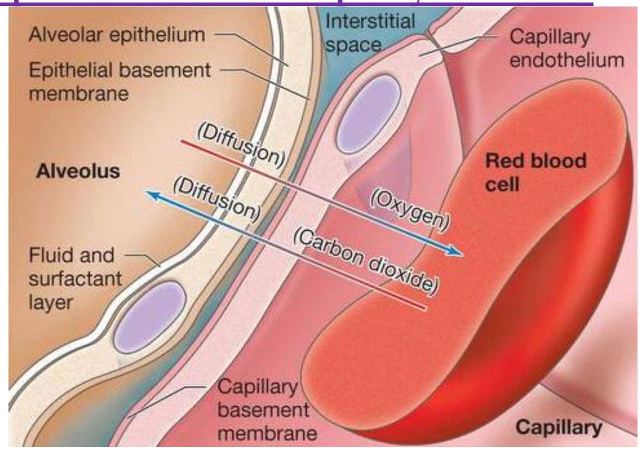
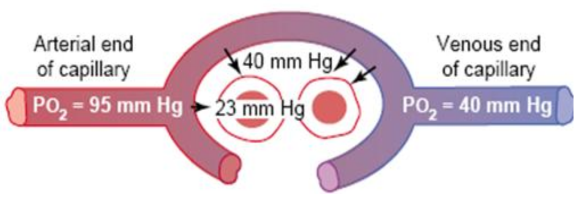
Unit II – Problem 5 – Physiology: Gas Diffusion/ Diffusion Capacity of The Lung

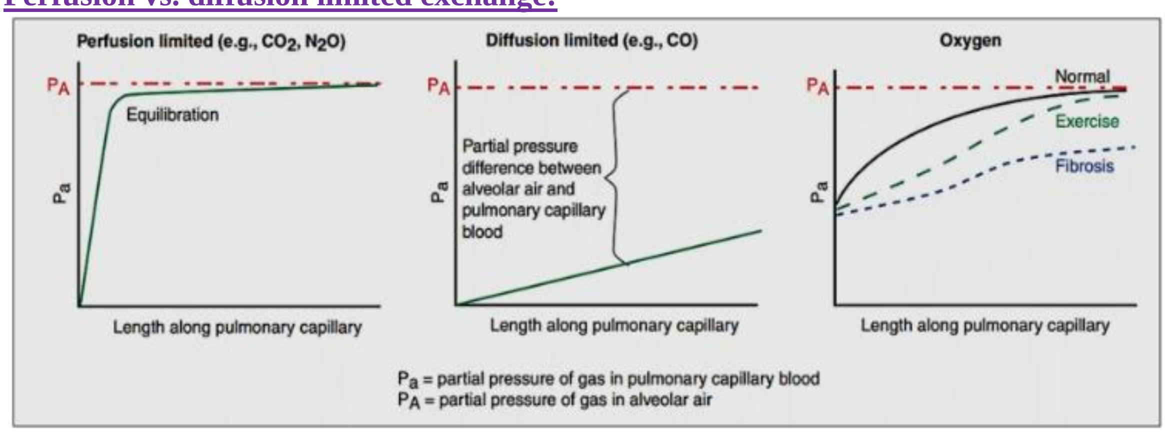
- **The image below represents the alveolar-capillary membrane:**



- **Gas exchange through respiratory membrane is efficient due to the following factors:**
  - Partial pressure gradient (differences in pressures of gases in alveoli and those in capillaries. Therefore, gas exchange occurs from the area of high pressure to the area of low pressure).
  - Thickness of respiratory membrane (which represents a small diffusion distance).
  - Large surface area of alveoli.
  - Lipid-soluble gases – diffusion coefficient (notice that CO_2 diffuses 20 times more rapidly than O_2).
- **For more details about O_2 and CO_2 exchange between capillaries and alveoli review physiology note of problem 4.**



  - **Factors affecting O_2 exchange are:**
    - ✓ Heavy exercise: in this condition there is high blood flow through the capillaries thus PO_2 across alveolar membrane barely equilibrates by the end of pulmonary capillaries.
    - ✓ Reduced alveolar O_2: thus there is reduction in pressure gradient across respiratory membrane resulting in decreased rate of O_2 diffusion.
    - ✓ Thickening of alveolar membrane with some pathological conditions.
- **Perfusion vs. diffusion limited exchange:**



- **Diffusion capacities of the lung (DL):**
  - DL estimates the transfer of oxygen from alveolar gas to red blood cells in capillaries.
  - Carbon monoxide (CO) is used as a surrogate بديل for oxygen.

- **DL is a products of two variables:**
  - ✓ Rate of CO uptake.
  - ✓ Alveolar ventilation V_A.
- **Diffusion capacity of a gas is calculated as the volume of gas absorbed by pulmonary blood (V) divided by pressure gradient between alveolar gas (P_A) and capillary blood (P_{cap}). Example on diffusion capacity of oxygen:**
  - ✓ $DL_{O2} = \frac{V_{O2}}{(P_{AO2} - P_{capO2})}$
  - ✓ The higher the diffusing capacity (DL) the more gas will be transferred into the lungs per unit time for a given gradient in partial pressure (or concentration) of the gas.
  - ✓ Sampling oxygen in pulmonary artery is highly invasive procedure. CO is rapidly and tightly bound to hemoglobin in blood. For this reason, CO is generally the test gas used to measure the diffusing capacity and the DL equation is simplified to:
    - ❖ $DL_{CO} = \frac{V_{CO}}{P_{ACO}}$
  - ✓ <u>So as a summery, why do we choose CO?</u>
    - ❖ Not normally present in alveoli/blood.
    - ❖ Transfer is diffusion limited rather than perfusion limited.
    - ❖ Avidly binds to hemoglobin (210 times more than O_2).
    - ❖ Solubility coefficient of CO (0.002) is close to that of O_2 (0.003).
    - ❖ Harmless at low concentrations (<0.3%).
  - ✓ <u>Lung diseases which reduce diffusion capacity (DL_{CO}):</u>
    - ❖ Loss of lung parenchyma in diseases such as emphysema.
    - ❖ Diseases which scar the lung (interstitial lung diseases) such as idiopathic pulmonary fibrosis or sarcoidosis.
  - ✓ <u>Single-breath method for estimating DL_{CO}:</u>
    - ❖ The person exhales to residual volume and then inhales to maximal breath a gas mixture containing very low concentration of CO + helium.
    - ❖ After sufficient expiration to clear the dead space, a gas sample is collected to estimate final alveolar CO and helium fractions and analyzed.
    - ❖ By measuring the concentration of the exhaled CO and helium, the value of DL_{CO} can be computed.
    - ❖ The helium is used to calculate TLC and the exhaled CO is used to calculate the amount of CO transferred to the blood.
- **The only gases with measurable diffusing capacities are**: O_2, CO and NO.