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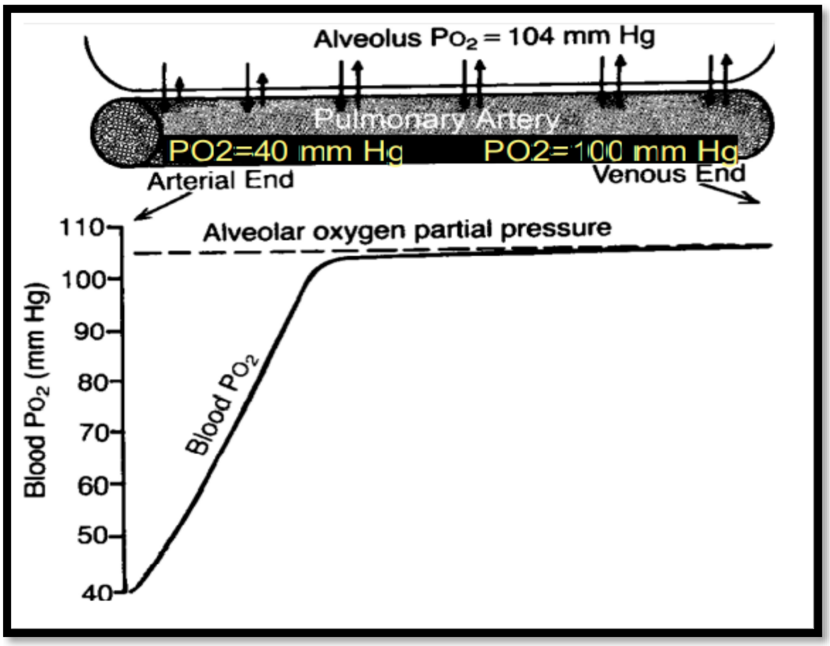
Gas Exchange

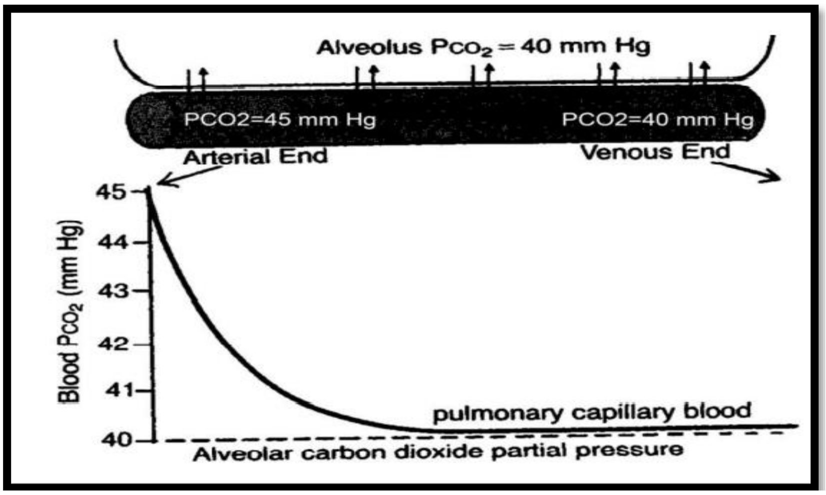
Movement of O2 from Alveoli to Blood

- Gases move from regions of higher partial pressure to regions of lower partial pressure (P).
- PO2 in the alveoli is near 100 mm Hg. The PO2 in the blood returning to the lungs is near 40 mm Hg.
- Thus, diffusion will cause oxygen to move from the alveolus to the blood.



