Background Information on Lab 10 (Respiration)

Respiration has 3 functions:

1. Ventilation (breathing)
2. Gas exchange between air and blood **AND** blood and cells
3. Oxygen usage or cellular respiration

Ventilation

- External respiration
- Mechanical
- Involves inspiration and expiration
- Air enters the lungs because the atmospheric pressure is greater than the intrapulmonary pressure
- Expiration occurs when the intrapulmonary pressure is greater than atmospheric pressure
- Pressure is also a function of lung volume
    - Boyle's Law:
        - An increase in lung volume during inspiration makes intrapulmonary pressure decrease…air moves inward
        - A decrease in lung volume increases intrapulmonary pressure so air moves outside
- Relies on:
    - Lung compliance / ability of lungs to expand
        - Lungs must have high compliance
        - Factors that can reduce compliance, reduce the functioning of lungs
        - Example: Lung tissue is replaced with connective tissue in pulmonary fibrosis
    - Elasticity / tendency of the lungs to return to normal size after being stretched
        - Lungs are highly elastic and recoil during expiration
    - Surface tension / force of fluid in the alveoli
        - The fluid normally forms a thin layer of fluid on the surface of the alveolus
        - In the fluid, the H_20 molecules are more attracted to other H_20 molecules than air

        - The surface H_20 molecules are held tightly together exerting a force on the alveolus underneath; this raises the pressure inside the alveolus which results in the alveoli losing air
    - If this is so, why don't lungs collapse during expiration?
        - The fluid on the alveolus contains a **surfactant**
        - Surface active agent is a phospholipids that goes between the water molecules to disperse them and decrease surface tension which prevents the alveoli from complete collapse
        - Some residual volume of air remains in the alveoli
        - If surfactant is not present, as in premature babies, the alveoli can collapse, Respiratory Distress Syndrome (RDS)
            - Babies born at less than 28 weeks have ~ 60% occurrence
            - Babies born 28 – 34 weeks have ~ 30% occurrence
            - Babies born after 34 weeks have ~ 5% occurrence
        - Mothers can be given corticosteroids to accelerate the developing of the fetus's lungs
        - Acute Respiratory Distress Syndrome (ARDS)
            - Inflammation causes an excess amount of fluid to accumulate in the lungs
            - Accompanied by less surfactant
            - Lowers compliance of the lung tissue
            - Reduces amount of O_2 in blood leaving the lungs
- Controlled by:
    - Medulla oblongata
        - Rhythmicity center controls automatic breathing
        - Contains interacting pools of neurons
            - I neurons fire during inspiration, stimulating spinal nerves that run to respiratory muscles
            - E neurons work passively when I neurons are inhibited
        - Alternating workings of these neurons provide the rhythmic pattern of breathing

- Pons has 2 respiratory centers
    - Apneustic center that stimulates the I neurons, promotes inspiration
    - Pneumotaxic center works against the apneustic center & inhibits inspiration
- Chemoreceptors in the medulla, aorta, and carotid arteries control breathing indirectly via sensory nerve fibers in the medulla
    - Respond to changes in blood levels of CO_2, O_2, and pH
- Cerebral cortex has control over it all, including voluntary breathing (See Figure 16.27)
    - Voluntary and involuntary pathways are separated

  What if nerve damage affects the voluntary pathway?

  What if automatic pathway is damage?
    - Ondine's Curse – people must remind themselves to breathe and need mechanical respirator at night
- Receptors in lungs that influence brainstem activity via the vagus nerve
    - Unmyelinated C fibers:
        - stimulated by capsaicin (the chemical found in hot peppers) produce an initial apnea, followed by shallow, rapid breathing
        - also stimulated by histamine that is released in response to allergens
    - Irritant receptors in the larynx and rapidly adapting receptors in the lungs are stimulated by components of smoke, smog, inhaled particles or increase in fluid; results in coughing
    - Pulmonary stretch receptors stimulate the Hering-Bruer reflex, a reflex in which distension of the lungs stimulates stretch receptors, which in turn inhibit further distension of the lungs preventing the lungs from distending too far; helps to maintain the rhythmicity of ventilation
        - Very important in newborns to help maintain normal ventilation

- Ventilation changes
    - Hypoventilation
        - Insufficient ventilation to remove CO_2

        - CO_2 stays in blood, mixes with H_2O to form carbonic acid, blood pH drops = respiratory acidosis
    - Hyperventilation
        - Rate of ventilation is greater than CO_2 production
        - Less CO_2, less carbonic acid, pH rises = respiratory alkalosis
- Ventilation during exercise increases by
    - Neurogenic mechanisms
        - Nerve activity from the limbs involved in exercise stimulate respiratory muscles either by spinal reflexes or by the brainstem respiratory centers
        - Input from cerebral cortex stimulates brainstem to increase ventilation
    - Humoral (chemical) mechanisms stimulate chemoreceptors sensitive to CO_2, O_2, and pH levels
    - These 2 mechanisms are involved in the increased total ventilation during exercise = hypernea

Review Figures 16. 25 – 16.30 in text