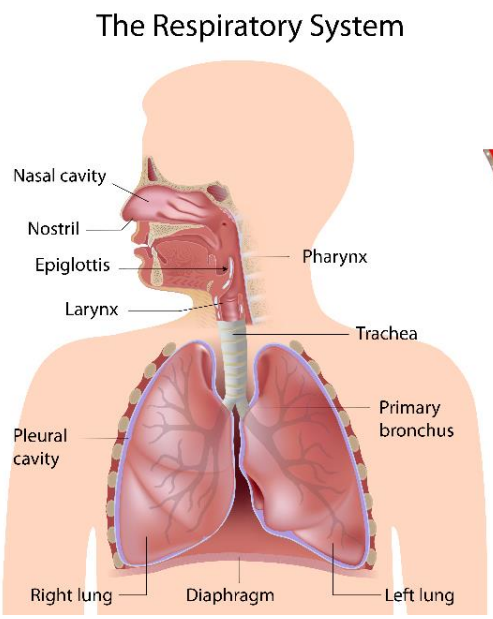
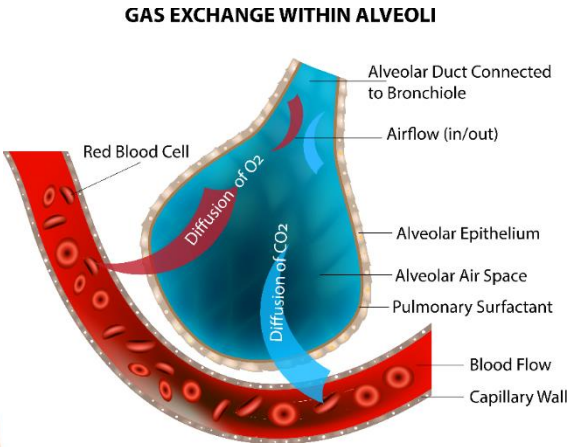
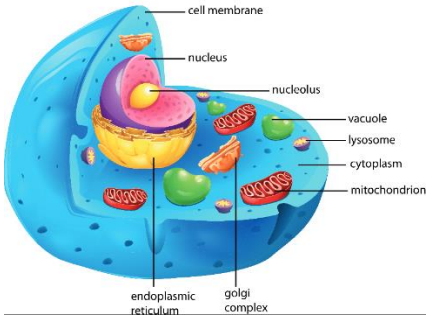
CONCEPT: RESPIRATORY PHYSIOLOGY

- Gas exchange allows animals to get O_2 for cellular respiration, and get rid of waste CO_2 from metabolism
- Small animals can perform gas exchange across their body surfaces due to high SA:V
- Respiratory organs provide surface area for gas exchange in larger organisms

EXAMPLE:

