Physiology Study Guide Exam 12

<u>Ventilation continued…</u>

-Air pressure dependent on
- -Temperature (Pv=nRT) → but should remain stable in lungs/blood (98.6)
  - -Like weather: Heating up during day, temperature change → wind issues
  - *Not important factor here
- -Gases present: in partial pressures = P_x (proportional to amount of gas present)
  - -Air = 79% Nitrogen, little CO_2 and H_2O (variable)
    - -P_{O2} = 160 mm Hg (~21% O_2)
    - -P_{CO2} = 0.3 mm Hg

-Gases diffuse based on partial pressure (P_x) gradients from high P_x → low P_x
- *Don't use concentrations b/c hard to calculate volumes
- *Numbers used for diffusion into and out of liquids from air/between liquids
  - -Between alveoli and blood:
    - -For blood returning to lungs (via pulm. veins – deoxygenated):
      - -P_{CO2}= 46 mm Hg, P_{O2}= 40 mm Hg
    - -For air in alveoli:
      - - P_{CO2}= 40 mm Hg, P_{O2}= 105 mm Hg
  - *O_2 → into blood / CO_2 → out to alveoli (bringing waste product back)
- *But why are values off in alveoli? (P_{CO2}= 40, NOT 0.3, P_{O2}= 105, NOT 160)
  - -Residual volume = lot of CO_2 / little O_2 never removed from lungs
    - -average O_2 / average CO_2
  - -Cannot expel all used air → mixes with new air entering
- *Only time numbers are equal is when a person is first born

-O_2 (nonpolar) in blood (polar) = polarity problem
1. Little dissolved, poorly soluble (1%) → Free O_2 moving with water
2. 99% reversibly bound to Hb located in RBCs

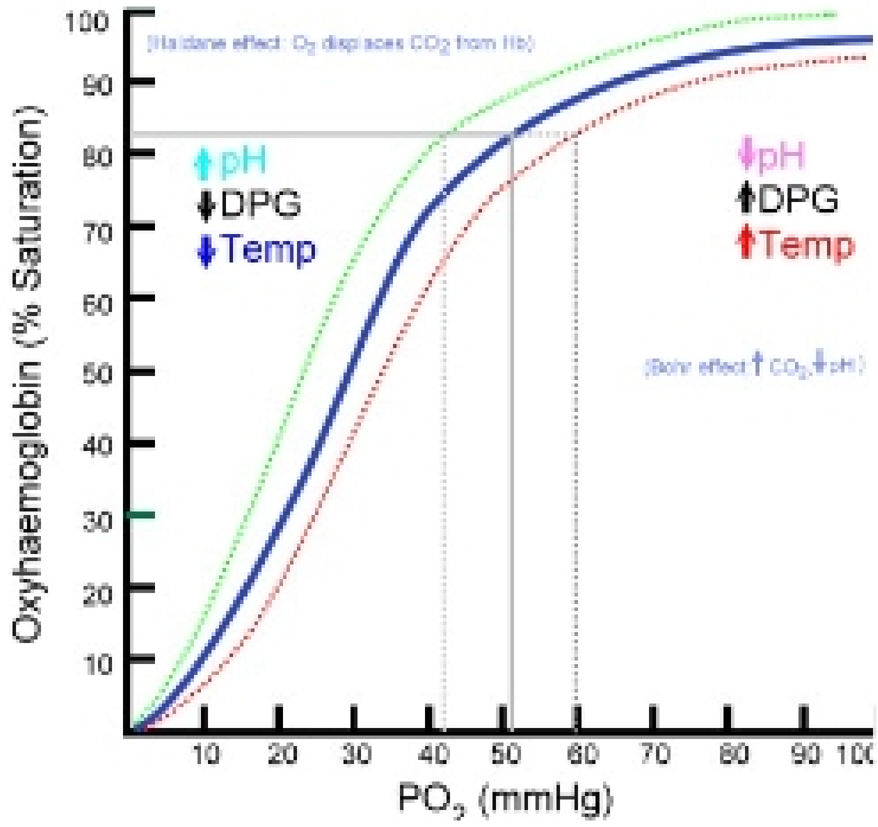
-Hemoglobin (Hb): 4 identical subunits (protein made up of proteins)
- -Iron shares electrons with O_2 (makes reversible binding possible)
  - -Need O_2 to remain the same for metabolism in tissues
  - -Want transport to be like a bus → get on and off the exact same
  - -Iron = like seatbelt → straps you in but can be taken off
- -Cooperativity between units
  - -Shape change at 1 site changes all sites and increases affinity at others
    - -1st O_2 binding affinity at others
    - -1st unbinding affinity at others
  - *If we were flash frozen → most Hb have either no O_2's or 4 O_2's
- -Increases O_2 transferred
  - -Gradient only includes free O_2 present
    - -Without Hb: Free O_2 = 6 vs. 6 (2 transferred)
    - -With Hb: Free O_2 = 6 vs. 2 (10 transferred)
- -Factors affinity for O_2 (kick if off)
  - -CO_2, H+, Temp., DPG (glycolysis) = all change protein's shape → changes shape of binding site
    - -All change shape → doesn't interfere directly

NOTE: Question of Week: What ties these all together? What makes us want to have these to □ affinity of oxygen?

