TRANSPORT OF OXYGEN

PARTIAL PRESSURE OF GASES

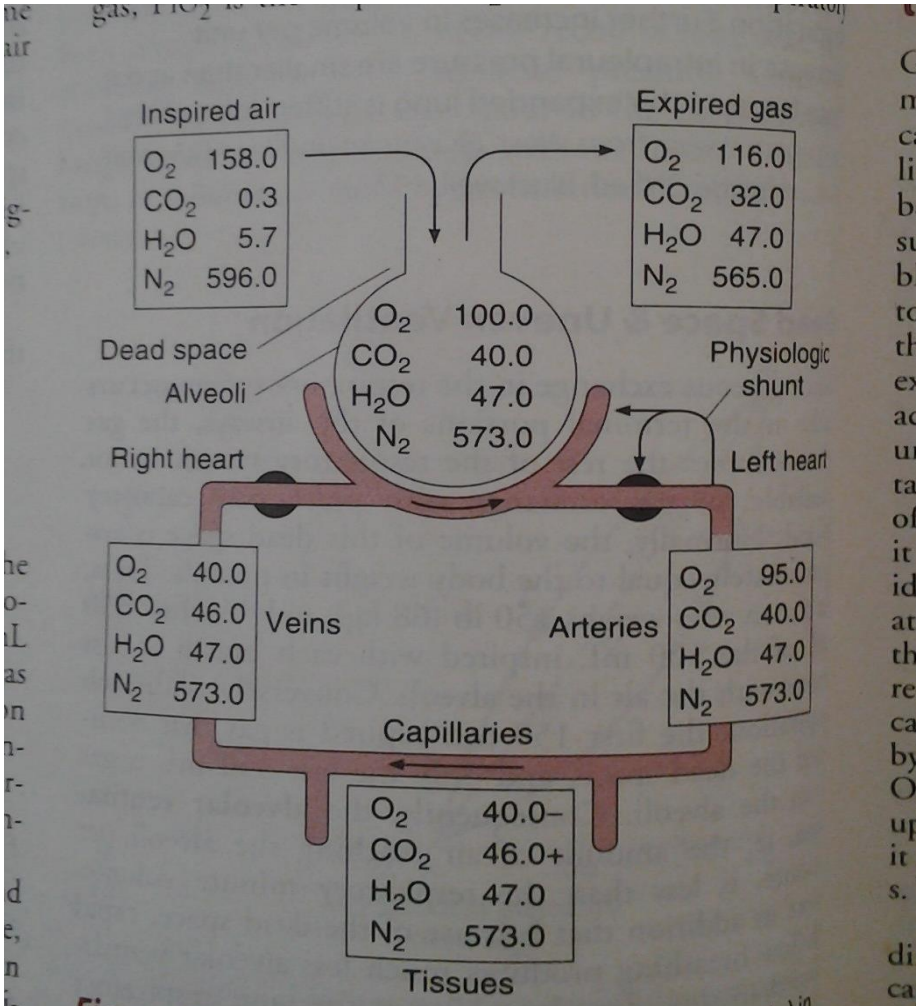


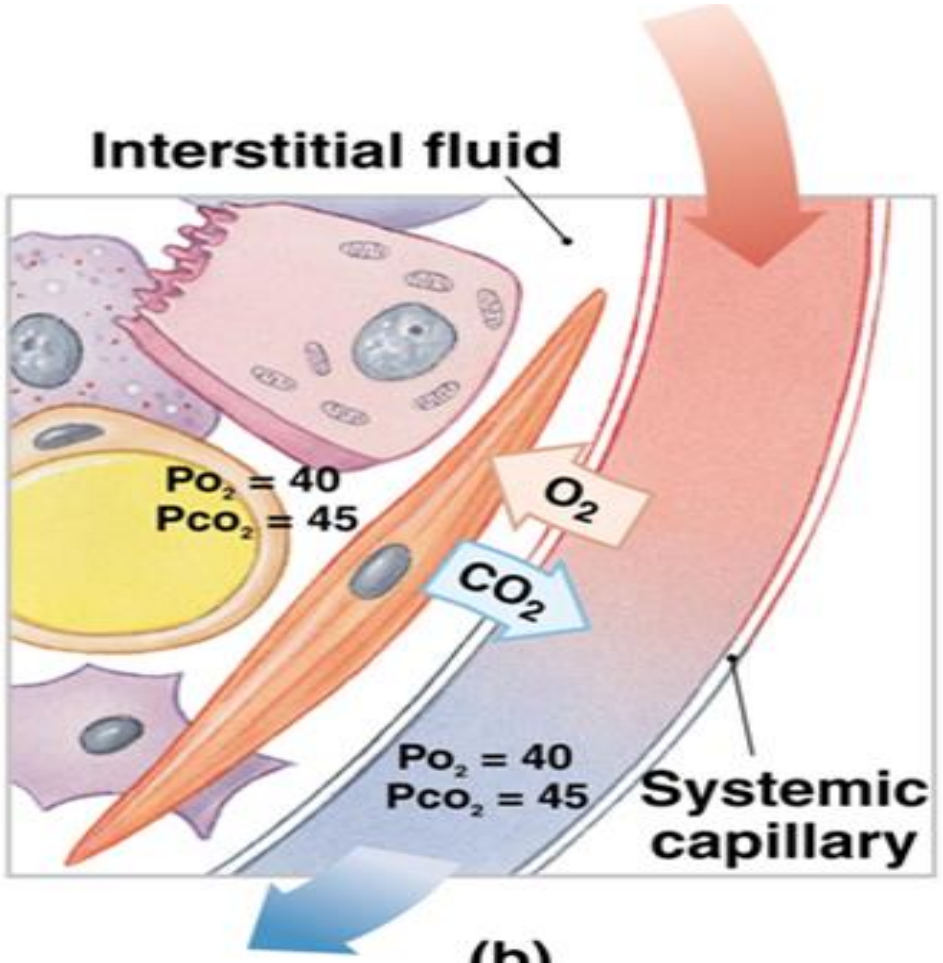
Figure 34–18. Partial pressures of gases (mm Hg) in various parts of the respiratory system and in the circulatory system.