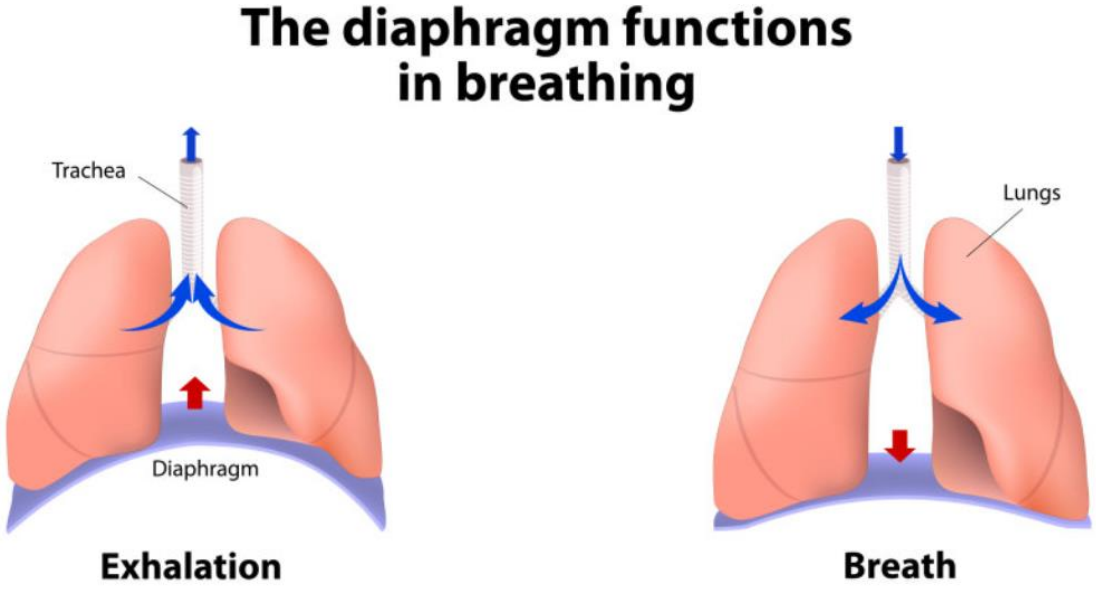






- Positive pressure is like pushing, negative pressure is like pulling
  - □ ***Positive pressure ventilation*** – air is pushed into the lungs
  - □ ***Negative pressure ventilation*** – air is pulled into the lungs
    - ***Diaphragm*** pulls downward and ribs pull upward on thoracic cavity, creating negative pressure

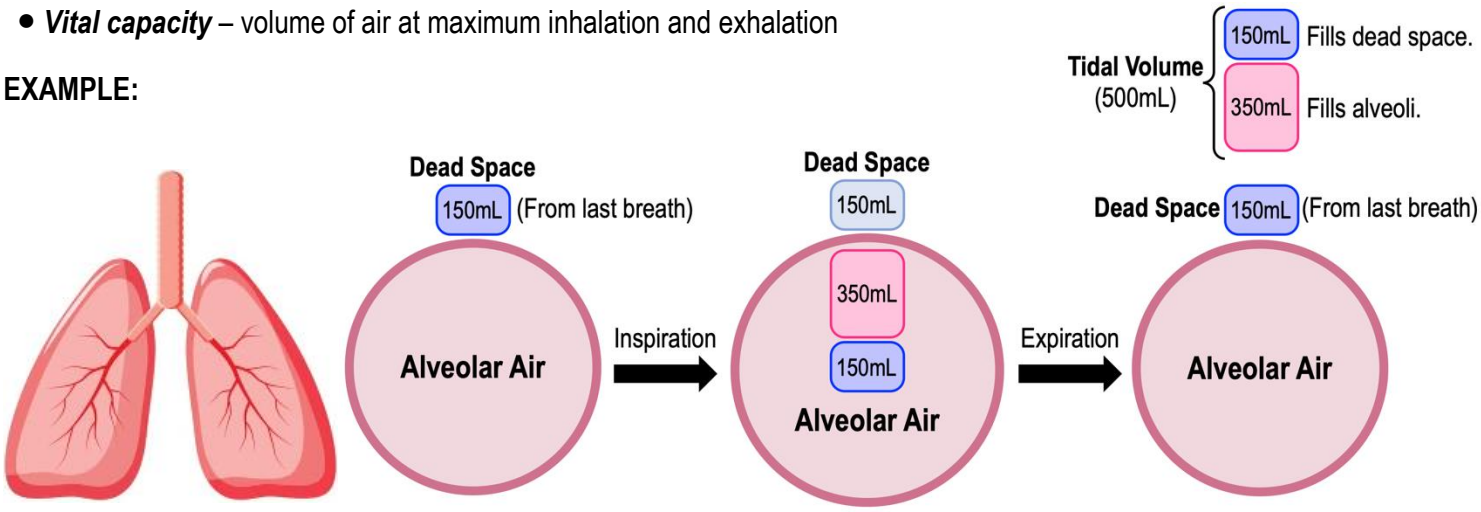
EXAMPLE:



