Respiratory System
Control of Respiration (and a few other things)

I. The Respiratory Center
   A. Function of respiratory center.
      1. Respiratory effort must meet metabolic demand for oxygen.
      2. Respiratory muscles change the size of the thoracic cavity resulting in inspiration or expiration
      3. Nerve impulses from the respiratory center in the brain regulate these muscles and the basic respiratory activities
      4. Various conditions in the body (i.e. CO\textsubscript{2}, pH, O\textsubscript{2}, H\textsuperscript{+}, psychological factors, pain, body temperature, and other ANS input) can influence these areas of the brain and their output and therefore respiration.

   B. Nervous control of respiration through the respiratory center
      1. Three components of the respiratory center
         a. Medullary rhythmicity area in the medulla oblongata (inspiratory and expiratory areas)
         b. Apneustic area in the pons
         c. Pneumotaxic area in the pons
      2. Medullary Rhythmicity area
         a. Inherent rhythmicity—autonomic rhythmicity of breathing
         b. Inspiratory area
            1) Inspiratory area sends impulses to the diaphragm via the phrenic nerve
            2) Diaphragm contracts and volume in thoracic cavity increases resulting in negative pressure gradient.
            3) Alveoli open and inspiration occurs
            4) Lasts about 2 seconds
            5) Expiration usually follows because diaphragm relaxes passively and the elastic recoil of alveoli causes them to close—expiration usually lasts about 3 seconds.
            6) During heavy breathing the inspiratory area also sends impulses to the external intercostals, sternocleidomastoids, and others that increase the size of the chest cavity and causes a more forceful inspiration.
            7) During heavy breathing the inspiratory area will also send impulses to the expiratory area.
         b. Expiratory area
            1) Stimulated by the inspiratory area during heavy breathing
            2) Stimulates internal intercostals and abdominal muscles resulting in decreased thoracic volume and a more forceful expiration
         c. Other areas of the respiratory center influence the medullary rhythmicity area to make a smooth transition between inspiration and expiration.
Respiratory System
Control of Respiration (and a few other things)

3. Pneumotaxic Area
   a. Located in the pons
   b. Prevents apneusis—turns off inspiration—causes expiration (backup to cause expiration)
   c. Prevents overinflation of lungs
   d. If there is a delay in expiration then pneumotaxic center sends impulses to expiratory center
   e. Expiration occurs
   f. Stimulation of pneumotaxic center inhibits apneustic area (inhibits inspiratory area)
   g. \( \uparrow \) pneumotaxic stimulation = \( \uparrow \) respiratory rate

4. Apneustic Area
   a. Located in the pons
   b. Stimulation of apneustic area results in prolonged inspiration and short expiration = “apneusis”
   c. Occurs when the pneumotaxic area is inactive—pneumotaxic area will override the apneustic area.

5. Hering-Breuer Reflex (inflation reflex)
   a. Lungs inflate due to inspiration
   b. Baroreceptors (stretch receptors) stimulated
   c. Inhibitory impulses sent along Vagus Nerve X to expiratory center and apneustic area—these areas are inhibited
   d. Therefore inspiration is inhibited
   e. Expiration occurs
   f. This is a protective, backup response to overinflation of the lungs (perhaps when pneumotaxic area is not working)

C. Control of respiration through the cerebral cortex
1. Voluntarily alter breathing pattern
2. Why is it just an idle threat when a child threatens his/her mother with "I'll hold my breath 'til I die."

D. Control of respiration through chemical factors
1. CO\(_2\) as main chemical stimulus for respiration
   a. Actually H\(^+\) ions as stimulus
   b. Formula: CO\(_2\) + H\(_2\)O \(\rightarrow\) H\(_2\)CO\(_3\)\(^-\) + H\(^+\)
   d. Stimulus on respiratory center (chemosensitive area in medulla)
   d. Chemoreceptors in aortic and carotid bodies stimulated by CO\(_2\)(H\(^+\)) level
   e. Normal arterial pCO\(_2\) = 40mmHg
   f. Hypercapnia
   g. Hyperventilation
   h. Hypoventilation
Respiratory System
Control of Respiration (and a few other things)

2. O₂ as stimulus for respiration
   a. Insignificant normally
   b. Normal pO₂ =
   c. pO₂ drop from 100 to 50 will stimulate respiratory center (dramatic drop)
   d. pO₂ < 70, cells for the respiratory center have O₂ starvation (cells are depressed) and breathing stops.

3. Exception to normal chemical control mechanism
   a. Patients with COPD (chronic obstructive pulmonary disease)
   b. Over time pts become adapted to high levels of CO₂
   c. Respiratory center no longer responds to CO₂
   d. Low O₂ levels is now main respiratory stimulus
   e. Why would you need to be careful when administering O₂ to a COPD patient?

D. Control of respiration through pressoreceptors (baroreceptors) in carotid and aortic bodies.
   1. Increased blood pressure results in (increased or decreased) respiratory rate.
   2. How does a decrease in blood pressure affect respiratory rate?

E. Other factors that influence respiration
   1. Emotions and the limbic system
   2. Temperature
   3. Pain
   4. Stretching anal sphincter (parasympathetic response—review cardiovascular notes)
   5. Irritation of the airways

II. What role does the respiratory system play in maintaining acid-base balance?
A. Normal pH of blood

B. Respiratory responses to lowered blood pH
   1. Respiratory causes for lowered blood pH
   2. Other sources of hydrogen ions
   3. What does the respiratory system do to help out?

C. Respiratory acidosis
   1. What does this mean?
   2. Urinary compensation?
Respiratory System
Control of Respiration (and a few other things)

III. Read and outline from text “Exercise and the Respiratory System.” Tie this in with your cardiovascular studies and cellular respiration?

IV. Read and outline: “Why Smokers Have Lowered Respiratory Efficiency” in text pg. 884.

V. Read and outline the following disorders at the end of the respiratory chapter. Think about what you know and apply it to your reading. Use this as an important review of the respiratory system.

A. Asthma
B. COPD
C. Emphysema
D. Chronic bronchitis
E. Lung Cancer
F. Pneumonia
G. Tuberculosis
H. Cystic Fibrosis
I. Pulmonary Edema

VI. Define the following respiratory terms—cleaning up loose ends, a review of terms, and an opportunity to tie in to the cardiovascular system. Most of these have something to do with breathing.

• Apnea
• Apneusis
• Aspiration
• Asphyxia
• Atelectasis
• Compliance
• Dyspnea
• Diaphragm
• Diaphragmatic breathing
• Eupnea
• Hypoxia
• Hyperventilation
• Hypoventilation
• Hypercapnia
• Orthopnea