OXYGEN DELIVERY TO THE TISSUE

- Depends on
  - 1. Amount of oxygen entering the lungs
  - 2.Adequecy of pulmonary gas exchange
  - 3. Blood flow to the tissues
  - 4.The capacity of blood to carry oxygen

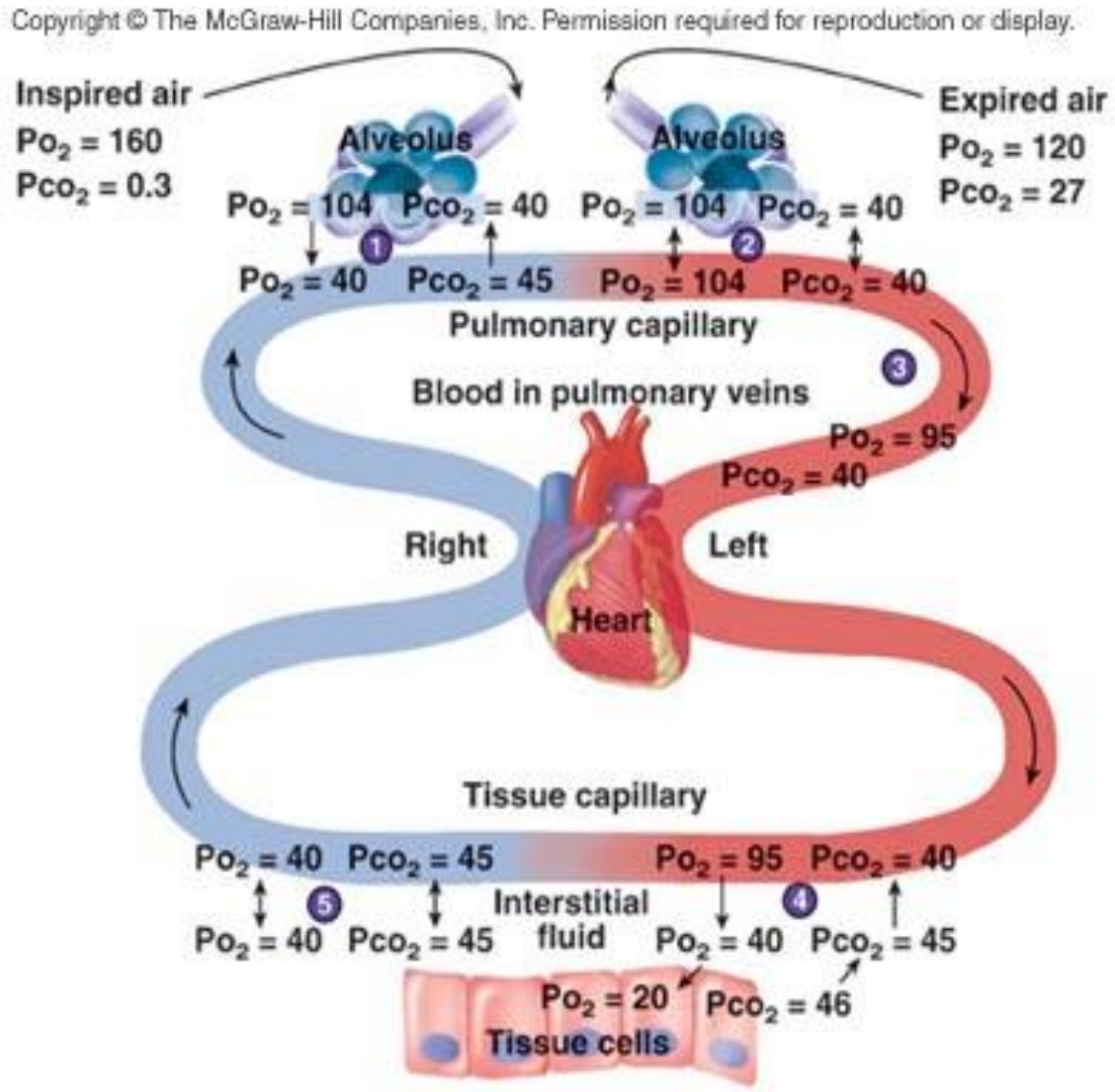
Difference in the partial pressures

- Why the arterial PO2 is less than alveolar PO2?


