

called capillaries. See Figure 9.3⁶ for an illustration of the systemic arteries that carry oxygenated blood throughout the body to organs and tissues, as indicated by the red color.

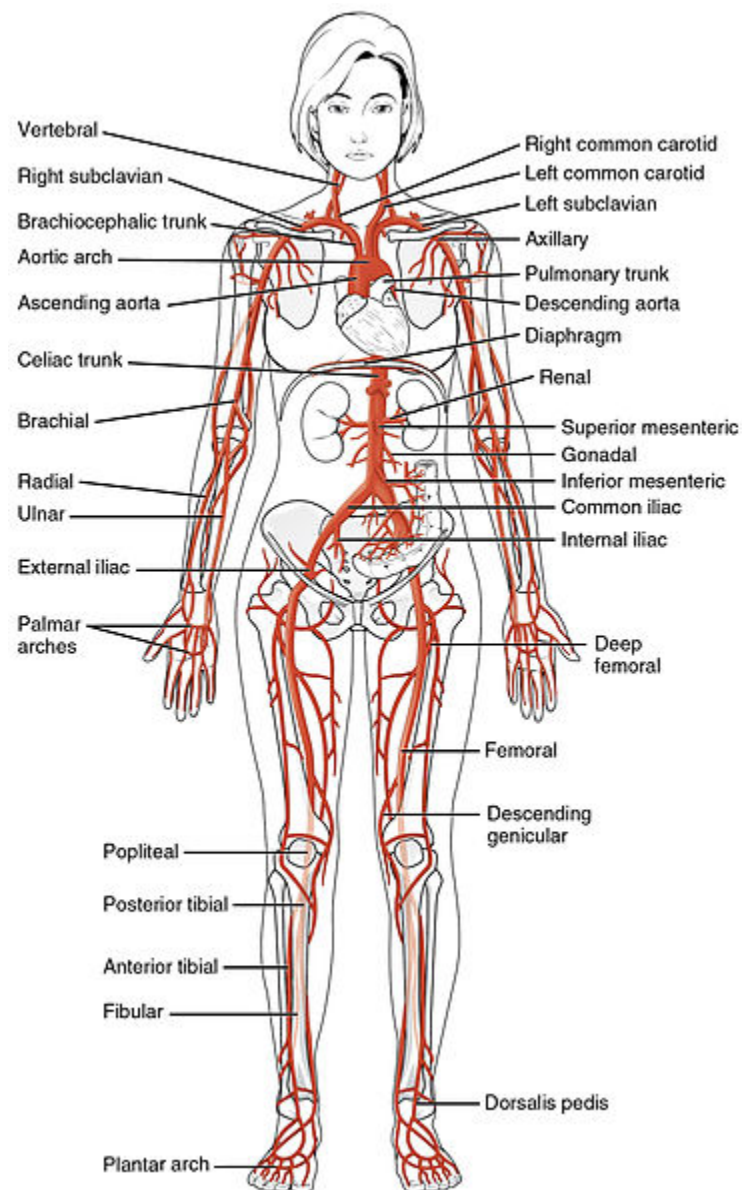


Figure 9.3 Arteries

6. “2120_Major_Systemic_Artery.jpg” by OpenStax College is licensed under [CC BY 3.0](#)

Oxygen and nutrients are exchanged with cells at the **capillary** (KAP-ĭ-lār-ē) level. A capillary is a microscopic channel that supplies blood to the tissue cells. Capillaries connect arterioles and **venules** (VEN-yoolz), small **veins** (VĀNZ). See Figure 9.4⁷ for an illustration of capillaries supplying blood to tissue cells.⁸

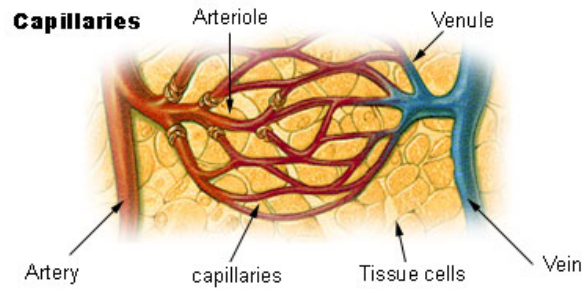


Figure 9.4 Capillaries

Veins return blood to the heart. Two large veins, the **inferior vena cava** and **superior vena cava** (VĒ-nă KĀ-vă), connect to the heart. See Figure 9.5⁹ for an illustration of the systemic veins that carry deoxygenated blood back to the heart, indicated in blue. Medications may be administered by health care professionals into veins, referred to **intravenous** (ĭn-tră-VĒ-nŭs) **(IV)** medications.¹⁰

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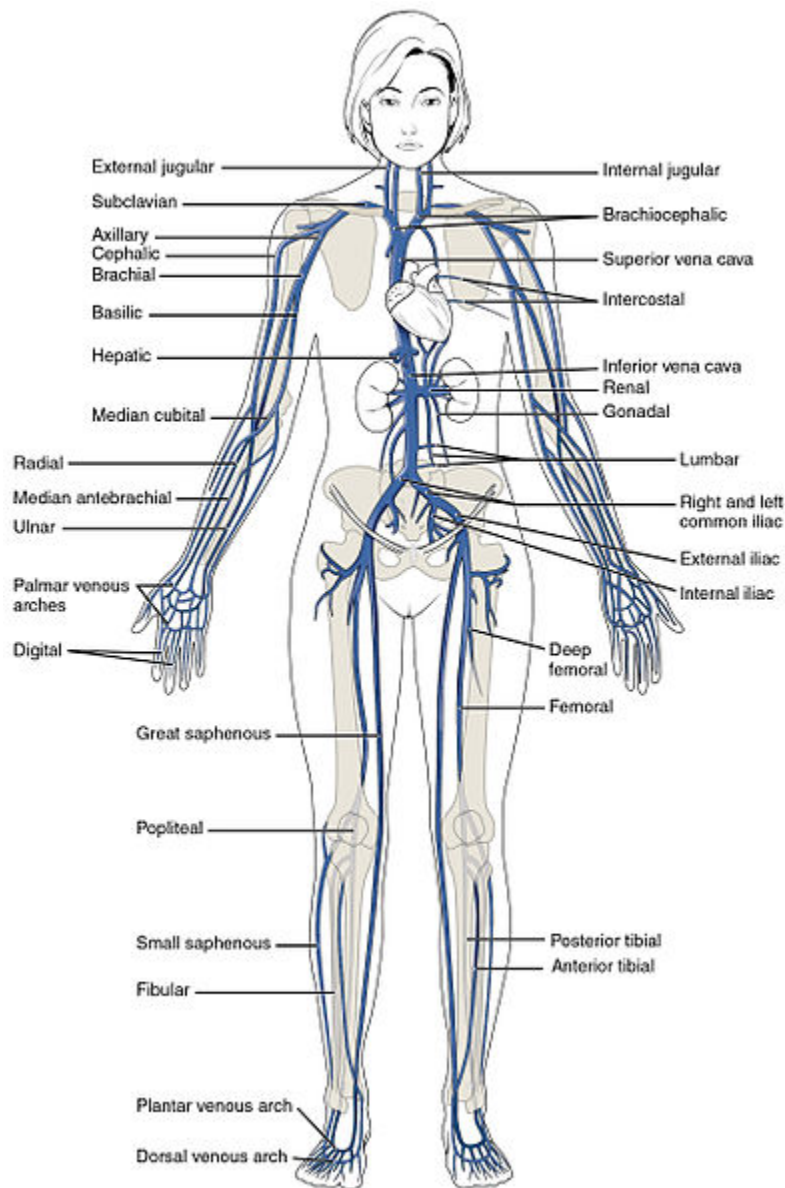


Figure 9.5 Systemic Veins

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View the following YouTube video¹¹ on blood vessels:

▶ [Blood Vessels, Part 1 – Form and Function: Crash Course Anatomy & Physiology #27](https://youtu.be/v43ej5lCeBo)

Coronary Arteries and Veins

Coronary arteries are arteries that branch off the aorta and carry oxygenated blood to the heart muscle itself. Coronary veins bring deoxygenated blood back to the right atrium. Blood circulates through the coronary arteries and veins with each heartbeat. See Figure 9.6¹² for an illustration of the coronary arteries and veins.

11. CrashCourse. (2015, July 20). *Blood Vessels, Part 1 – Form and function: Crash Course Anatomy & Physiology #27*. [Video]. YouTube. All rights reserved. <https://youtu.be/v43ej5lCeBo>

12. “[Surface Anatomy of the Heart](#)” by [OpenStax College](#) is licensed under [CC BY 4.0](#)

