STUDY MATERIAL FOR DEGREE PART II

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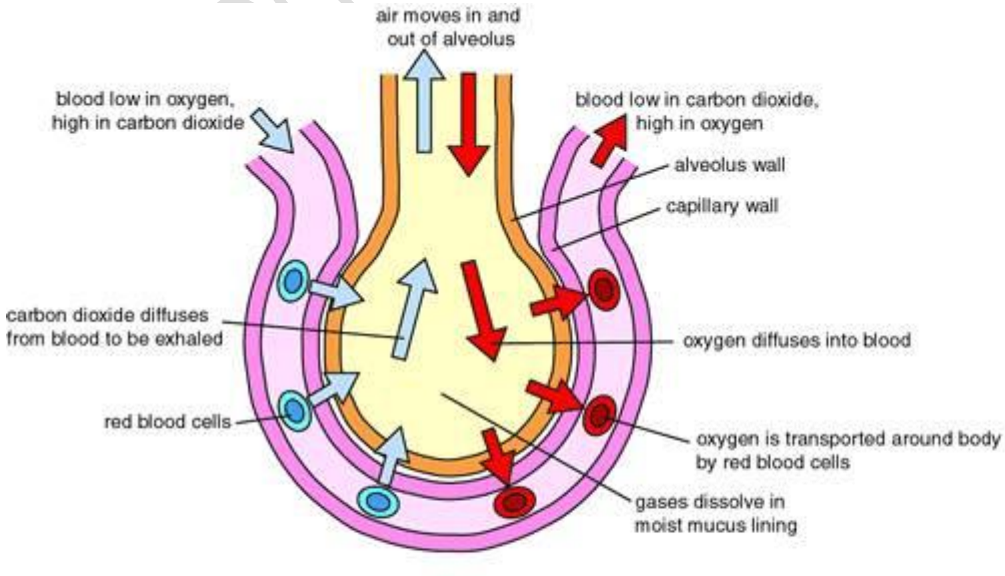
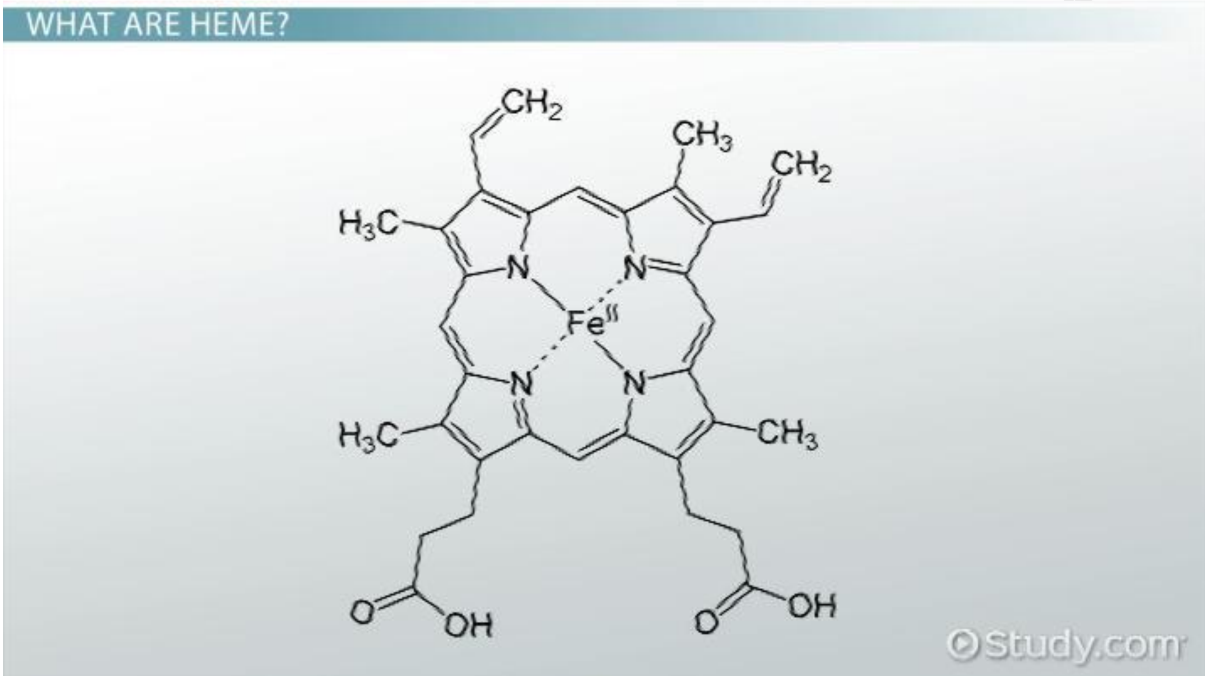
TRANSPORT OF GASES