Elimination of CO 2

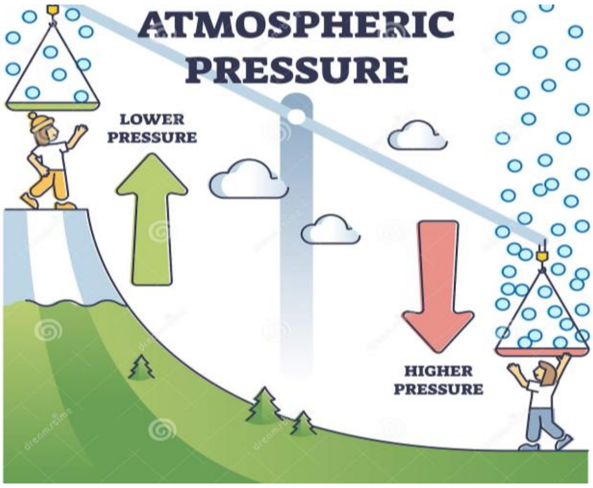
- CO2 a major waste product of cells, is picked -up by the blood in the systemic capillaries and transported to the lungs for elimination.



- Carbon dioxide returning to the lungs from the systemic circulation has a partial pressure of ~45 mm Hg, whereas the partial pressure in the alveolus is ~40 mm Hg. Thus, diffusion causes CO2 to be eliminated from the blood.

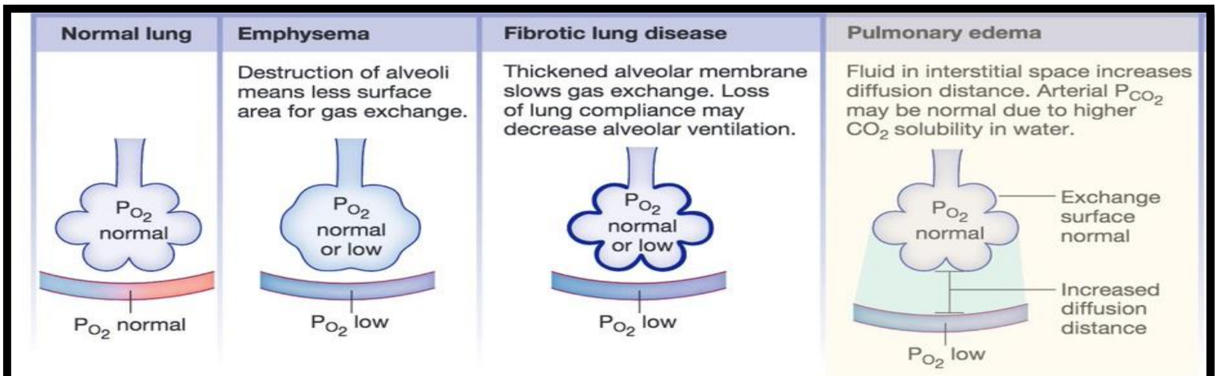
Impairment of Gas Exchange

1- Drop in partial pressure of oxygen in alveoli due to diseases (asthma) or if atmospheric pressure drops (at high altitudes).



2. Decrease in the surface area available for gas exchange, or if there is an increase in the diffusion distance between air and the blood.
3. Diseases such as:

Fibrosis can lead to a thickening of the alveoli, which will affect diffusion of gases into the blood, and PO2 will be low. **Pulmonary edema**, an expansion of fluid volume in the interstitial space of the lung.



Source: Human Physiology: An Integrated Approach, Sixth Edition.

