- [ ] I. Unit 13: The Respiratory System
  - [ ] A. Organs of the Respiratory System
    - [ ] 1. Nose
    - [ ] 2. Pharynx
    - [ ] 3. Larynx
    - [ ] 4. Trachea
    - [ ] 5. Bronchi
    - [ ] 6. Lungs - alveoli
  - [ ] B. Functions of the Respiratory System
    - [ ] 1. Gas exchanges between the blood and external environment
      - [ ] a) Occurs in the alveoli of the lungs
    - [ ] 2. Passageways to the lungs purify, humidify, and warm the incoming air
  - [ ] C. The Nose
    - [ ] 1. Only externally visible part of the respiratory system
    - [ ] 2. Air enters the nose through the external nostrils (nares)
    - [ ] 3. Interior of the nose consists of a nasal cavity divided by a nasal septum
  - [ ] D. Upper Respiratory Tract
    - [ ] 1. Anatomy of the Nasal Cavity
      - [ ] a) Olfactory receptors are located in the mucosa on the superior surface
      - [ ] b) The rest of the cavity is lined with respiratory mucosa that
        - [ ] (1) Moisten air
        - [ ] (2) Trap incoming foreign particles
      - [ ] c) Lateral walls have projections called conchae
        - [ ] (1) Increase surface area
        - [ ] (2) Increase air turbulence within the nasal cavity
      - [ ] d) The nasal cavity is separated from the oral cavity by the palate
        - [ ] (1) Anterior hard palate (bone)
        - [ ] (2) Posterior soft palate (muscle)
    - [ ] 2. Paranasal Sinuses
      - [ ] a) Cavities within bones surrounding the nasal cavity are called sinuses

- [ ] b) Sinuses are located in the following bones
  - [ ] (1) Frontal bone
  - [ ] (2) Sphenoid bone
  - [ ] (3) Ethmoid bone
  - [ ] (4) Maxillary bone
- [ ] c) Function of the sinuses
  - [ ] (1) Lighten the skull
  - [ ] (2) Act as resonance chambers for speech
  - [ ] (3) Produce mucus that drains into the nasal cavity

- [ ] 3. Pharynx (Throat)
  - [ ] a) Muscular passage from nasal cavity to larynx
  - [ ] b) Three regions of the pharynx
    - [ ] (1) Nasopharynx - superior region behind nasal cavity
    - [ ] (2) Oropharynx - middle region behind mouth
    - [ ] (3) Laryngopharynx - inferior region attached to larynx
  - [ ] c) The oropharynx and laryngopharynx are common passageways for air and food
  - [ ] d) Structures of the Pharynx
    - [ ] (1) Pharyngotympanic tubes open into the nasopharynx
    - [ ] (2) Tonsils of the pharynx
      - [ ] (a) Pharyngeal tonsil (adenoids) are located in the nasopharynx
      - [ ] (b) Palatine tonsils are located in the oropharynx
      - [ ] (c) Lingual tonsils are found at the base of the tongue

- [ ] 4. Larynx (Voice Box)
  - [ ] a) Routes air and food into proper channels
  - [ ] b) Plays a role in speech
  - [ ] c) Made of eight rigid hyaline cartilages and a spoon-shaped flap of elastic cartilage (epiglottis)
  - [ ] d) Structures of the Larynx
    - [ ] (1) Thyroid cartilage

- (a) Largest of the hyaline cartilages
- (b) Protrudes anteriorly (Adam's apple)

(2) Epiglottis

- (a) Protects the superior opening of the larynx
- (b) Routes food to the esophagus and air toward the trachea
- (c) When swallowing, the epiglottis rises and forms a lid over the opening of the larynx

(3) Vocal folds (true vocal cords)

- (a) Vibrate with expelled air to create sound (speech)

(4) Glottis - opening between vocal cords

5. Trachea (Windpipe)

- a) Four-inch-long tube that connects larynx with bronchi
- b) Walls are reinforced with C-shaped hyaline cartilage
- c) Lined with ciliated mucosa
  - (1) Beat continuously in the opposite direction of incoming air
  - (2) Expel mucus loaded with dust and other debris away from lungs

6. Respiratory Membrane (Air-Blood Barrier)

- a) Thin squamous epithelial layer lines alveolar walls
- b) Alveolar pores connect neighboring air sacs
- c) Pulmonary capillaries cover external surfaces of alveoli
- d) On one side of the membrane is air and on the other side is blood