Interstitial fluid
$Po_2 = 40$
$Pco_2 = 45$
O_2
CO_2
$Po_2 = 40$
$Pco_2 = 45$
Systemic capillary

(b)

DIFFUSION AT TISSUE LEVEL



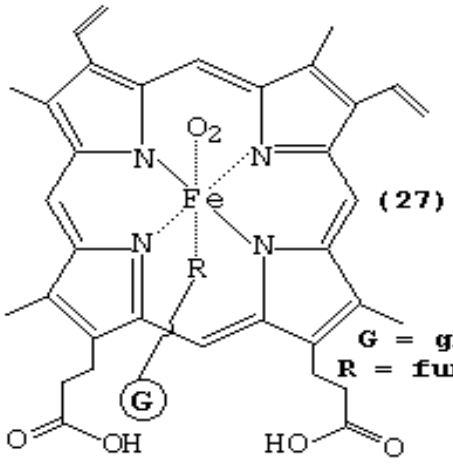
METHODS OF OXYGEN TRANSPORT

- 1. Combined with Hemoglobin- 97%
- 2. Dissolved in the plasma- 3%
  - 0.3ml of Oxygen/ 100 ml of blood (considering an arterial PO2 of 100 mmHg

REVERSIBLE COMBINATION WITH Hb

- Oxygen molecule combines loosely & reversibly with hemoglobin when PO_2 is high (pulmonary capillaries)
- When PO_2 is low, Oxygen is released from Hb (Tissue capillaries)
- **This is the basis of Oxygen transport from lungs to the tissues**

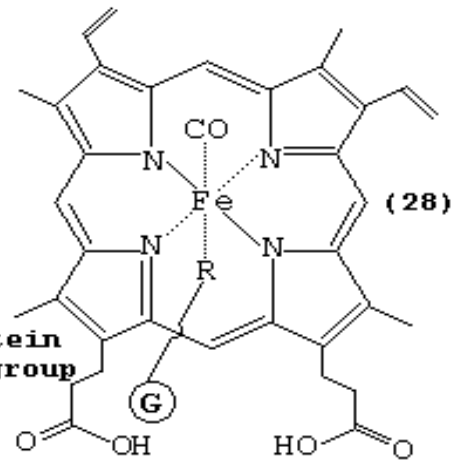
OXYHEMOGLOBIN



(27)

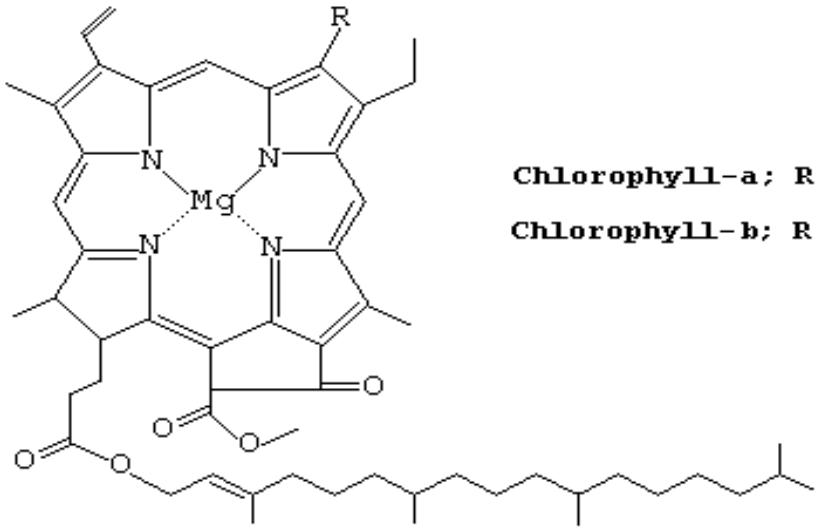
Oxyhaemoglobin

G = globin protein
R = functional group



(28)

Carboxyhaemoglobin



Chlorophyll-a; R = H (29)

Chlorophyll-b; R = CH_3 (30)

ROLE OF Hb IN OXYGEN TRANSPORT

- Reversible combination of Oxygen with Hb
- Reaction of Hb & Oxygen- Oxygenation
- $Hb_4 + O_2 \leftrightarrow Hb_4O_2$
- $Hb_4O_2 + O2 \leftrightarrow Hb_4O_4$
- $Hb_4O_4 + O_2 \leftrightarrow Hb_4O_6$
- $Hb_4\ O_6 + O_2 \leftrightarrow Hb_4\ O_8$

Oxygenation is rapid requiring < 0.01 sec.