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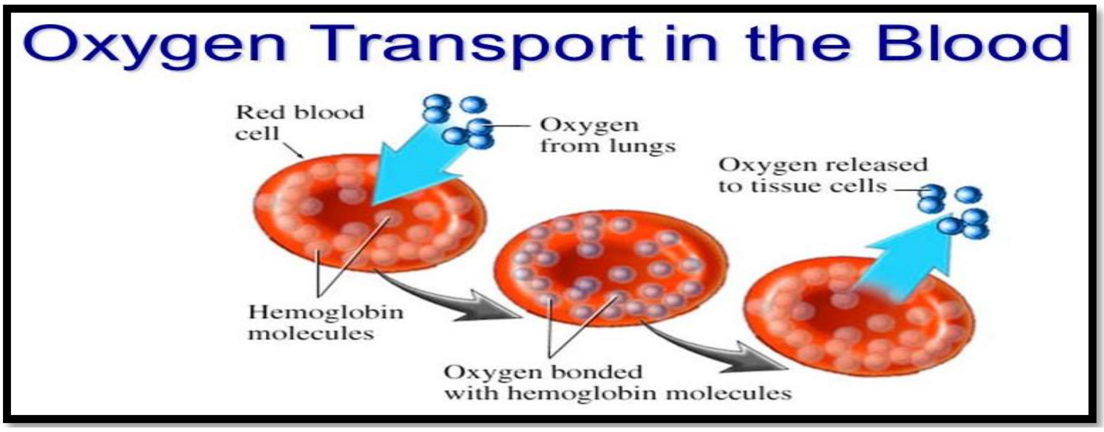
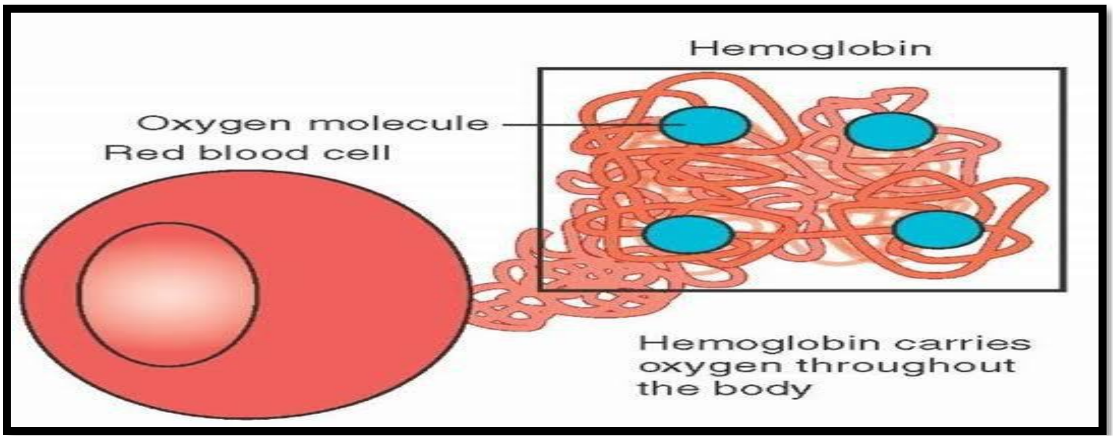
Transport of O2 by blood Role of Hemoglobin

- Normally, about 97% of the oxygen carried in the blood is bound to hemoglobin in the red blood cells. The other 3% is dissolved in the plasma. Thus, hemoglobin greatly increases the oxygen-carrying capacity of blood.



- The amount of oxygen that binds to hemoglobin directly depends on two factors:
  1. PO2 of the plasma.
  2. Number of free hemoglobin oxygen binding sites.



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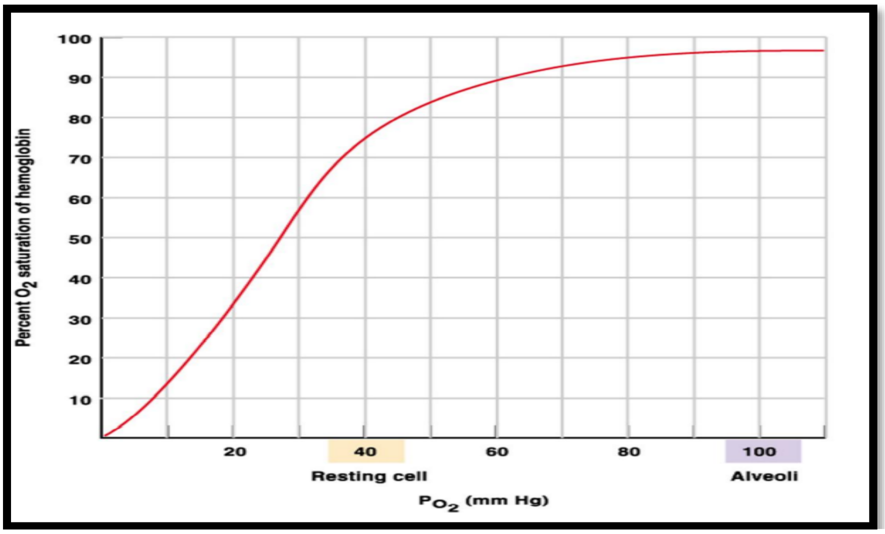
Transport of O2 by Blood