7. Gas Exchange

- a) Gas crosses the respiratory membrane by diffusion
- b) Oxygen enters the blood
- c) Carbon dioxide enters the alveoli
- d) Alveolar macrophages ("dust cells") add protection by picking up bacteria, carbon particles, and other debris
- e) Surfactant (a lipid molecule) coats gas-exposed alveolar surfaces

8. Main (Primary) Bronchi

- a) Formed by division of the trachea

- [ ] b) Enters the lung at the hilum (medial depression)
- [ ] c) Right bronchus is wider, shorter, and straighter than left
- [ ] d) Bronchi subdivide into smaller and smaller branches

- [ ] 9. Lungs
  - [ ] a) Occupy most of the thoracic cavity
    - [ ] (1) Heart occupies central portion called mediastinum
  - [ ] b) Apex is near the clavicle (superior portion)
  - [ ] c) Base rests on the diaphragm (inferior portion)
  - [ ] d) Each lung is divided into lobes by fissures
    - [ ] (1) Left lung - two lobes
    - [ ] (2) Right lung - three lobes
  - [ ] e) Coverings of the Lungs
    - [ ] (1) Serosa covers the outer surface of the lungs
      - [ ] (a) Pulmonary (visceral) pleura covers the lung surface
      - [ ] (b) Parietal pleura lines the walls of the thoracic cavity
    - [ ] (2) Pleural fluid fills the area between layers of pleura to allow gliding
    - [ ] (3) These two pleural layers resist being pulled apart
- [ ] 10. Bronchial (Respiratory) Tree Divisions
  - [ ] a) All but the smallest of these passageways have reinforcing cartilage in their walls
    - [ ] (1) Primary bronchi
    - [ ] (2) Secondary bronchi
    - [ ] (3) Tertiary bronchi
    - [ ] (4) Bronchioles
    - [ ] (5) Terminal bronchioles
- [ ] 11. Respiratory Zone
  - [ ] a) Structures
    - [ ] (1) Respiratory bronchioles
    - [ ] (2) Alveolar ducts
    - [ ] (3) Alveolar sacs

- [ ] (4) Alveoli (air sacs)
- [ ] b) Site of gas exchange = alveoli only

- [ ] E. Four Events of Respiration
  - [ ] 1. Pulmonary ventilation - moving air in and out of the lungs (commonly called breathing)
  - [ ] 2. External respiration - gas exchange between pulmonary blood and alveoli
    - [ ] a) Oxygen is loaded into the blood
    - [ ] b) Carbon dioxide is unloaded from the blood
  - [ ] 3. Respiratory gas transport - transport of oxygen and carbon dioxide via the bloodstream
  - [ ] 4. Internal respiration - gas exchange between blood and tissue cells in systemic capillaries

- [ ] F. Four Events of Respiration
  - [ ] 1. Mechanics of Breathing (Pulmonary Ventilation)
    - [ ] a) Completely mechanical process that depends on volume changes in the thoracic cavity
      - [ ] (1) Volume changes lead to pressure changes, which lead to the flow of gases to equalize pressure
    - [ ] b) Two phases
      - [ ] (1) Inspiration = inhalation
        - [ ] (a) flow of air into lungs
        - [ ] (b) Diaphragm and external intercostal muscles contract
        - [ ] (c) The size of the thoracic cavity increases
        - [ ] (d) External air is pulled into the lungs due to
          - [ ] (i) Increase in intrapulmonary volume
          - [ ] (ii) Decrease in gas pressure
      - [ ] (2) Expiration = exhalation
        - [ ] (a) air leaving lungs
        - [ ] (b) Largely a passive process which depends on natural lung elasticity
        - [ ] (c) As muscles relax, air is pushed out of the lungs due to
          - [ ] (i) Decrease in intrapulmonary volume

- (ii) Increase in gas pressure
- (d) Forced expiration can occur mostly by contracting internal intercostal muscles to depress the rib cage

