

# CHAPTER 9

## RESPIRATORY SYSTEM

### **LEARNING OUTCOMES**

#### **9.1 The Respiratory System**

1. Summarize the role of the respiratory system.
2. Distinguish between inspiration and expiration.
3. Identify the structures of the human respiratory system.

#### **9.2 The Upper Respiratory Tract**

1. Summarize the role of the nose, pharynx, and larynx in respiration.
2. Identify the structures of the upper respiratory system and provide their function.
3. Explain how sound is produced by the larynx.

#### **9.3 The Lower Respiratory Tract**

1. Summarize the role of the trachea, bronchial tree, and lungs in respiration.
2. Identify the structures of the lower respiratory system and provide their function.
3. Explain how the alveoli increase the efficiency of the respiratory system.

#### **9.4 Mechanism of Breathing**

1. Contrast the processes of inspiration and expiration during ventilation.
2. Define the terms *tidal volume*, *vital capacity*, and *residual volume* in relation to ventilation.
3. Summarize the purpose of the inspiratory and expiratory reserve volumes.

#### **9.5 Control of Ventilation**

1. Explain how the nervous system controls the process of breathing.
2. Explain the role of chemoreceptors and pH levels in regulating breathing rate.

#### **9.6 Gas Exchanges in the Body**

1. Distinguish between external and internal respiration.
2. Summarize the chemical processes that are involved in external and internal respiration.
3. Identify the role of carbonic anhydrase and carbaminohemoglobin in respiration.

#### **9.7 Respiration and Health**

1. Identify the symptoms and causes of selected upper respiratory tract infections.
2. Identify the symptoms and causes of selected lower respiratory tract disorders.
3. Summarize the relationship between smoking, cancer, and emphysema.

## **EXTENDED LECTURE OUTLINE**

### **9.1 The Respiratory System**

The organs of the respiratory system ensure that oxygen enters the body and carbon dioxide leaves the body. Ventilation is another term for breathing that includes both inspiration or inhalation, and expiration or exhalation. Gas exchange is necessary because the cells of the body carry out cellular respiration to make energy in the form of ATP.

### **9.2 The Upper Respiratory Tract**

The nasal cavities, pharynx, and larynx are the organs of the upper respiratory tract.

#### **The Nose**

The two nasal cavities, which contain receptor cells, receive tear ducts from eyes and communicate with sinuses. The auditory tube from middle ear communicates with the nasopharynx. The nose warms and cleanses incoming air. Auditory tubes connected to the nasopharynx also connect to the middle ear. When air pressure in the middle ears equalizes with that of the pharynx, a popping sensation may be heard.

#### **The Pharynx**

The pharynx, a passageway from the nasal cavities to oral cavities and to larynx, contains the tonsils. The pharynx takes air from the nose to the larynx and transports food from the oral cavity to the esophagus. If someone swallows and food enters the larynx, coughing occurs to dislodge the food. The Heimlich maneuver can be used to dislodge food blocking the airway.

#### **The Larynx**

The epiglottis covers the glottis, an opening to the larynx which contains vocal cords. The vocal cords are mucosal folds supported by elastic ligaments. The high or low pitch of the voice is regulated by changing the tension on the vocal cords.

### **9.3 The Lower Respiratory Tract**

The trachea and the rest of the respiratory system are in the lower respiratory tract.

#### **The Trachea**

The trachea, supported by C-shaped cartilaginous rings, is lined by ciliated cells which sweep impurities up to the throat. The trachea takes air to the bronchial tree.

#### **The Bronchial Tree**

Two primary bronchi, which divide into ever smaller bronchioles, conduct air into and within the lungs. During an asthma attack, bronchioles constrict. Each bronchiole leads to an elongated space enclosed by air pockets called alveoli.

#### **The Lungs**

The lungs are paired, cone-shaped organs within the thoracic cavity. The right lung has three lobes, while the left has two lobes. Each lung is enclosed by pleurae, serous membranes that produce serous fluid.

#### **The Alveoli**

The alveoli are the air sacs lined by squamous epithelium and surrounded by blood capillaries. Alveoli function in gas exchange between air in the alveoli and capillary blood. Premature infants often suffer from respiratory distress syndrome due to lack of surfactant, which lowers the surface tension of water.

### **9.4 Mechanism of Breathing**

Ventilation or breathing has two phases: inspiration which moves air into the lungs and expiration which moves air out of the lungs.

#### **Inspiration**

During inspiration, the diaphragm and external intercostal muscles contract, increasing the volume of the thoracic cavity, which creates a partial vacuum in the lungs, causing air to move into the lungs. Humans inhale by negative pressure.

### **Expiration**

Expiration is the passive phase of breathing. The elastic properties of the thoracic wall and lungs cause them to recoil, moving air out.

#### **Maximum Inspiratory Effort and Forced Expiration**

Maximum inspiratory effort involves muscles of the back, chest, and neck, which increases the size of the thoracic cavity larger than normal. Although expiration is normally passive, it can also be forced. This is necessary to sing and blow out air.

#### **Volumes of Air Exchanged During Ventilation**

A spirometer is used to measure the amount of air that is moving into and out of the lungs.

##### **Tidal Volume**

The tidal volume, only about 500 ml, is the small amount of air that moves in and out with each breath when we are relaxed.

##### **Vital Capacity**

The maximum amount of air that can be moved in plus the maximum amount that can be moved out during a single breath is called the vital capacity because your life depends on breathing.

##### **Inspiratory and Expiratory Reserve Volume**

The reserve volumes are measured during forced inspiration and expiration. The vital capacity is the sum of the tidal, inspiratory and expiratory reserve volumes.

##### **Residual Volume**

Some air always remains in the lungs. This is the residual volume and is no longer useful for gas exchange. Some of the inhaled air fills the nasal cavities, trachea, bronchi and bronchioles, which are not used for gas exchange. They contain dead air space.

## **9.5 Control of Ventilation**

### **Nervous Control of Breathing**

Normally adults have a breathing rate of 12 to 20 ventilations per minute. This rhythm is controlled by a respiratory control center located in the medulla oblongata of the brain. It is thought that a faulty respiratory center signal is the cause of sudden infant death syndrome (SIDS). We can voluntarily change our breathing pattern to accommodate various activities.

### **Chemical Control of Breathing**

Chemoreceptors are sensory receptors in the body that are sensitive to chemical composition of body fluids. The pH of blood will become more acidic when there is more carbon dioxide in the blood. Two sets of chemoreceptors, carotid and aortic bodies, that are sensitive to pH can cause breathing to speed up.

## **9.6 Gas Exchanges in the Body**

Gas exchange is critical to homeostasis. The principles of diffusion govern whether oxygen or carbon dioxide enters or leaves the blood in the lungs and in the tissues. The amount of pressure a gas exerts is its partial pressure.

### **External Respiration**

External respiration is the diffusion of CO<sub>2</sub> from pulmonary capillaries into alveolar sacs and O<sub>2</sub> from alveolar sacs into pulmonary capillaries. CO<sub>2</sub> is carried in the body as bicarbonate ions HCO<sub>3</sub><sup>-</sup>. The enzyme carbonic anhydrase speeds breakdown of carbonic acid H<sub>2</sub>CO<sub>3</sub> in red blood cells. When hemoglobin takes up oxygen it is called oxyhemoglobin.

### **Internal Respiration**

Internal respiration is the diffusion of O<sub>2</sub> from systemic capillaries into tissues and CO<sub>2</sub> from tissue fluid into systemic capillaries. When CO<sub>2</sub> diffuses into the blood a small amount is taken up by hemoglobin, forming carbaminohemoglobin, HbCO<sub>2</sub>.

## **9.7 Respiration and Health**

The respiratory tract is constantly exposed to environmental air and therefore to pathogens.

### **Upper Respiratory Tract Infections**

What we call “strep throat” is a bacterial infection caused by *Streptococcus pyogenes*. It can be treated with antibiotics. Upper respiratory tract infections also include the following:

#### **Sinusitis**

Infection of cranial sinuses. Symptoms include facial pain and postnasal discharge.

#### **Otitis Media**

Infection of the middle ear. It can spread by way of the auditory tube to the middle ear.

#### **Tonsillitis**

Infection of tonsils. The tonsils can be removed surgically in a tonsillectomy.

#### **Laryngitis**

Infection of larynx, leading to inability to speak audibly.

### **Lower Respiratory Tract Disorders**

Lower respiratory tract disorders include infections, restrictive and obstructive pulmonary disorders, and lung cancer.

#### **Lower Respiratory Infections**

Lower respiratory infections include acute bronchitis (infection of primary and secondary bronchi), pneumonia (infection of lungs), and pulmonary tuberculosis (infection caused by tubercle bacillus).

#### **Restrictive Pulmonary Disorders**

Restrictive pulmonary disorders involve a reduction of vital capacity and can be caused by, for example, asbestos, which causes pulmonary fibrosis.

#### **Obstructive Pulmonary Disorders**

Obstructive pulmonary disorders includes chronic bronchitis (inflamed airways) and emphysema (alveolar walls break down and the surface area for gas exchange is reduced). Asthma is a disease of the bronchi and bronchioles that is marked by an unusual sensitivity to specific irritants. Asthma is not curable but it is treatable by special inhalers which control inflammation or stop muscle spasms during an attack.

#### **Lung Cancer**

Lung cancer has surpassed breast cancer as a cause of death in women and follows this sequence of events: thickening of airway cells, loss of cilia, atypical

nuclei, tumor, and metastasis. An operation to remove a lobe or a whole lung before metastasis has occurred is called pneumonectomy. Secondhand smoke exposure can also cause lung cancer and lung disease.