-shift**.	6. We will talk more about all this in the **Acid Base System** (*coming …*)