EXCHANGE OF GASES

Gas exchange in organisms occurs predominantly through simple diffusion, primarily driven by pressure or concentration gradients. The exchange of oxygen (O_2) and carbon dioxide (CO_2) is elucidated by studying partial pressures, which represent the pressure exerted by individual gases within a gas mixture. Oxygen partial pressure is denoted as pO_2, and for carbon dioxide, it is PCO_2. Gases diffuse from regions of higher partial pressure to regions of lower partial pressure.

Several factors influence the rate of diffusion:

- **Solubility of Gases:** Gases with higher solubility diffuse more rapidly than those with lower solubility. For example, CO_2, with a solubility 20-25 times higher than O_2, diffuses more efficiently across the diffusion membrane.
- **Partial Pressure:** Gases diffuse according to their partial pressures. For instance, O_2 diffuses from atmospheric air (pO_2 = 159 mm Hg) to the alveoli (pO_2 = 104 mm Hg).
- **Thickness of the Membrane:** The rate of diffusion is inversely proportional to the thickness of the membrane. Thinner membranes promote faster diffusion, while thicker membranes impede it. Hence, an ideal diffusion membrane should be extremely thin.

Gas exchange primarily occurs at two sites:

- **Exchange of Gases between Alveoli and Blood**
  Diffusion Membrane: The alveolar-capillary membrane consists of three layers:
  Thin squamous epithelium lining the alveoli.
  Endothelial lining surrounding the alveolar capillaries.
  Basement substance between the alveolar epithelium and capillary endothelium.
  These layers collectively form an incredibly thin diffusion membrane, approximately 0.2 to 0.3 μm thick.
  O_2 moves from atmospheric air into the alveoli and then into the bloodstream, while CO_2 moves in the opposite direction, from the bloodstream to the alveoli.

Understanding these mechanisms provides insights into how gases are efficiently exchanged to meet the metabolic demands of the organism.

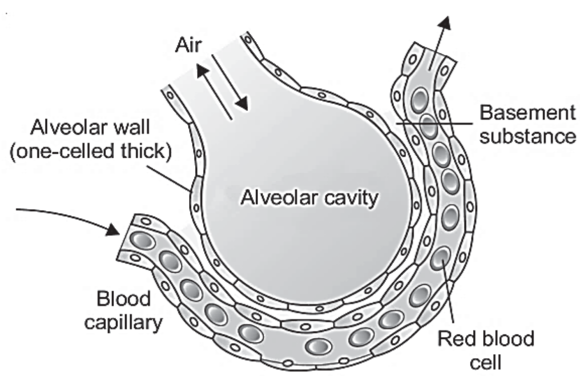

Fig. : A diagram of a section of an alveolus with a pulmonary capillary

Table: Partial Pressures (in mm Hg) of Oxygen and Carbon dioxide at different parts involved in diffusion in comparison to those in atmosphere

Respiratory Gas	Atmospheric Air	Alveoli	Blood (Deoxygenated)	Blood (Oxygenated)	Tissues	Expired Air
O_2	159	104	40	95	40	120
CO_2	0.3	40	45	40	45	27

- The partial pressure of oxygen (pO_2) is higher in atmospheric air, approximately 159 mm Hg, compared to the alveoli, where it measures around 104 mm Hg. Conversely, the pO_2 in the alveoli is higher than that in deoxygenated blood within the capillaries of the pulmonary arteries, which typically registers at 40 mm Hg. Given that gases diffuse from regions of higher to lower partial pressure, oxygen moves from the atmospheric air to the alveoli and eventually into the bloodstream.
- On the other hand, carbon dioxide (CO_2) exhibits an opposite movement. The partial pressure of CO_2 (pCO_2) is higher in deoxygenated blood, around 45 mm Hg, than in the alveoli, where it is about 40 mm Hg. Moreover, the pCO_2 is even lower in atmospheric air, approximately 0.3 mm Hg. Consequently, CO_2 migrates from the deoxygenated blood to the alveoli and eventually exits into the atmosphere.

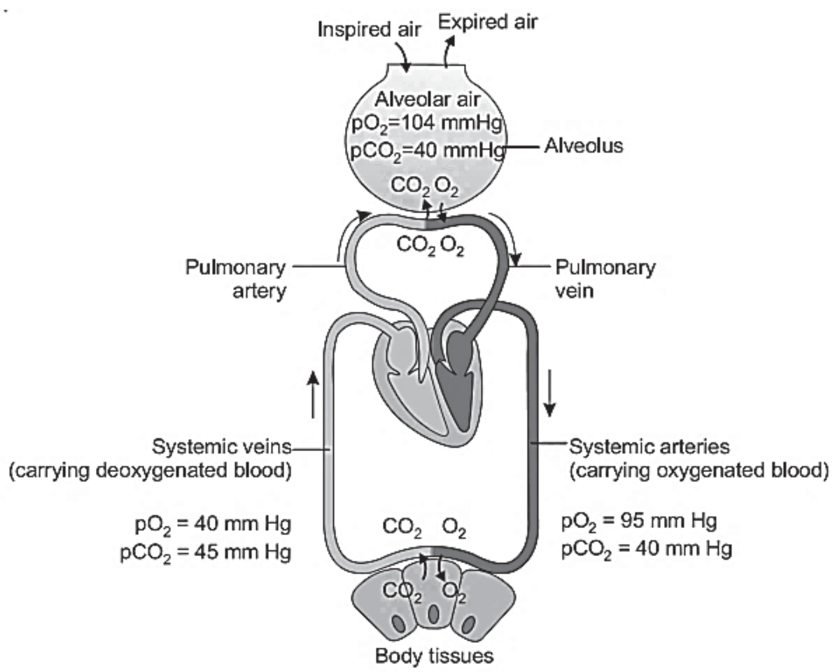

Fig. : Diagrammatic representation of exchange of gases at the alveolus and the body tissues with blood and transport of oxygen and carbon dioxide

- **Exchange of Gases between Blood and Tissues**
  Oxygen (O_2) and carbon dioxide (CO_2) are exchanged between blood capillaries and body cells, and vice versa. In systemic arteries carrying oxygenated blood, the partial pressure of oxygen (pO_2) is higher, typically around 95 mm Hg, compared to the pO_2 in tissues or body cells, which is approximately 40 mm Hg. Consequently, oxygen migrates from systemic arteries to body cells, where it is utilized in catabolic reactions that produce carbon dioxide (CO_2), water (H_2O), and energy.

As CO_2 is generated within the body cells, its partial pressure (pCO_2) increases to around 45 mm Hg, surpassing the pCO_2 in blood capillaries, which remains at 40 mm Hg. Therefore, CO_2 moves from the body cells to the blood capillaries through tissue fluid. Subsequently, the blood becomes deoxygenated and is transported to the heart, then to the lungs via the pulmonary artery for reoxygenation.