- CaO2 = arterial O2content (O2/ml blood)
- CvO2 = venous O2content (O2/ml blood)
- F = blood flow (ml/min)
- Rate of O2 delivery = F * CaO2 (O2/min)
- Rate of O2 removal = F * CvO2 (O2/min)
- The arterial blood contains 20 cm3 of O2 and Venous blood 15
- This means that every 100 cm3 of blood gain in the lung and lose in the tissues about 5 cm3 at rest and increases during exercise.

Hemoglobin-Oxygen Dissociation Curve

- The oxygen-hemoglobin dissociation curve shows the relationship between PO2 and binding of oxygen to hemoglobin. If PO2 > 60 mm Hg, then hemoglobin will still be almost totally saturated with oxygen.
- When blood reaches the systemic capillaries, and PO2of the plasma drops, then oxygen will tend to dissociate from the hemoglobin. Note,
- however, even at typical tissue levels of PO2, hemoglobin still carries about 75% of the oxygen that it is capable of moving.



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Dissociation Curve Shifts

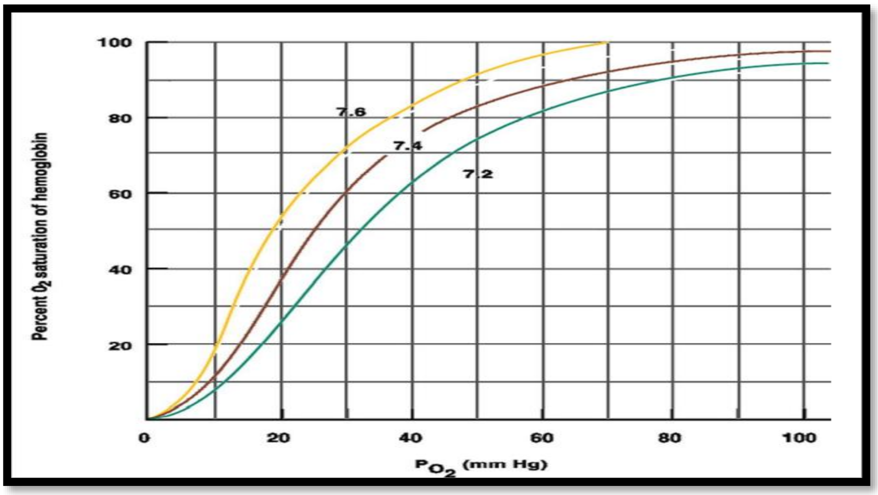
Hb is uniquely sensitive to tissue needs, allowing it to deliver increasing amount of O2when metabolism increases. This is made possible through allosteric changes that decrease the protein's O2 affinity and promote unloading. These changes manifest as a rightward shift in the Hb-O2 dissociation curve.

1. Rightward Shifts

Metabolism generates heat and CO2 and acidifies the local environment. All three changes reduce HB's O2 affinity and cause to unload O2.