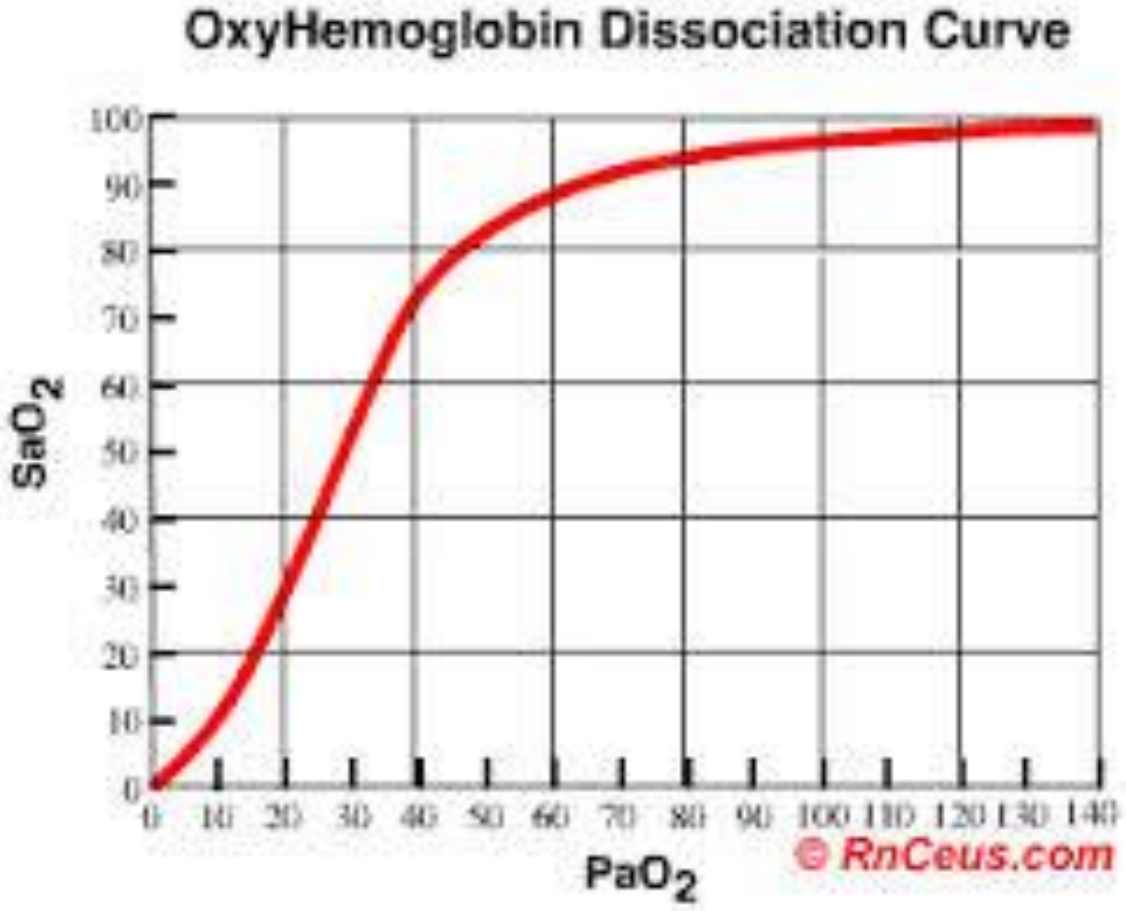
Deoxygenation is also rapid

OXYGEN HEMOGLOBIN DISSOCIATION CURVE

- The curve relating the percentage saturation of oxygen carrying of hemoglobin to PO2.

- Sigmoid in shape

OXYGEN HEMOGLOBIN DISSOCIATION CURVE



MOLECULAR BASIS OF SIGMOID CURVE

- T-R interconversion
- In deoxyHb, globin units are tightly bound in a **tense 'T' configuration**- Reduced affinity for Oxygen
- Binding with first molecule of Oxygen, bonds holding , globin units are released producing **relaxed – Relaxed (R) configuration-** exposes more oxygen binding state.
- Binding of First molecule of oxygen make the binding of second molecule easier and so on

MOLECULAR BASIS OF SIGMOID CURVE

- Saturation rises steeply between 15 mm Hg and 40mm Hg
- Beyond 60 mm Hg- Plateau- Most of the binding sites are already occupied by Oxygen

ADVANTAGES OF SIGMOID SHAPE

- Amount of Oxygen carried by hemoglobin does not change much If PO_2 drops from 100 to 60%- Beneficial at high altitude
- Steep portion of curve- Between 15 and 40mm Hg- Any small increase in PO2 – Oxygen carrying capacity of blood is increased markedly.