- c) Pressure Differences in the Thoracic Cavity
  - (1) Normal pressure within the pleural space is always negative (intrapleural pressure)
  - (2) Differences in lung and pleural space pressures keep lungs
- d) Nonrespiratory Air (Gas) Movements
  - (1) Can be caused by reflexes or voluntary actions
  - (2) Examples:
    - (a) Cough and sneeze - clears lungs of debris
    - (b) Crying - emotionally induced mechanism
    - (c) Laughing - similar to crying
    - (d) Hiccup - sudden inspirations
    - (e) Yawn - very deep inspiration
- e) Respiratory Volumes and Capacities
  - (1) Normal breathing moves about 500 mL of air with each breath
    - (a) This respiratory volume is tidal volume (TV)
  - (2) Many factors that affect respiratory capacity
    - (a) A person’s size
    - (b) Sex
    - (c) Age
    - (d) Physical condition
  - (3) Inspiratory reserve volume (IRV)
    - (a) Amount of air that can be taken in forcibly over the tidal volume
      - (i) Usually between 2100 and 3200 mL
  - (4) Expiratory reserve volume (ERV)
    - (a) Amount of air that can be forcibly exhaled
    - (b) Approximately 1200 mL
  - (5) Residual volume

- (a) Air remaining in lung after expiration
- (b) About 1200 ml

(6) Vital capacity

- (a) The total amount of exchangeable air
  - (i) Vital capacity = TV + IRV + ERV

(7) Dead space volume

- (a) Air that remains in conducting zone and never reaches alveoli
  - (i) About 150 mL

(8) Functional volume

- (a) Air that actually reaches the respiratory zone
  - (i) Usually about 350 mL

(9) Respiratory capacities are measured with a spirometer

f) Respiratory Sounds

(1) Sounds are monitored with a stethoscope

(2) Two recognizable sounds can be heard with a stethoscope

- (a) Bronchial sounds - produced by air rushing through trachea and bronchi
- (b) Vesicular breathing sounds - soft sounds of air filling alveoli

2. External Respiration

a) Oxygen loaded into the blood

(1) The alveoli always have more oxygen than the blood

(2) Oxygen moves by diffusion towards the area of lower concentration

(3) Pulmonary capillary blood gains oxygen

b) Carbon dioxide unloaded out of the blood

(1) Blood returning from tissues has higher concentrations of carbon dioxide than air in the alveoli

(2) Pulmonary capillary blood gives up carbon dioxide to be exhaled

c) Blood leaving the lungs is oxygen-rich and carbon dioxide-poor

3. Gas Transport in the Blood

a) Oxygen transport in the blood

- (1) Most oxygen attached to hemoglobin to form oxyhemoglobin (HbO_2)
- (2) A small dissolved amount is carried in the plasma

b) Carbon dioxide transport in the blood

- (1) Most is transported in the plasma as bicarbonate ion (HCO_3^-)
- (2) A small amount is carried inside red blood cells on hemoglobin, but at different binding sites than those of oxygen
- (3) For carbon dioxide to diffuse out of blood into the alveoli, it must be released from its bicarbonate form:
  - (a) Bicarbonate ions enter RBC
  - (b) Combine with hydrogen ions
  - (c) Form carbonic acid (H_2CO_3)
  - (d) Carbonic acid splits to form water + CO_2
  - (e) Carbon dioxide diffuses from blood into alveoli

4. Internal Respiration

a) Exchange of gases between blood and body cells

b) An opposite reaction to what occurs in the lungs

- (1) Carbon dioxide diffuses out of tissue to blood (called loading)
- (2) Oxygen diffuses from blood into tissue (called unloading)

G. Neural Regulation of Respiration

1. Activity of respiratory muscles is transmitted to and from the brain by phrenic and intercostal nerves

2. Neural centers that control rate and depth are located in the medulla and pons

a) Medulla - sets basic rhythm of breathing and contains a pacemaker called the self-exciting inspiratory center

b) Pons - appears to smooth out respiratory rate

3. Normal respiratory rate (eupnea)

a) 12–15 respirations per minute

4. Hyperpnea

a) Increased respiratory rate often due to extra oxygen needs

H. Non-Neural Factors Influencing Respiratory Rate and Depth

1. Physical factors

- [ ] a) Increased body temperature
- [ ] b) Exercise
- [ ] c) Talking
- [ ] d) Coughing
- [ ] e) Volition (conscious control)
- [ ] f) Emotional factors

- [ ] 2. Chemical factors: CO_2 levels
  - [ ] a) The body's need to rid itself of CO_2 is the most important stimulus
  - [ ] b) Increased levels of carbon dioxide (and thus, a decreased or acidic pH) in the blood increase the rate and depth of breathing
  - [ ] c) Changes in carbon dioxide act directly on the medulla oblongata
- [ ] 3. Chemical factors: oxygen levels
  - [ ] a) Changes in oxygen concentration in the blood are detected by chemoreceptors in the aorta and common carotid artery
  - [ ] b) Information is sent to the medulla

