Respiratory Physiology

1. Overview
    1. ventilation- breathing
    2. external respiration- O_2 enters and CO_2 leaves blood in lungs
    3. respiratory gas transport- via vessels
    4. internal respiration- CO_2 enters and O_2 leaves blood in tissues
2. Terms
    1. volumes
        1. tidal volume (TV): normal breath, ~500 ml
        2. inspiratory reserve volume (IRV): amount forcibly inhaled after tidal, ~2100-3200 ml
        3. expiratory reserve volume (ERV): amount forcibly exhaled after tidal, ~1000-1200 ml
        4. residual volume (RV): amount left over after extreme expiration, ~1200 ml
    2. capacities
        1. inspiratory capacity (IC): amount inspired after tidal expiration = TV + IRV
        2. functional residual capacity (FRC): RV + ERV, amount left in lungs after tidal expiration
        3. vital capacity (VC): total amount of exchangeable air = TV + IRV + ERV
        4. total lung capacity (TLC): sum of all lung volumes, ~6000 ml
    3. dead space
        1. anatomical: conducting zone volume; ~150 ml
            1. if tidal volume = 500 ml, then only 350 ml in alveolar ventilation
        2. alveolar dead space
            1. alveolar collapse
            2. obstruction by mucus
3. Function Tests
    1. minute or total ventilation = total amount of resp. tract gas flow/minute
        1. typically 6 L/ min (500 ml/ breath * 12 breaths/ min)
        2. up to 200 L/min during vigorous exercise!
    2. forced vital capacity (FVC)
        1. deep breath
        2. max volume exhaled
        3. as rapidly as possible
        4. note if FVC is low then restrictive diease (e.g., TB, polio)
    3. forced expiratory volume (FEV)
        1. amount of air during specific time interval
        2. FEV_1 = FV in 1 second
            1. should be 80% of FVC
            2. if not, obstructive pulmonary disease (e.g., bronchitis or asthma)
4. Gas Exchange
    1. Dalton's Law
        1. total pressure of gas mixture = sum of independent gas pressures
        2. partial pressure is directly proportional to percentage in total gas mixture
        3. e.g., partial pressure of O_2 is 20.9% of 760 mm Hg = 159 mm Hg
        4. if @ high altitude, need masks
    2. Henry's Law
        1. at air - gas interface, gas dissolves in liquid in proportion to partial pressure
        2. gas movement is determined by partial pressures in two phases
    3. External Respiration
        1. partial pressure gradients
            1.

source	PO2 (mm Hg)	PCO2 (mm
inspired air	160	0.3
expired air	120	27
alveoli	104	40
tissues	< 40	> 45
veins	40	45

        2. gas solubility
            1. CO_2 is 20 times more soluble in plasma than than O_2!
            2. diffuses even though the gradient is smaller (i.e., 5mm Hg)
        3. functional aspects
            1. alveolar ventilation
            2. ventilation-perfusion coupling
                1. ventilation- amount of gas reaching alveoli
                2. perfusion- blood flow in alveolar capillaries
            3. respiratory membranes
                1. thickness: 0.5 -1 □m
                2. surface area: 140 m^2, 40 times skin area
5. Oxygen Transport by Blood
    1. Hb has an S-shaped O_2 uptake curve
        1. shape reflects cooperative interaction of HB subunits
    2. Effects of Temperature & pH
        1. temperature
        2. Bohr Shift
        3. right shift = lower O_2 affinity, therefore O_2 unloaded when/where needed most

        4. fetal hemoglobin
            1. left shifted = high affinity for O_2, therefore takes it from maternal Hb
        5. myoglobin
            1. very left shifted = very high affinity
                1. doesn't give up O_2 unless very low PO_2
                2. not S-shaped
                    1. reflects single subunit (no cooperation)
6. Control
    1. diaphragm: phrenic nerve
    2. medulla oblongata
        1. self-exciting reserve center
        2. pons smooths signal
        3. 12 - 15 respirations/minute, "eupnea" = normal breathing
    3. stretch receptors in bronchioles & alveoli
    4. chemo receptors
        1. brain stem
        2. neck vessels
        3. most sensitive to high CO_2
    5. factors
        1. physical
        2. volition (will)
        3. emotional
        4. chemical
    6. figure
7. Developmental Aspects