OXYGEN CARRYING CAPACITY OF HEMOGLOBIN

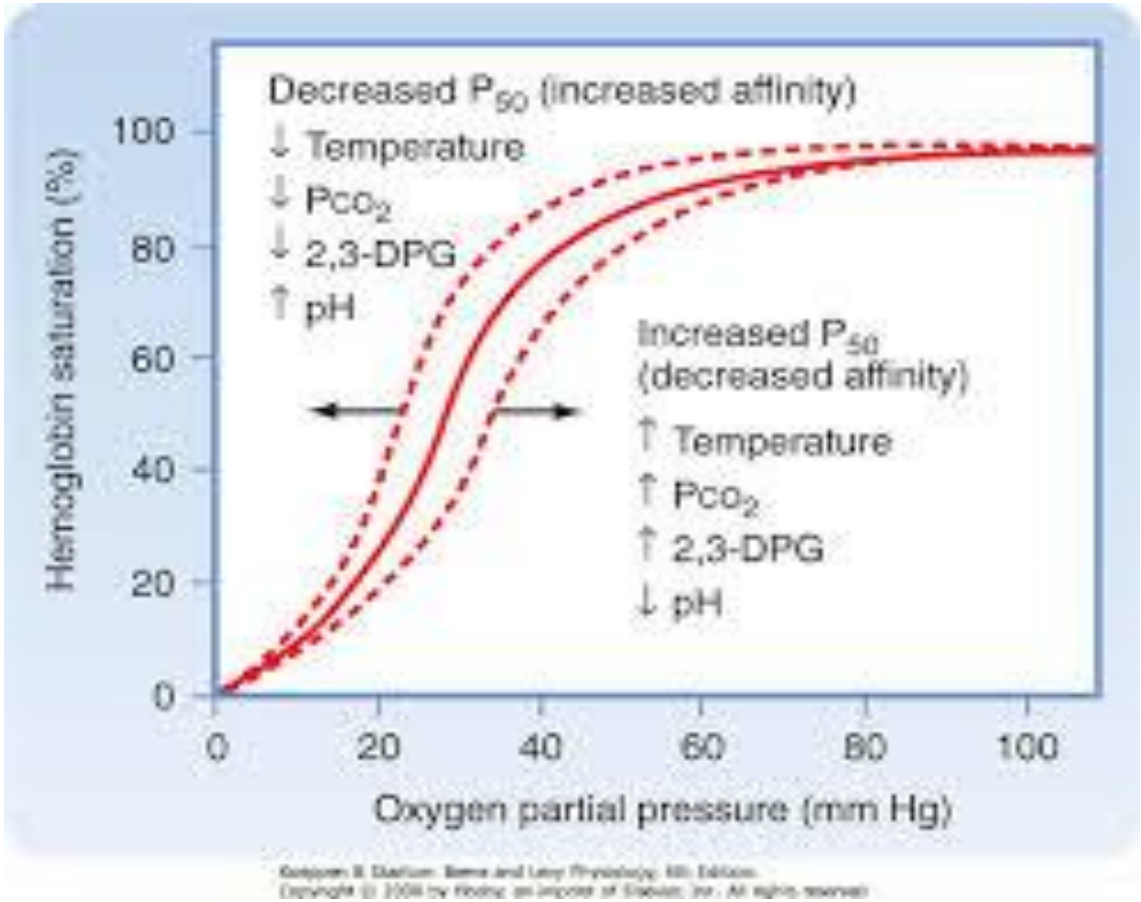
- 1 g of fully saturated normal Hb-

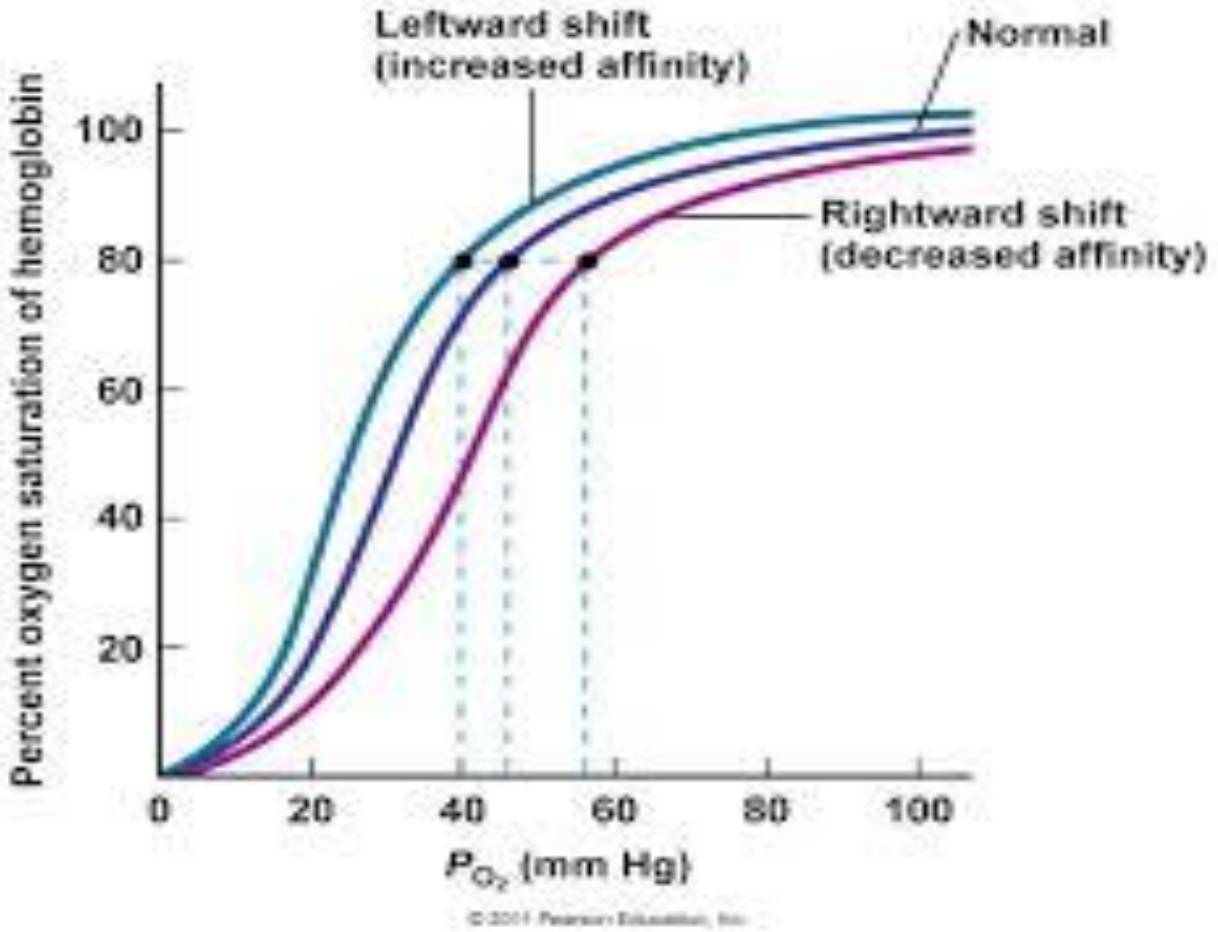
  Contain **1.39 ml** of oxygen
- As blood normally contains small amount of inactive derivatives, measured value is lower
  - **1.34 ml of Oxygen**
- Hb conc. In blood of Hb. 15g/dl = 20.1l/dL- when Hb is 100% saturarted.
- Dissolved Oxygen – linear function of PO2- 0.003ml/dl blood/mm Hg

AMOUNT OF OXYGEN RELEASED

- Oxygen content of normal **systemic arterial blood** (97.5 percent saturated) is **19.8ml/ 100ml of blood**
- (19.5 ml bound to Hb & 0.29 ml in solution)
- **Venous blood** - (PO2 – 40mm Hg- 75 percent saturated) – **15.2 ml/ 100ml**
- (15.1 ml bound to Hb & 0.12 ml in solution)
- Amount of Oxygen removed at tissue- **4.6ml/dl**

OXYGEN TRANSFER




Leftward shift
(increased affinity)
Normal
Rightward shift
(decreased affinity)
Percent oxygen saturation of hemoglobin
100
80
60
40
20
0
20
40
60
80
100
P_{O_2} (mm Hg)

BOHR EFFECT

- The right shift of oxygen hemoglobin dissociation curve brought about by an increase in PCO_2 is called Bohr effect
- Possibly mediated by an increase in H^+ concentration
- When H+ binds with Hb→ Configurational change in Hb → Accessibility of Oxygen to heme group is reduced

P_{50}

- P_{50} is the PO_2 at which Hemoglobin is 50% saturated
- Normal value about 26.6mm Hg at pCO_2, pH 7.4 and temperature 37^0C
- Significance of P_{50}- Helps to determine Hb affinity for oxygen
- Hb affinity for Oxygen is an inverse function of P_{50} value- Higher the P_{50}, lower the affinity for Hb to Oxygen