CONCEPT: RESPIRATORY PHYSIOLOGY

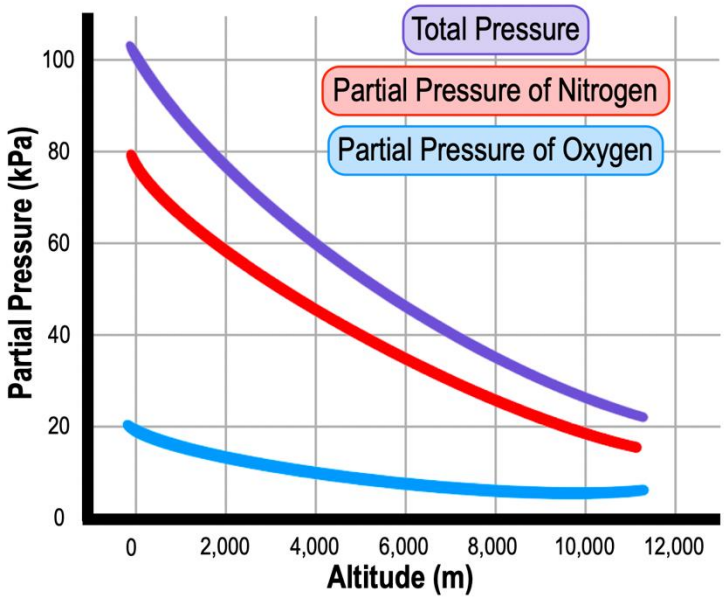
- ***Dead space*** – inhaled air that does not take part in gas exchange, trachea, bronchi, and bronchioles
- ***Tidal volume*** – volume of air inhaled and exhaled with each breath
- ***Vital capacity*** – volume of air at maximum inhalation and exhalation

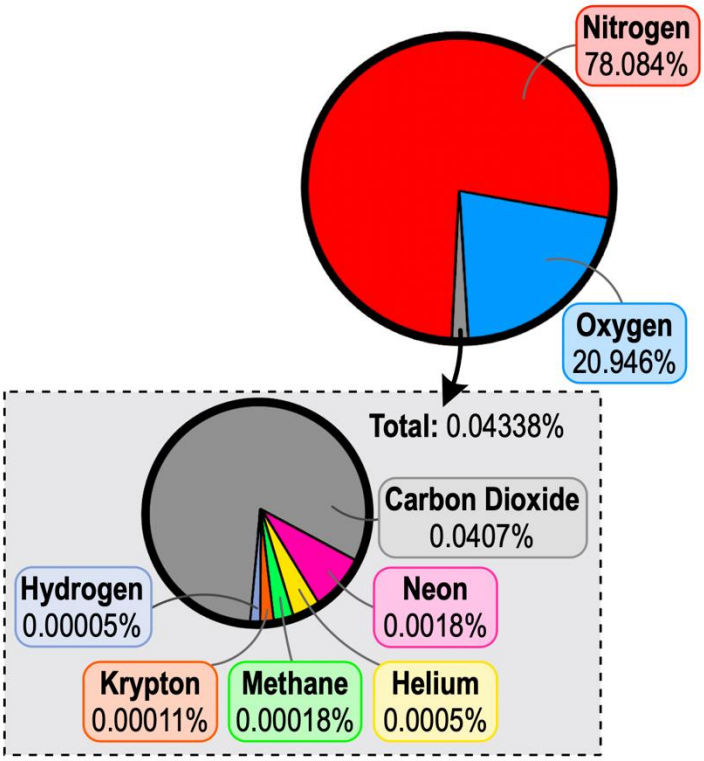
EXAMPLE:



- ***Partial pressure*** (P_X) – hypothetical pressure of a gas alone, but occupying the same volume at same temperature
  - □ Partial pressure = total pressure x % composition of gas mixture
  - □ At high altitude and sea level the % of each gas in atmosphere is the same, but the total pressure differs
    - Partial pressures of gases are lower at higher altitudes
  - □ Gases diffuse based on partial pressures, move from higher partial pressure to lower partial pressure

EXAMPLE:

