Chapter 16: Respiratory System

• Introduction
  o Respiration = the entire process of exchanging gases between the atmosphere and body cells
    1. Ventilation (breathing) = inspiration (inhalation) and expiration (exhalation)
    2. Gas exchange = gas exchanges between the blood and the lungs
    3. Gas transport = movement of the gases in the bloodstream and internal breathing, the gas transport between the blood and the somatic or body cells
    4. Cellular respiration = utilization of oxygen and the production of carbon dioxide at the cellular level

• Organs of the Respiratory System

REFER TO FIGURE 16.1 AND TABLE 16.1

o Upper Respiratory Tract

REFER TO FIGURE 16.2

□ Nose
  • Structure that is supported by bone and cartilage
  • Provides an entrance for air
  • Possess coarse hairs inside the nostrils to filter incoming air

□ Nasal Cavity
  • Space posterior to the nose
  • Nasal septum divides the nasal cavity medially into right and left portions
  • Nasal conchae (superior, middle, and inferior nasal conchae) will divide the cavity into different passageways lined with mucous membrane.
  • The passageways will increase surface area to warm and filter the air.
  • Mucous secreted in the nasal cavity will trap particles and debris and moisten the region.

□ Paranasal sinuses
  • Air-filled spaces in the skull (maxillary, frontal, ethmoid, and sphenoid bones) lined with mucous membrane
  • Functions
    o Reduces the weight of the skull
    o Resonant chamber that influence the quality of voice
  • Opens to the nasal cavity and is continuous with its lining

□ Pharynx (throat region)
  • Passageway for food and air
  • Aids to produce sounds for speech
  • Auditory tube connects the pharynx to the middle ear

o Lower Respiratory Tract
  □ Larynx = Enlargement in the airway made up of muscles, cartilage, and elastic tissue
REFER TO FIGURE 16.4
- Lies superior to the trachea but inferior to the pharynx
  - Houses vocal cords

REFER TO FIGURE 16.5
- 2 pairs of folds made up of muscles, connective tissue, and mucous membrane with a triangular silt between the fold called the glottis
  - False vocal cords = upper folds surrounding the glottis that do not produce sound
    - Function of the false vocal cords—with the epiglottis (mass of cartilage) these false vocal cords will aid in closing the glottis and the passageway to the trachea during the swallowing reflex
  - True vocal cords are the lateral borders of the glottis.
    - Function of the true vocal cords—When air is forced on and travels between the true vocal cords sound waves are generated causing vibrations. Tension of the vocal cords affects the pitch while the force of air affects the volume or loudness.
- During breathing, the cords relax and glottis open

Trachea

REFER TO FIGURE 16.3 AND FIGURE 16.6
- Location: Anterior to the esophagus and extends into the thoracic cavity
- The lumen is lined with pseudostratified ciliated columnar epithelium and goblet cells
- The goblet cells will secrete mucous to trap debris while the epithelium will “sweep” the debris up the respiratory tract.
- Within the thoracic cavity, the trachea will diverge into right and left primary bronchi
- The tracheal wall is supported anteriorly by 20 incomplete cartilaginous rings to prevent collapsing or blocking of the airway. Smooth muscles and connective tissue fill in the gaps between the ends of the cartilaginous rings posteriorly.