CARBON MONOXIDE POISONING

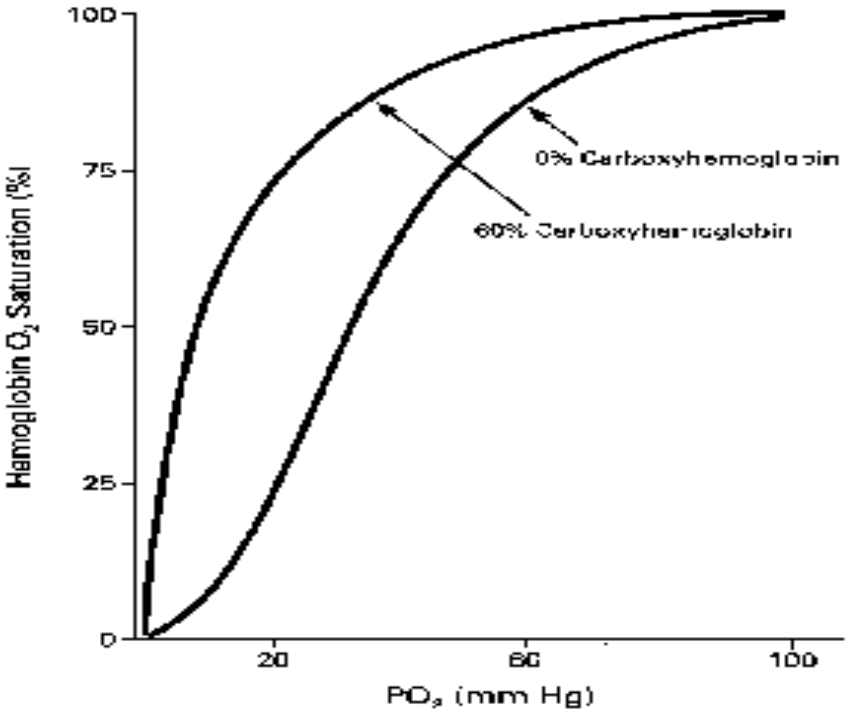
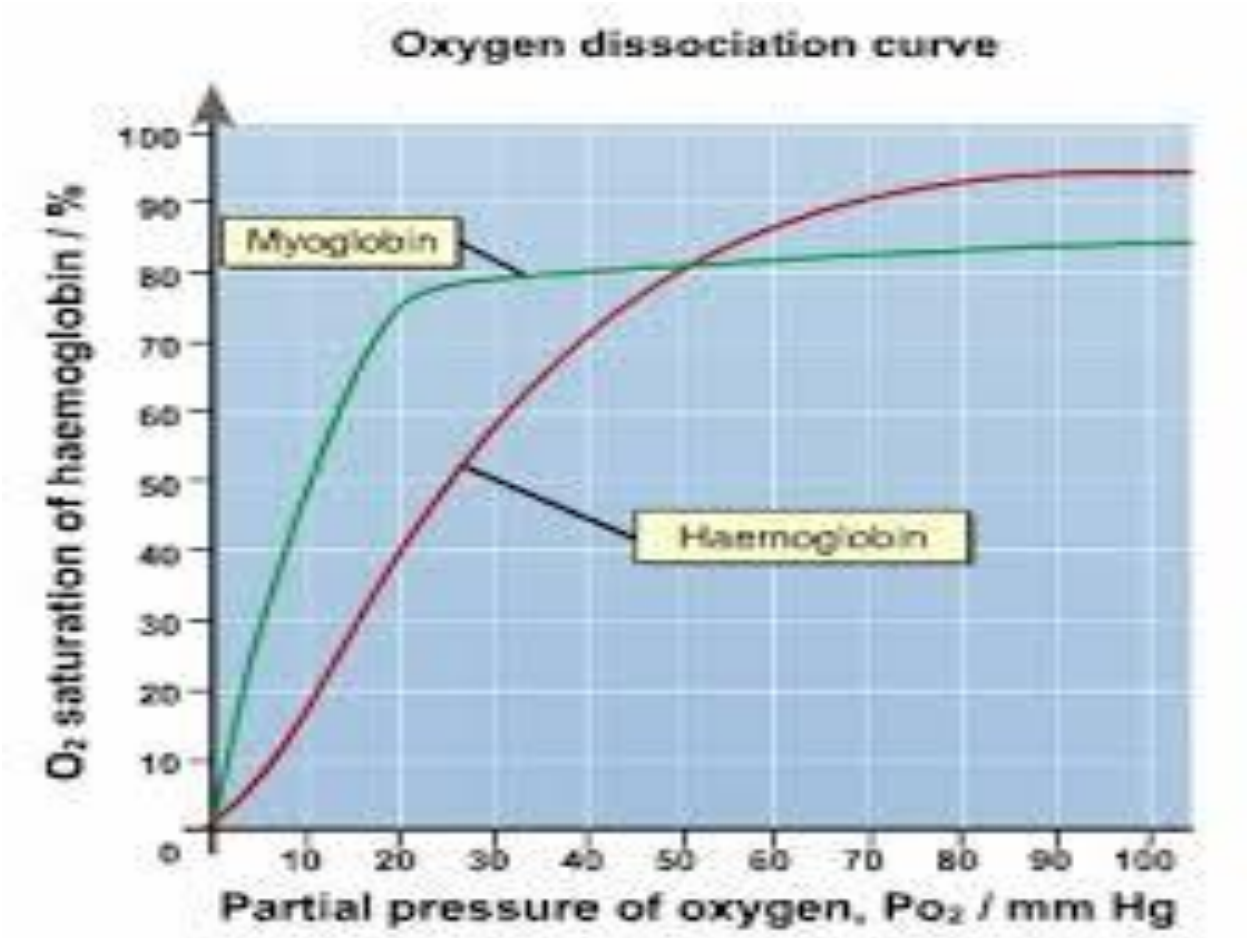


Figure 1. Oxygen--Hemoglobin Dissociation Curve.
The presence of carboxyhemoglobin shifts the curve to the left and changes it to a more hyperbolic shape. This results in a decrease in oxygen carrying capacity and impaired release of oxygen at the tissue level.