Aerobic life , characteristic of animals demands a steady flow of o_2 into the cells & ready removal of the co_2 which arises from their metabolism. In higher animals the transportation of respiratory gases (o_2 &co_2) is effected through the blood, the component of which are very much sensitive to the respiratory gases. O_2 has to move across the alveolar membranes into the pulmonary capillaries and to be carried by the blood to the tissues. CO_2 has to follow a reverse course.

Transport of gases is simply by the process of diffusion ,i.e; gas passes from a region of higher conc^n to lower conc^n. The venous blood reaching the lungs from the body tissues has a low conc^n (40mmHg O_2 or 12.5%) and a high CO_2 and high CO_2 conc^n (46mmHg co_2 or 56%).The O_2 conc^n in alveolar air is high (98mmHg o_2 or13.8%) while its co_2 conc^n is low (40mmHg co_2 or5.5%). Therefore, o_2 diffuses into the blood ,while co_2 diffusees from the blood towards the alveoli because of difference in concentration gradients.



TRANSPORT OF O_2 :-- In the alveoli o_2 passes through the alveolar wall and diffuses into the blood capillary surrounding it. Blood itself is not the carrier of the respiratory gases but contains a respiratory pigment which act as a carrier of the gases.The blood contains haemoglobin packeted in the R.B.C. A haemoglobin molecule is composed of 4 pyrrole rings with an atom of iron in the Fe^{++} state. The mol.wt of Hb is 68000.



ST. OF HAEMOGLOBIN

Each haem group is a binding site for o_2. A single molecule of Hb can combine with 4 mol. Of o_2 in a loose combination. So, the o_2 carrying capacity of the blood depends on the amount of Hb it contains. The Hb in association with o_2 is called oxyhaemoglobin , a fully saturated oxyhaemoglobin mol. Contains 4 molecule of o_2.

$$Hb + o_2 \rightleftharpoons Hbo_2$$

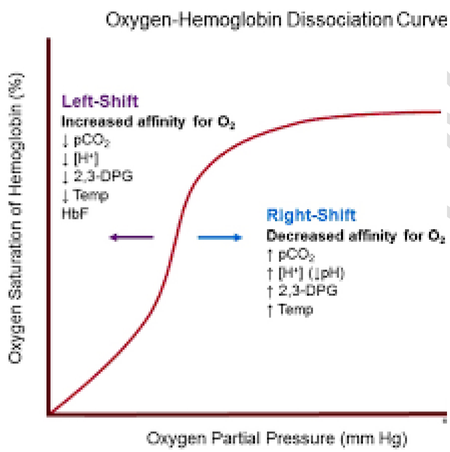
Haemoglobin Oxyhaemoglobin

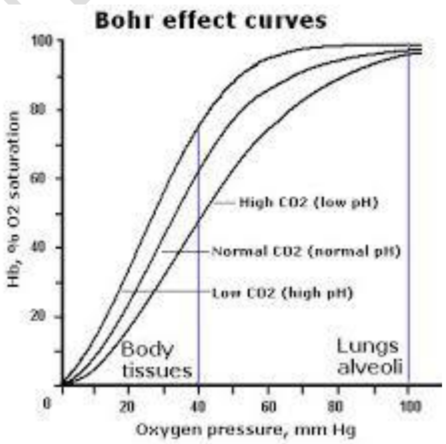
Oxyhaemoglobin on reaching at cellular level ,where partial pressure of the o_2 is very low ,dissociates into free o_2 and Hb. This is a reduction process.

Oxygenation of one of the 4 haeme units accelerates the picking up of o_2 by the other haeme groups. This is called haeme- haeme effect and increases the efficiency of o_2 uptake by blood . This effect also speeds up the oxygenation of

Hb. The amount of o_2 may be expressed as % saturation. The amount of o_2 carried by the Hb molecule in the blood is related to the partial pressure of o_2 (PO_2) in the blood. If the datas are plotted in a graph % saturation of haemoglobin molecules against the PO_2 in mmHg, a sigmoid or S- shaped curve is the result of the action of haeme- haeme effect, and makes Hb an ideal molecule for the transport of O_2.

The curve also show the influence of different CO_2 pressure in the dissociation of oxyhaemoglobin of human blood. The chart also shows that when Po_2 increases the oxyhaemoglobin is formed in great amount as in the lungs. When Po_2 decreases (in the tissues) more o_2 is liberated. As the CO_2 partial pressure increases the dissociation curves are shifted towards the right. This states that if more co_2 is present the haemoglobin can hold less o_2 , a phenomenon called as “BOHR EFFECT” after its discoverer.





A shift in the dissociation curve to the right obviously result in greater release of o_2 from Hbo_2 at a given Po_2 i.e. the shift to the right decreases the affinity of Hb to O_2 .Four major factors shift curve to the right. They are—

1. Increasing temperature.

2.Increasing PCO_2 .

3.Increasing acidity or decreasing Ph.

4.Increasing erythrocyte conc^n of 2'-3' diphosphoglycerate (DPG).

This often happens when there is greater demand of o_2 by the tissues. DPG favours deoxygenation of Hbo_2 thus

DPG

$$Hbo_2 \rightleftharpoons Hb.DPG + O_2$$

DPG

TRANSPORT OF CO_2:--- Due to oxidation of energy rich organic molecules in the cells, co_2 is evolved as a byproduct. The amount of co_2 which is soluble in plasma of blood at pco_2 obtaining in the body cells (40mmHg to 46 mmHg) is quite small, much smaller than the large amount of co_2 which must be constantly returned back from the tissues to the lungs.Transport of co_2 from tissues to lungs alveoli can be summarised in 4 steps—

Co_2 diffuses from cells and tissues into blood capillaries and gets dissolved in the water of blood plasma. The rate of dissociation is slow.

$$Co_2 + H_2o \rightleftharpoons H_2Co_3 \text{ (carbonic acid).}$$

Any change in PH due to H_2co_3 in the plasma is produced by the buffering action of Na_2HPo_4 are of the buffer systems available in the blood.

$$H_2Co_3 + Na_2HPo_4 \rightarrow NaH_2Po_4 + NaHCo_3$$

$$NaHCo_3 \rightarrow Na^+ + HCo_3^-$$

2. Some of the dissolved co_2 passes into the erythrocytes from the plasma. Formation of H_2Co_3 in the R.B.C is faster because carbonic anhydrase catalysing the solution of Co_2 in water is present in fair amount in the R.B.C. H_2Co_3 formed then dissociates into H^+ and HCo_3.

$$Co_2 + H_2o \rightarrow H_2co_3 \rightarrow H^+ + HCo_3$$

Most of the HCo_3 diffuses back into plasma.

To maintain the electric charge balance across the R.B.C cell membrane, there is simultaneous inward diffusion of chlorine from plasma to erythrocytes. This is called chlorine shift or " Hamburger phenomenon. About 80 -85 % of Co_2 is transported as HCo_3 in the plasma.

3. Some of the H_2Co_3 formed in the RBC remains inside & may react withKHb (k^+ present inside the cell combine with Hb mol.) forming acid Hb or H.Hb.

$$KHb + H_2Co_3 \rightarrow KHCo_3 + H.Hb.$$

Some of the dissolved co_2 inside the RBC react with the free NH_2 group of Hb to form carbamino compounds or carbhaemoglobin.

$$HbNH_2 + Co_2 \rightarrow HbNHCOOH \rightarrow HbNHCOO + H^+$$

As the Co_2 in the form of bicarbonate, carbhaemoglobin & carbonic acid reaches the respiratory surface where it starts diffusion from the blood into the external environmrnt. This movement of Co_2 from blood to the environment becomes possible due to low partial pressure of the Co_2 at the respiratory surface.

END