-CO = competitor → binds to site

-Hb has much higher affinity for CO than O_2

-Hemoglobin saturation curve (directly dependent on P_{O2})



-At □ P_{O2}, "pick up" (Lungs) –100% sat. Hb

-At □ P_{O2}, "drop off" (to tissues) < 80% sat. Hb

-deoxygenated blood (not unoxygenated)– still attached to Hb

*Venous reserve = unused/returning oxygen

-CPR change → just chest compressions (not breaths)

1. Didn't want to touch lips
2. O_2 already in body still → just need to start up convection

-But only works for so long: reserve □ as activity □ (inverse)

-Oxygen getting used up by cells (more dropped off)

-Can $P_{O2} = 0$?

-Yes in cells, but NOT in blood (Can't survive if all cells anaerobic)

-Arterial levels in 80s = sluggish, 60s = flat out

-Carbon dioxide (CO_2)

-Nonpolar, but more soluble than O_2 → ~10% free CO_2; ~30% carried on Hb

-Other 60% converted to bicarbonate (HCO_3^-) → why?

-Via equation 3 ($CO_2 + H_2O \rightarrow HCO_3^- + H^+$)

*Pro: Bicarbonate is polar = soluble → solves transport problem to lungs

*Con: pH issue

-Plasma is buffered system (resists pH change) due to Hb/albumin (attaches free H+) → drives equation to products (□ bicarbonate)

*More bicarbonate made in blood than water

-Water is a better buffer

-Plasma adds more H+ per bicarbonate formed

-Plasma has component that binds bicarbonate

*Still small pH changes occur

-Venous pH < arterial pH

[H+] > [H+]

-Venous side: tissues making CO_2 (eq. 2)→ drives equation right

-Eq. 3 converts into bicarbonate → □ H+ (lowers pH)

-CO_2 offloaded in lungs: Drives equation right (reverse eq. 3)

-Sent out of body during exhale

-<u>Problems with Ventilation</u>

-**Hypoventilation** (too little)

-CO_2 not released → too much present

-□ arterial P_{CO2} → □H+/HCO_3^- = respiratory acidosis (blood too acidic)
-Can't bind as much O_2 → Causes □ O_2 on Hb (binding CO_2 kicks off O_2)
*Proteins can't function properly
-Ex: In pool you breathe out underwater to □ acidity and be able to hold breathe longer

-**Hyperventilation** (too much)
-□□ CO_2 released
-□ arterial P_{CO2} → □ H+ (basic) = respiratory alkalosis
-Causes □ O_2 on Hb → Stays bound too much
*Proteins can't function right
-Treatment: Paper bag → creates pocket of □ CO_2 to breathe more in

*Recall: similar P_{CO2} levels in alveoli and blood coming back to lungs→ want smaller gradient to limit diffusion (don't want to breathe off too much)
-Allows us to stay in appropriate range → need right pH level to do so

<u>Control of Ventilation</u>

-Brainstem (medulla oblongata)
-**Respiratory rhythm generator (RRG**) – section of cells that determine rate
-Inputs: 1. Pacemaker potentials → cells triggered at certain rate
2. Chemoreceptors
3. Pulmonary stretch receptors

-Pattern from RRG

1. Connect to skeletal muscles, which are connected to regular somatic efferents and neurons from medulla oblongata (RRG)
-Stimulation → contraction → bigger cavity → □ P → air in → expansion/ inspiration
-No stimulation → relax muscles → rebound of lungs → □ P → expiration
*Can't inhibit skeletal muscle
*This takes over if voluntary control messed up

2. Mechanoreceptors measure stretch in alveolar cells
-Large inhale (heavy exercise) → alveolar cells can only expand so much
-Stretch receptors stop movement in lungs when too big
-Pulmonary stretch receptors activated that inhibit motor neurons
-Forces relaxation = expiration
*CANNOT put adult sized bag on a child → will overinflate lungs
-Receptors will inhibit motor neurons running diaphragm/intercostals → you blow lungs out from the inside
-Medical-caused pneumothorax from the inside

3. Chemoreceptors for $P_{O2,}$ $Pc_{O2,}$ and H+

-Impact of P_{O2}
-Threshold at ~60 (Hb ~100%) → 99% of oxygen attached to Hb
-When P_{O2} = 60 : Hb saturation starts □, ventilation rate starts □
-Breathe more to get Hb back to full saturation
*Don't need to □ ventilation rate if Hb fully saturated (> 60) → don't need to increase oxygen
-But chemoreceptors only bind free oxygen (1%)
*Ones attached to Hb not counted by receptors