CARBONMONOXIDE POISONING

- CO has more affinity for Hb than Oxygen (210) times
- So even at low conc. Of CO, it can displace Oxygen.
- Oxygen delivery to the tissue is also affected.
- Lethal conc. Of CO in air is 0.1%
- Treatment Of CO poisoning-
  - 100% Oxygen
  - Hyperbaric Oxygen therapy

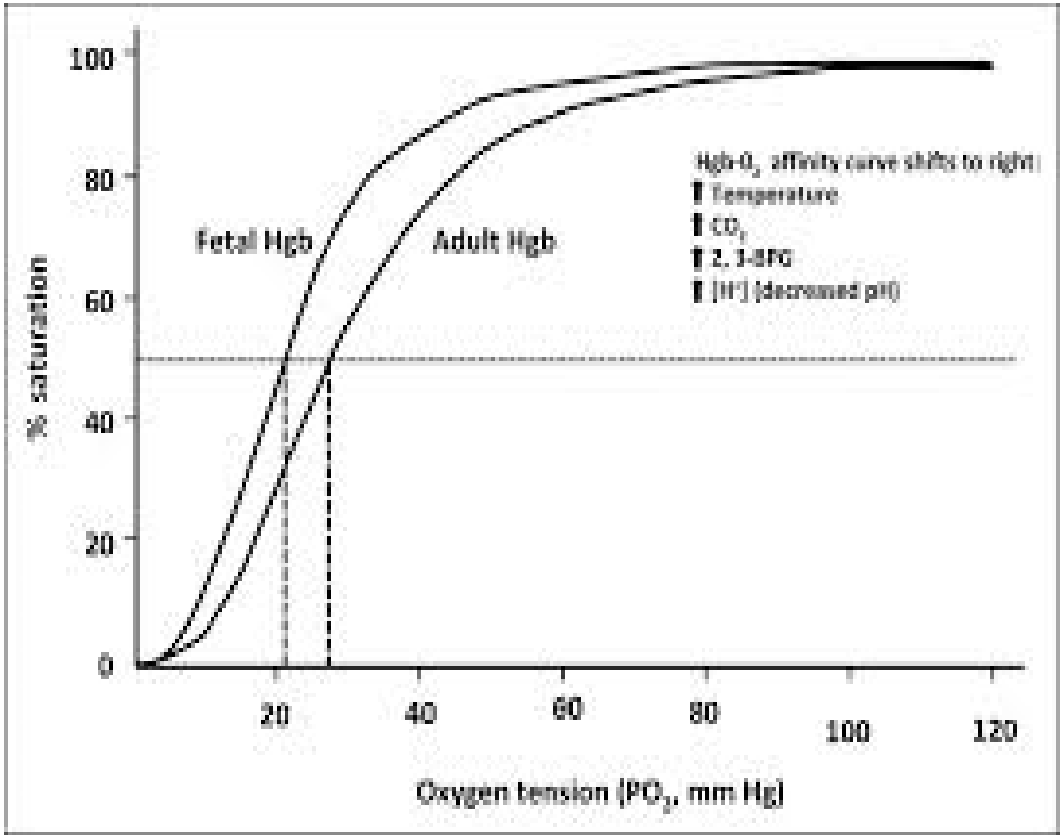
MYOGLOBIN


Oxygen dissociation curve
Myoglobin
Haemoglobin
O2 saturation of haemoglobin / %
0
10
20
30
40
50
60
70
80
90
100
Partial pressure of oxygen, Po2 / mm Hg

MYOGLOBIN

- Shape of dissociation curve is rectangular hyperbola
- As the curve is left to Oxygen Hb curve, it takes up oxygen from Hb in the blood.
- Releases Oxygen only at low PO_2

FETAL HEMOGLOBIN



FOETAL HEMOGLOBIN

- The greater affinity of Hb F than adult Hb for Oxygen facilitate movement of Oxygen from mother to fetus

DISSOLVED FORM

- At normal arterial PO_2, 95 mm Hg- Dissolved Oxygen is 0.29ml/100ml
- At PO_2 , 40mm Hg – 0.12ml
- Oxygen transported in dissolved Oxygen – 0.17 ml/ 100ml arterial blood flow

FUNCTIONS OF HEMOGLOBIN

- 1. Facilitate oxygen transport
- 2. Facilitate carbon dioxide transport
- 3. Buffer
- 4. Transport of Nitric oxide