

## **The Respiratory System**

The respiratory system includes the passages that transport air to and from the lungs and the air sacs, in which gas exchanges occur. Respiration is the entire process by which gases are exchanged between the atmosphere and the body cells.

### **Organs of the Respiratory System**

The respiratory system includes the nose, nasal cavity, sinuses, pharynx, larynx, trachea, bronchial tree, and lungs. The upper respiratory tract includes the respiratory organs outside of the thorax; the lower respiratory tract includes those within the thorax.

1. Nose
  - a. The nose is supported by bone and cartilage
  - b. The nostrils provide entrances for air.
2. Nasal cavity
  - a. The nasal conchae divides the cavity into passageways and help increase the surface area of the mucous membrane.
  - b. The mucous membrane filters, warms, and moistens the incoming air.
  - c. Particles trapped in the mucus are carried to the pharynx by ciliary action and swallowed.
3. Sinuses
  - a. The sinuses are spaces in the bones of the skull that open into the nasal cavity.
  - b. They are lined with mucous membranes.
4. Pharynx
  - a. The pharynx is located behind the mouth and between the nasal cavity and the larynx.
  - b. It functions as a common passage for air and food.
5. Larynx
  - a. The larynx serves as a passageway for air and helps prevent foreign objects from entering the trachea.
  - b. It is composed of muscles and cartilages.
  - c. It contains the vocal cords, which produce sounds by vibrating as air passes over them.
  - d. The glottis and epiglottis help prevent food and liquids from entering the trachea.
6. Trachea
  - a. The trachea extends in the thoracic cavity in front of the esophagus.
  - b. It divides into right and left bronchi.

7. Bronchial tree
  - a. The bronchial tree consists of branched air passages that lead from the trachea to the air sacs (alveoli).
  - b. The alveoli are located at the distal end of the finest tubes.
8. Lungs
  - a. The left and right lungs are separated by the mediastinum and enclosed by the diaphragm and thoracic cage.
  - b. The visceral pleura is attached to the surface of the lungs; the parietal pleura lines the thoracic cavity.
  - c. Each lobe is composed of alveoli, blood vessels, and supporting tissues.

### **Breathing Mechanism**

Inspiration and expiration movements are accompanied by changes in the size of the thoracic cavity.

1. Inspiration
  - a. Air is forced into the lungs by atmospheric pressure.
  - b. Inspiration occurs when the pressure inside the alveoli is reduced.
  - c. Pressure within the alveoli is reduced when the diaphragm moves downward and the thoracic cage moves upward and outward.
  - d. Expansion of the lungs is aided by surface tension.
2. Expiration
  - a. The forces of expiration come from the elastic recoil of tissues and from the surface tension within the alveoli.
  - b. Expiration can be aided by the thoracic and abdominal wall muscles.
3. Respiratory air volumes
  - a. The amount of air that normally moves in and out during quiet breathing is the tidal volume.
  - b. The additional air that can be inhaled is the inspiratory reserve volume; the additional air that can be exhaled is the expiratory reserve volume.
  - c. Residual air remains in the lungs and is mixed with newly inhaled air.
  - d. The vital capacity is the maximum amount of air a person can exhale after taking the deepest breath possible.
  - e. The total lung capacity is equal to the vital capacity plus the residual air volume.
4. Nonrespiratory air movements
  - a. Nonrespiratory air movements include coughing, sneezing, laughing, crying, hiccuping, yawning, and speaking.

## Control of Breathing

Normal breathing is rhythmic and voluntary.

1. Respiratory center
  - a. The respiratory center is located in the brain stem and includes portions of the pons and medulla oblongata.
  - b. The medullary rhythmicity area includes two groups of neurons.
    - i. The dorsal respiratory group is responsible for the basic rhythm of breathing
    - ii. The ventral respiratory group increases inspiratory and expiratory movements during forceful breathing.
  - c. The pneumotaxic area regulates the rate of breathing.
2. Factors affecting breathing
  - a. Breathing is affected by certain chemicals, stretching of the lung tissues, and emotional states.
  - b. Chemosensitive areas are associated with the respiratory center.
    - i. Chemosensitive areas are influenced by the blood concentration of carbon dioxide and hydrogen ions.
    - ii. Stimulation of these areas causes the breathing rate to increase.
  - c. There are chemoreceptors in the walls of certain large arteries.
    - i. These chemoreceptors are sensitive to a low oxygen concentration.
    - ii. When the oxygen concentration is low, the breathing rate is increased.
  - d. An inflation reflex is triggered by overstretching the lung tissues.
    - i. This reflex reduces the duration of inspiratory movements.
    - ii. This prevents overinflation of the lungs during forceful breathing.
  - e. Hyperventilation causes the blood carbon dioxide concentration to decrease, but *this is dangerous when associated with underwater swimming*.

## Alveolar Gas Exchanges

1. Alveoli
  - a. The alveoli are tiny air sacs clustered at the distal ends of the alveolar ducts.
2. Respiratory membrane
  - a. This membrane consists of the alveolar and capillary walls.
  - b. Gas exchanges take place through these walls.
  - c. Diffusion through the respiratory membrane

- i. The partial pressure of a gas is determined by the concentration of that gas in a mixture or the concentration dissolved in a liquid.
- ii. Gases diffuse from regions of higher partial pressure towards regions of lower partial pressure.
- iii. Oxygen diffuses from the alveolar air into the blood; carbon dioxide diffuses from the blood into the alveolar air.

### **Transport of Gases**

Blood transports gases between the lungs and the body cells.

1. Oxygen transport
  - a. Oxygen is mainly transported in combination with hemoglobin molecules.
  - b. The resulting oxyhemoglobin is relatively unstable and releases its oxygen in regions where  $PO_2$  is low.
  - c. More oxygen is released as the blood concentration of carbon dioxide increases, the blood becomes more acidic, or the blood temperature increases.
2. Carbon dioxide transport
  - a. Carbon dioxide may be carried in solution either bound to hemoglobin or as bicarbonate ions.
  - b. Most carbon dioxide is transported in the form of bicarbonate ions.
  - c. The enzyme, carbonic anhydrase, speeds the reaction between carbon dioxide and water.
  - d. Carbonic acid dissolves to release hydrogen ions and bicarbonate ions.