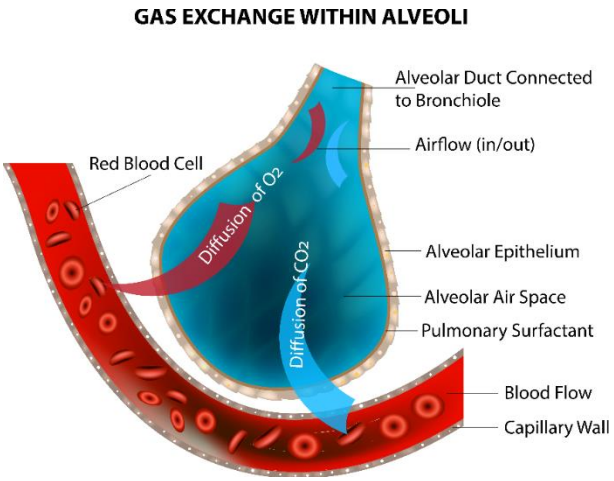




CONCEPT: RESPIRATORY PHYSIOLOGY

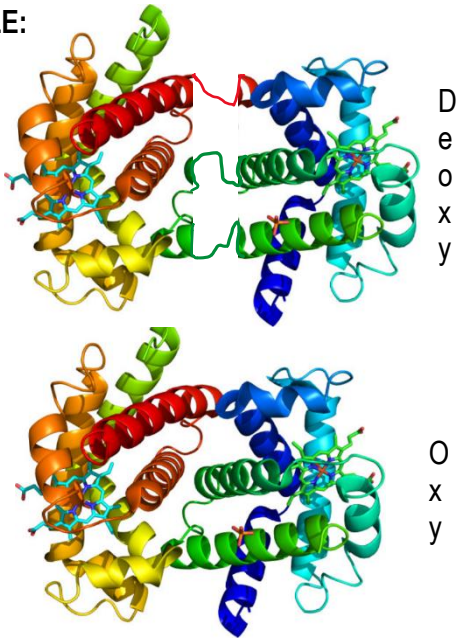
- ***Fick's law of diffusion*** – gases diffuse based on 5 criteria, most importantly surface area, distance, and partial pressure
  - □ Increasing surface area for gas exchange increases rate of diffusion
  - □ Decreasing the distance gases must travel, like the thickness of a membrane, increases rate of diffusion
  - □ Increasing the difference in partial pressure between the two environments increases rate of diffusion
- Partial pressure drives O_2 and CO_2 diffusion in the lungs, blood, and tissues
  - □ P_{O2} in the lungs is higher than P_{O2} in the blood, and P_{O2} in the blood is higher than P_{O2} in the tissues
  - □ P_{CO2} in the lungs is lower than P_{CO2} in the blood, and P_{CO2} in the blood is lower than P_{CO2} in the tissues
  - □ Muscles tend to have particularly low P_{O2}, especially during exercise when energy demands increase
- In mammals each breath mixes fresh air mixes with oxygen-depleted air, so P_{O2} in alveoli is less that atmosphere

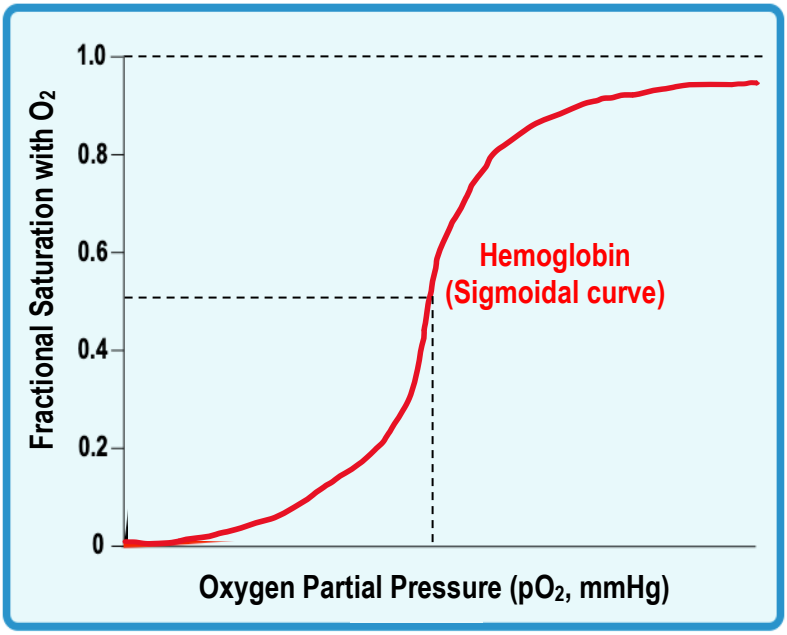
EXAMPLE:



- Hemoglobin binds O_2 to transport it in the blood, and unloads O_2 at the tissues
- ***Cooperative binding*** – in a binding system, the binding of one thing alters binding of subsequent things
  - □ When hemoglobin binds one O_2, it experiences a conformational change making it easier to bind another O_2
- High P_{O2} in lungs allows Hb to pick up lots of O_2, low P_{O2} in tissues allows Hb to unload lots of O_2

EXAMPLE:





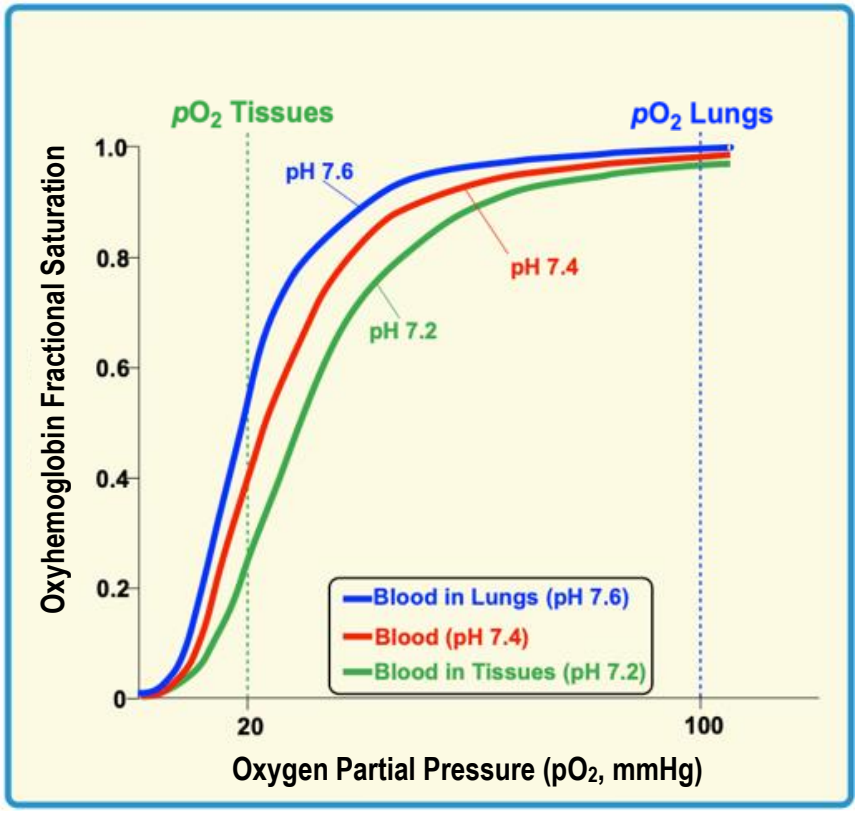
CONCEPT: RESPIRATORY PHYSIOLOGY

- ***Oxygen dissociation curve***, ***oxygen-hemoglobin equilibrium curve***, or ***oxyhemoglobin saturation curve***
  - □ Sigmoidal curve that shows the O_2 saturation of Hb at different P_{O2}
- ***Bohr shift*** – shift to the right of the oxygen dissociation curve due to decreasing pH and increasing P_{CO2}
  - □ Increasing P_{CO2} lowers Hb affinity for oxygen
    - Tissues that are consuming a lot of O_2 will generate a lot of CO_2, increasing P_{CO2}
  - □ Lowering pH (increasing acid concentration) lowers Hb affinity for oxygen
    - CO_2 combines with water to form carbonic acid in blood, lowering pH

EXAMPLE:

Left-Shifted Blue Curve

--Hb Increased O_2 Affinity
-Decreased Temp.
-Decreased 2,3-DPG
-Decreased pCO_2
-Decreased $[H^+]$
-Increased pH
-CO



Right-Shifted Green Curve

-Hb Reduced O_2 Affinity
-Increased Temp.
-Increased 2,3-DPG
-Increased pCO_2
-Increased $[H^+]$
-Decreased pH

- ***Carbonic anhydrase*** – enzyme that catalyzes the formation of carbonic acid (H_2CO_3) from CO_2 and H_2O
  - □ Lowers P_{CO2} in blood, and lowers pH, inducing the Bohr shift and making Hb better at unloading O_2
- pH detectors in the respiratory center of the medulla oblongata help regulate ventilation

EXAMPLE: