BREATHING AND EXCHANGE OF GASES

TRANSPORT OF GASES

- Blood is the medium of transport for O_2 and CO_2. About 97 per cent of O_2 is transported by RBCs in the blood. The remaining 3 per cent of O_2 is carried in a dissolved state through the plasma. Nearly 20-25 per cent of CO_2 is transported by RBCs whereas 70 per cent of it is carried as bicarbonate. About 7 per cent of CO_2 is carried in a dissolved state through plasma.

Transportation of O_2:

The O_2 that diffuses into the blood from the lungs is transported to various body tissues in the following form:

1. About 97% of the O_2 that diffuses into the blood combines with haemoglobin of RBCs forming an unstable compound, oxyhaemoglobin.
2. The remaining 3% O_2 dissolves into water of plasma.

- Haemoglobin is a red coloured iron containing pigment present in the RBC.
- Haemoglobin is made up of 4 units. Each unit has 1 Fe in +2 state. Each haemoglobin molecule can carry a maximum of four molecules of O_2.
- 1 gm of haemoglobin transports 1.34 ml of oxygen. 100 ml (1 dL) of blood contains normally 15 gm of haemoglobin, so 100 ml blood transports approximately 20 ml of oxygen.
- In a conducting cycle blood gives its 25% O_2 to tissues. So every 100 ml of oxygenated blood can deliver around 5 ml of O_2 to tissue under normal physiological condition.
- Binding of oxygen with haemoglobin is primarly related to partial pressure of O_2. But PCO_2, hydrogen ion concentration and temperature are the other factors which can interfere with this binding.
- Oxygen does not oxidise haemoglobin. Formation of oxyhaemoglobin is a process of oxygenation. The valency of iron is 2 in Oxyhaemoglobin. Some gases (e.g. Ozone) oxidise haemoglobin. This oxidised haemoglobin is called Methamoglobin. This type of gases are environmental pollutant.
- At the time, oxyhaemoglobin reaches upto the tissues it dissociates. O_2 freed from it goes into the tissue fluid from blood. In place of it, CO_2 from tissue fluid comes into blood. Gaseous

exchange between blood and tissue is called internal respiration or tissue respiration. It is also done by simple diffusion.

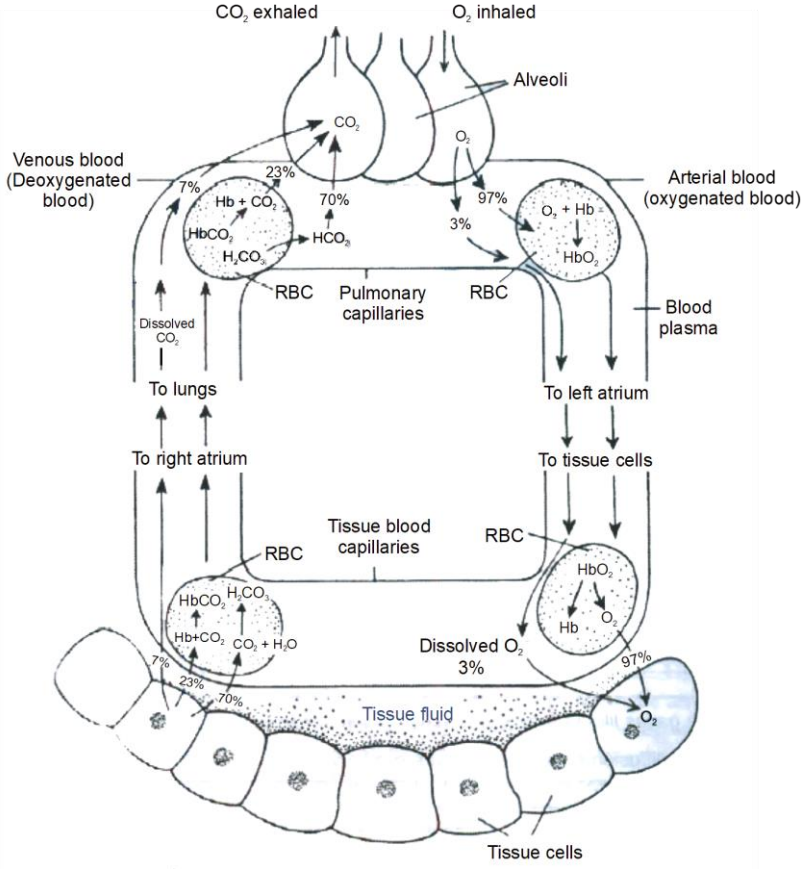
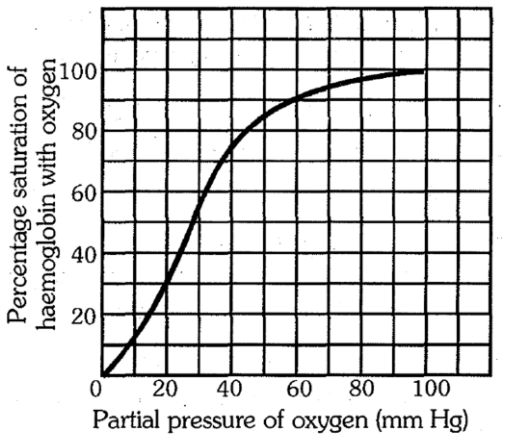


Fig. Transport of oxygen and carbon dioxide

OXYGEN DISSOCIATION CURVE

1. A graph is plotted between O_2 concentration and percentage saturation of haemoglobin with this curve is called Dissociation curve.
2. Dissociation curve is sigmoid shape.
3. This curve is highly useful in studying the effect of factors like P_{CO_2}, $H^{\pm}$ concentration, temperature on binding of O_2 with Haemoglobin.

❖ **Shift to left** Means that increase in affinity between O_2 and Hb.



Oxyhaemoglobin dissociation curve

- **Shift to Right** Means that decrease in affinity between O_2 and Hb and dissociation of oxyhaeinoglobin.
- In tissue following conditions are favourable for dissociation of oxygen from oxyhaemoglobin:
  1. Low PO_2
  2. High PCO_2
  3. High H^+ concentration
  4. Low pH
  5. Higher temperature.
- In the alveoli high PO_2, low PCO_2, Lesser H^+ concentration and lower temperature factors are favourable for the formation of oxyhaemoglobin.

Transportation of CO_2:

CO_2 produced as a result of cellular respiration is to be removed from the body. It is transported to the lungs from various body tissues for elimination as follows:

1. **As dissolved gas**: About 7% CO_2 gets dissolved in blood plasma and is carried in solution to the lungs.
2. **As Bicarbonates**: About 70% of CO_2 form bicarbonate and hydrogen ions.

- About 70 per cent of the carbon dioxide entering into the erythrocytes, reacts with water to from **carbonic acid.**

$$CO_2 + H_2O \overset{C.A.}{\rightleftharpoons} H_2CO_3$$

- This reaction is catalysed by a zinc containing enzyme, called **carbonic anhydrase.**
- In erythrocytes, carbonic acid forms bicarbonate:

$$H_2CO_3 \overset{C.A.}{\rightleftharpoons} H^+ + HCO_3^-$$

- Some of the bicarbonate $\left(HCO_3^-\right)$ is carried in erythrocytes while most of it comes out in the plasma to be carried by it.

3. **As carbaminohaemoglobin**: About 23% of CO_2 enter into the erythrocytes combines with the protein part of haemoglobin to form carbaminohaemoglobin.

   These unstable compounds when reach into the lungs release CO_2 because of high concentration of O_2 and presence of an enzyme, carbonic anhydrase.

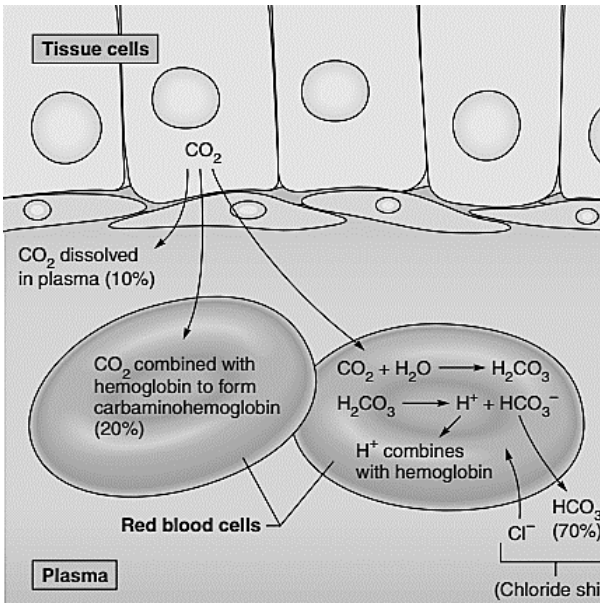


Fig.Carbon dioxide transport and the chloride shift.

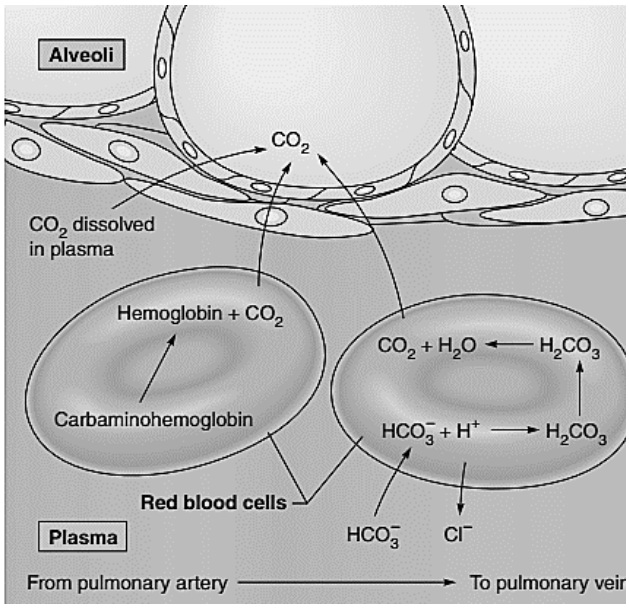


Fig. The reverse chloride shift in the lungs.

Gas Exchange in Tissues

- As in the lungs, so also in the tissues, gases are exchanged by diffusion.
- Tissue cells use up oxygen during their activities.
- So, in the tissue fluid around the cells, pO_2 falls below the arterial pO_2.
- Consequently, oxygen is released from oxyhaemoglobin and diffuses from the capillary blood to the tissue fluid and then, to the cells of the tissue.
- Carbon dioxide diffuses from the cells to the tissue fluid to raise is pCO_2 above the arterial pCO_2.
- This enables carbon dioxide to diffuse from the tissue fluid to the capillary blood. Unlike the blood, tissue fluids do not carry these gases in chemical combinations such as oxyhaemoglobin, carbaminohaemoglobin or bicarbonate.
- Only small amounts of the gases are held in solution in the tissue fluid while most of them diffuse as such through it.