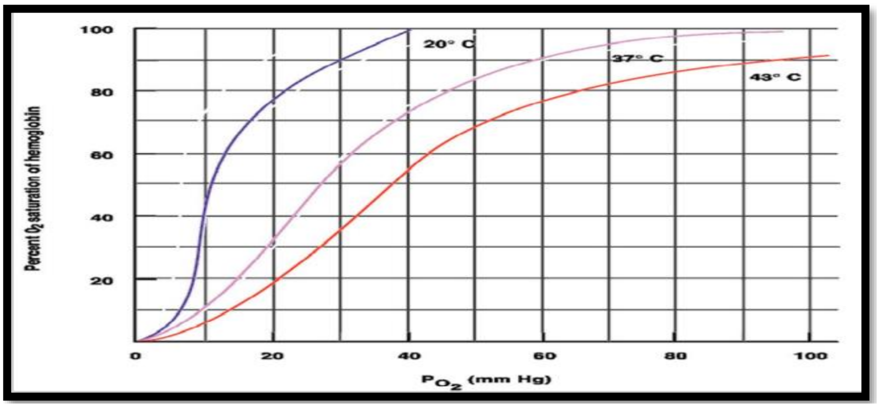
A. Effects of pH on Hemoglobin (Bohr Effect)

Increasing H+ in the blood (lowering pH) shifts the oxygen-hemoglobin dissociation curve to the right, so hemoglobin sheds oxygen more easily to the tissues.



B. Effects of Temperature on Hemoglobin

Increasing temperature shifts the oxygen-hemoglobin dissociation curve to the right, so hemoglobin sheds oxygen more easily to the tissues



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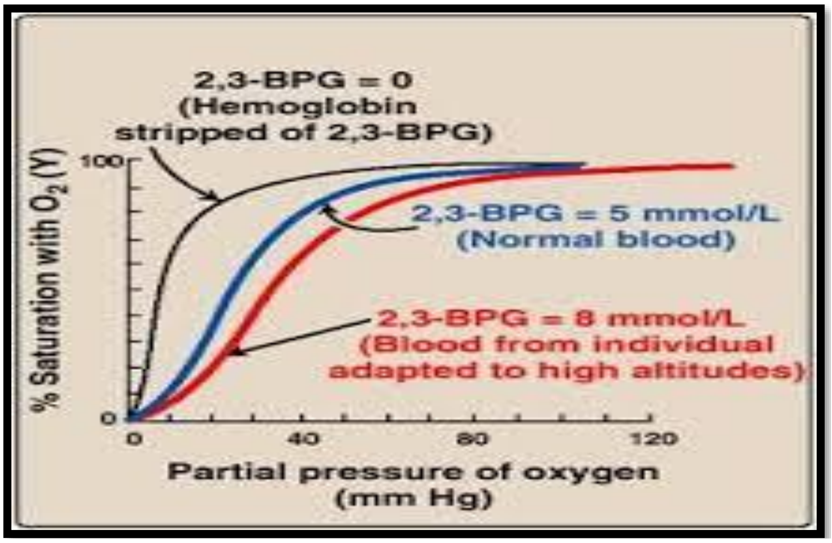
C. Effects of 2,3 DPG on Hemoglobin

- Oxygen-hemoglobin binding is also affected by 2,3-phosphoglycerate (2,3-DPG), a compound made from the intermediate of the glycolysis pathway.
- Through mechanisms that are not well understood, chronic hypoxia (as during anemia or high altitude exposure) leads to an increase in 2,3-DPG production by red blood cells.
- This compound shifts the oxygen-hemoglobin dissociation curve to the right, thereby causing more oxygen to be released at a particular PO2 level.



2. Leftward Shifts

- Hb-O2 affinity increases and the Hb-O2 dissociation curve shifts left when body temperature decreases as when CO2, H+ or 2,3 DPG levels decrease.
- All of these changes reflect decreased metabolic activity and a decreased need for O2 delivery to tissues.
- The leftward shift in the Hb-O2 dissociation curve is also observed in the fetus and as a result of CO binding to Hb.

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Shift to right

- Affinity of Hb with O_2 decreases
- So more O_2 is delivered to the tissues

Shift to left

- Affinity of Hb with O_2 increases
- So less O_2 is delivered to the tissues