Bronchial Tree

REFER TO FIGURES 16.7, 16.8, AND 16.9
- Anatomy: Branched tubes (right and left primary bronchi) leading from the trachea to the lungs
- Right and left primary bronchi will subdivide into smaller branches, bronchioles
- Bronchioles will give rise to terminal bronchioles that will lead to thin tubes called alveolar ducts
- Alveolar ducts will lead to thin-walled alveolar sacs
• Alveolar sacs will lead to smaller sacs called alveolus (singular) or alveoli (plural)
• Alveoli are the only sites where there is gas exchange between the air and blood. They are surrounded by blood capillaries.
  ▪ Lungs = Pair of organs (right and left) that are spongy and cone-shaped and are separated by the mediastinum
    • Enclosed by the diaphragm and thoracic cage
    • One primary bronchus and large blood vessels enter each lung
    • Lungs are divided into lobes which subdivide into lobules containing the air passages, alveoli, nerves, connective tissue, and blood and lymphatic vessels
    • Right lung is subdivided into three lobes while the left lung is subdivided into two lobes due to the apex of the heart tilted to the left.
  • Layers: 
    REFER TO FIGURE 16.11
    o Visceral pleura attaches to the lungs and folds back to form the parietal pleura
    o Parietal pleura lines the thoracic cavity where the lungs are housed
      ▪ Pleura cavity is the space that lies between the two membranes and contains serous fluid to lubricate
• Breathing Mechanism
  o Ventilation = breathing, moving air in and out of the lungs
  o Inspiration = occurs when atmospheric pressure forces air into the lungs
    REFER TO FIGURE 16.12 AND FIGURE 16.13
    ▪ Increasing the size of the thoracic cavity (by displacing the diaphragm down and raising ribs) decreases the intra-alveolar pressure within the lung
    ▪ Atmospheric pressure on the outside becomes greater and forces air into the respiratory tract
    ▪ For maximum inspiration, the thoracic muscles are recruited to raise the sternum and elevate the rib cage to increase the volume capacity
  o Expiration = occurs due to the elastic recoil of the lungs, muscle tissue, and the surface tension within the alveoli
    REFER TO FIGURE 16.12 AND FIGURE 16.14
    ▪ Tissues recoil, muscles relax, the diaphragm moves upward, and causes an increase intra-alveolar pressure ---air is squeezed out
    ▪ For maximum expiration, the thoracic muscles depress the ribs inward and compress the abdominal organs to force the diaphragm higher to squeeze additional air out.
• Control of Breathing
  o Normal breathing is a rhythmic, involuntary act even though the muscles are under voluntary control
- ***We can control the depth of inspiration and expiration***
  - Respiratory Center of the Brainstem
    - **Medulla oblongata**
      - Dorsal respiratory group is the set of neurons that control basic breathing
      - Ventral respiratory group is the set of neurons that control maximal or forceful breathing
    - **Pons**
      - Pneumotaxic area or pontine respiratory group is the set of neurons that controls the rate and rhythm of breathing
  - Factors Affecting Breathing
    - Chemoreceptors (CNS and PNS) = receptors that are sensitive to changes in carbon dioxide and hydrogen in the blood (PNS chemoreceptors) and cerebrospinal fluid (CNS chemoreceptors)
      - Refer to Figure 16.18
    - Hydrogen or carbon dioxide increases can result in increase in acidity in the blood and cerebrospinal fluid which will lead to homeostatic imbalances. Breathing rate needs to increase to eliminate excessive concentrations of hydrogen and carbon dioxide in the body
      - Hyperventilation or rapid breathing lowers the amount of carbon dioxide in the blood
      - Emotions and stress related to the emotions can increase breathing
      - Inflation reflex = receptors in the lungs detect if lung tissue stretching. The reflex will prevent over inflation and tissue damage of the lungs
      - Exercise will increase breathing as oxygen demand from the body increases
  - Respiratory Membrane
    - Refer to Figure 16.19
    - Alveoli are the only sites of gas exchange between the atmosphere and the blood
      - Respiratory Membrane
        - Consists of the fusing of the epithelial cells of the alveoli and the endothelial cells of the capillaries
        - The membranes fused and gas exchange occurs across the respiratory membrane
        - Gas will diffuse across the respiratory membrane from a region of high to low pressure (based on the Laws of Diffusion—states of matter move from a region of high concentration or pressure to a region of low concentration or pressure)
        - Refer to Figures 16.10 and Figure 16.20
      - Oxygen has a greater pressure in the lungs so that it will diffuse into the blood
      - Carbon dioxide has a greater pressure in the blood so that it will diffuse into the lungs
• Gas Transport
  o Oxygen

**REFER TO FIGURE 16.21**

- **Transportation of oxygen**
  • 98% bound and carried by hemoglobin, oxyhemoglobin
  • Oxyhemoglobin—unstable complex between the oxygen molecules and hemoglobin
    o Dissociation of oxyhemoglobin occurs when:
      ▪ A region has a low concentration of oxygen – signals supply cannot keep up with cellular demand
      ▪ A region has a high concentration of carbon dioxide – signals an increase in acidity
      ▪ There is a rise in blood temperature – signals cellular work

- **Carbon dioxide**
  - **Transportation of carbon dioxide**
    • Carried in blood plasma as carbon dioxide
    • Bound to hemoglobin as carbaminohemoglobin
    • Converted into bicarbonate ions—over 70% of carbon dioxide is carried in this way in the blood to reach the lungs

**REFER TO FIGURES 16.22 AND FIGURE 16.23**

- Buffer system in the blood—transporting of carbon dioxide
  ▪ $\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3$ (carbonic acid) $\rightarrow$ $\text{H}^+ + \text{HCO}_3^-$
    (bicarbonate ions)
  ▪ $\text{H}^+ + \text{HCO}_3^-$ (bicarbonate ions) $\rightarrow$ $\text{H}_2\text{CO}_3$ (carbonic acid) $\rightarrow$ $\text{H}_2\text{O} + \text{CO}_2$
    (LUNG-pulmonary)—converts bicarbonate ions back into carbon dioxide as it leaves the body during expiration