- [ ] I. Hyperventilation and Hypoventilation
  - [ ] 1. Hyperventilation
    - [ ] a) Results from increased CO_2 in the blood (acidosis)
    - [ ] b) Breathing becomes deeper and more rapid
    - [ ] c) Blows off more CO_2 to restore normal blood pH
  - [ ] 2. Hypoventilation
    - [ ] a) Results when blood becomes alkaline (alkalosis)
    - [ ] b) Extremely slow or shallow breathing
    - [ ] c) Allows CO_2 to accumulate in the blood
- [ ] J. Respiratory Disorders:
  - [ ] 1. Respiratory Disorders: Chronic Obstructive Pulmonary Disease (COPD)
    - [ ] a) Exemplified by chronic bronchitis and emphysema
    - [ ] b) Major causes of death and disability in the United States
    - [ ] c) Features of these diseases
      - [ ] (1) Patients almost always have a history of smoking

- (2) Labored breathing (dyspnea) becomes progressively more severe
- (3) Coughing and frequent pulmonary infections are common
- (4) Most victims are hypoxic, retain carbon dioxide, and have respiratory acidosis
- (5) Those infected will ultimately develop respiratory failure

2. Respiratory Disorders: Chronic Bronchitis

- a) Mucosa of the lower respiratory passages becomes severely inflamed
- b) Mucus production increases
- c) Pooled mucus impairs ventilation and gas exchange
- d) Risk of lung infection increases
- e) Pneumonia is common
- f) Called “blue bloaters” due to hypoxia and cyanosis

3. Respiratory Disorders: Emphysema

- a) Alveoli enlarge as adjacent chambers break through
- b) Chronic inflammation promotes lung fibrosis
- c) Airways collapse during expiration
- d) Patients use a large amount of energy to exhale
- e) Overinflation of the lungs leads to a permanently expanded barrel chest
- f) Cyanosis appears late in the disease; sufferers are often called

4. Respiratory Disorders: Lung Cancer

- a) Accounts for one-third of all cancer deaths in the United States
- b) Increased incidence is associated with smoking
- c) Three common types
  - (1) Squamous cell carcinoma
  - (2) Adenocarcinoma
  - (3) Small cell carcinoma

K. Developmental Aspects of the Respiratory System

1. Lungs are filled with fluid in the fetus
2. Lungs are not fully inflated with air until two weeks after birth
3. Surfactant is a fatty molecule made by alveolar cells

- [ ] a) Lowers alveolar surface tension so that lungs do not collapse
- [ ] b) Not present until late in fetal development and may not be present in premature babies

- [ ] 4. Appears around 28–30 weeks of pregnancy
- [ ] 5. Homeostatic imbalance
  - [ ] a) Infant respiratory distress syndrome (IRDS) - surfactant production is inadequate
  - [ ] b) Cystic fibrosis - oversecretion of thick mucus clogs the respiratory system
  - [ ] c) Respiratory rate changes throughout life
    - [ ] (1) Newborns: 40 to 80 respirations per minute
    - [ ] (2) Infants: 30 respirations per minute
    - [ ] (3) Age 5: 25 respirations per minute
    - [ ] (4) Adults: 12 to 18 respirations per minute
    - [ ] (5) Rate often increases somewhat with old age
  - [ ] d) Sudden Infant Death Syndrome (SIDS)
    - [ ] (1) Apparently healthy infant stops breathing and dies during sleep
    - [ ] (2) Some cases are thought to be a problem of the neural respiratory control center
    - [ ] (3) One third of cases appear to be due to heart rhythm abnormalities
    - [ ] (4) Recent research shows a genetic component
  - [ ] e) Asthma
    - [ ] (1) Chronic inflamed hypersensitive bronchiole passages
    - [ ] (2) Response to irritants with dyspnea, coughing, and wheezing
  - [ ] f) Aging effects
    - [ ] (1) Elasticity of lungs decreases
    - [ ] (2) Vital capacity decreases
    - [ ] (3) Blood oxygen levels decrease
    - [ ] (4) Stimulating effects of carbon dioxide decrease
    - [ ] (5) Elderly are often hypoxic and exhibit sleep apnea
    - [ ] (6) More risks of respiratory tract infection