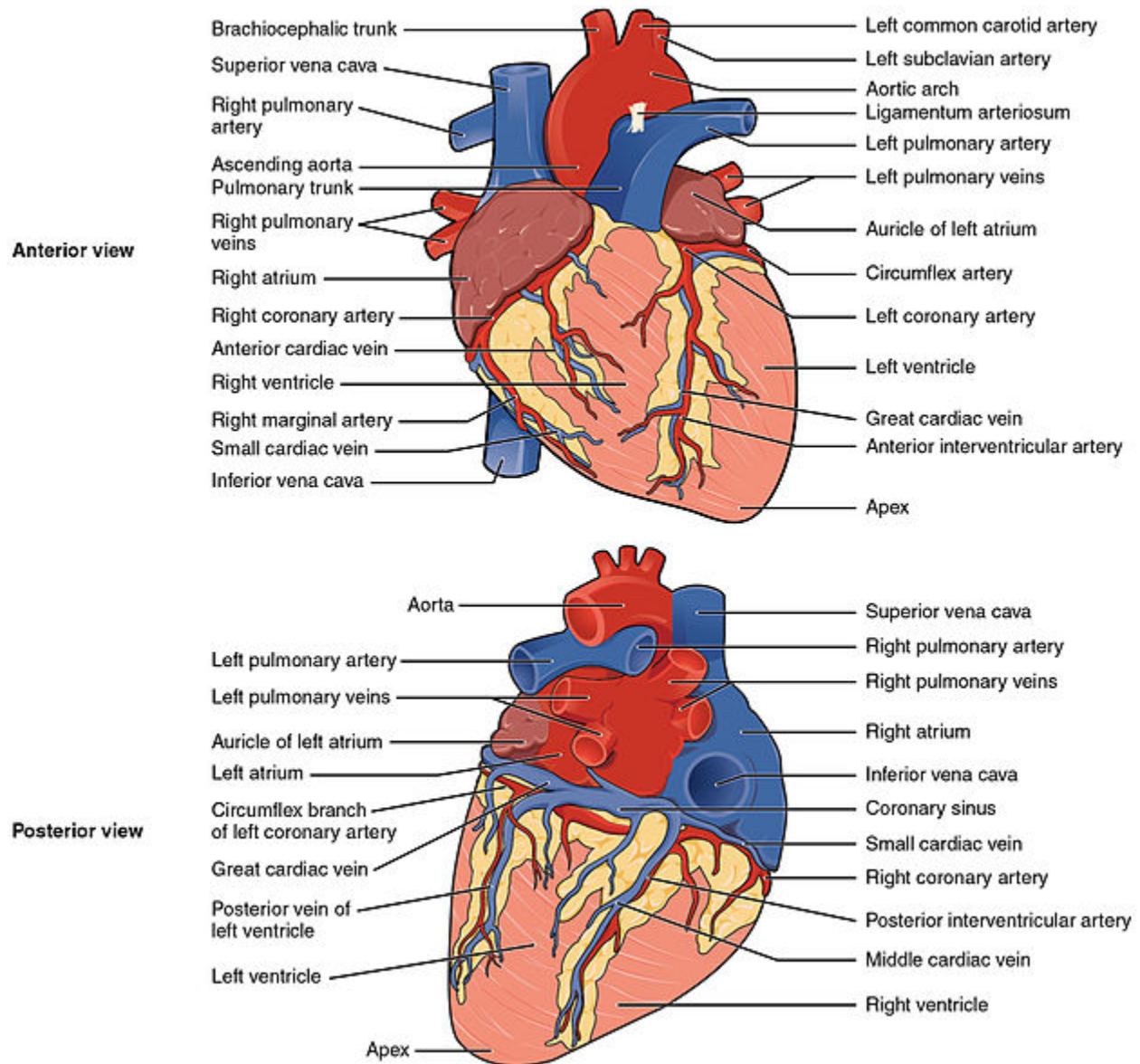


Figure 9.6 Coronary Arteries in the Heart

When a person has a **myocardial infarction** (mī-ō-kar'dē-ăl in-FARK-shŏn) (**MI**), a blockage in a coronary artery causes a lack of oxygenated blood flow to the heart muscle. If a significant area of the heart's muscle tissue dies from lack of oxygenation, the heart is no longer able to pump.

9.5 Physiology of the Cardiovascular System

PULMONARY AND SYSTEMIC CIRCULATION

There are two distinct but linked circuits in the human circulation called pulmonary and systemic circuits.

The pulmonary circuit transports oxygenated blood from the right ventricle to the lungs, where carbon dioxide is delivered for exhalation, oxygen is picked up, and this newly oxygenated blood returns to the left atrium of the heart.¹

The systemic circuit transports oxygenated blood from the left ventricle of the heart, through the aorta, and into the systemic arteries throughout the body where it diffuses into the tissues at the capillaries. Deoxygenated blood travels back to the heart by entering small veins that merge and eventually drain into the superior and inferior vena cava and into the right atrium of the heart. See Figure 9.7² for an illustration of blood flow through the pulmonary and systemic circuits.³

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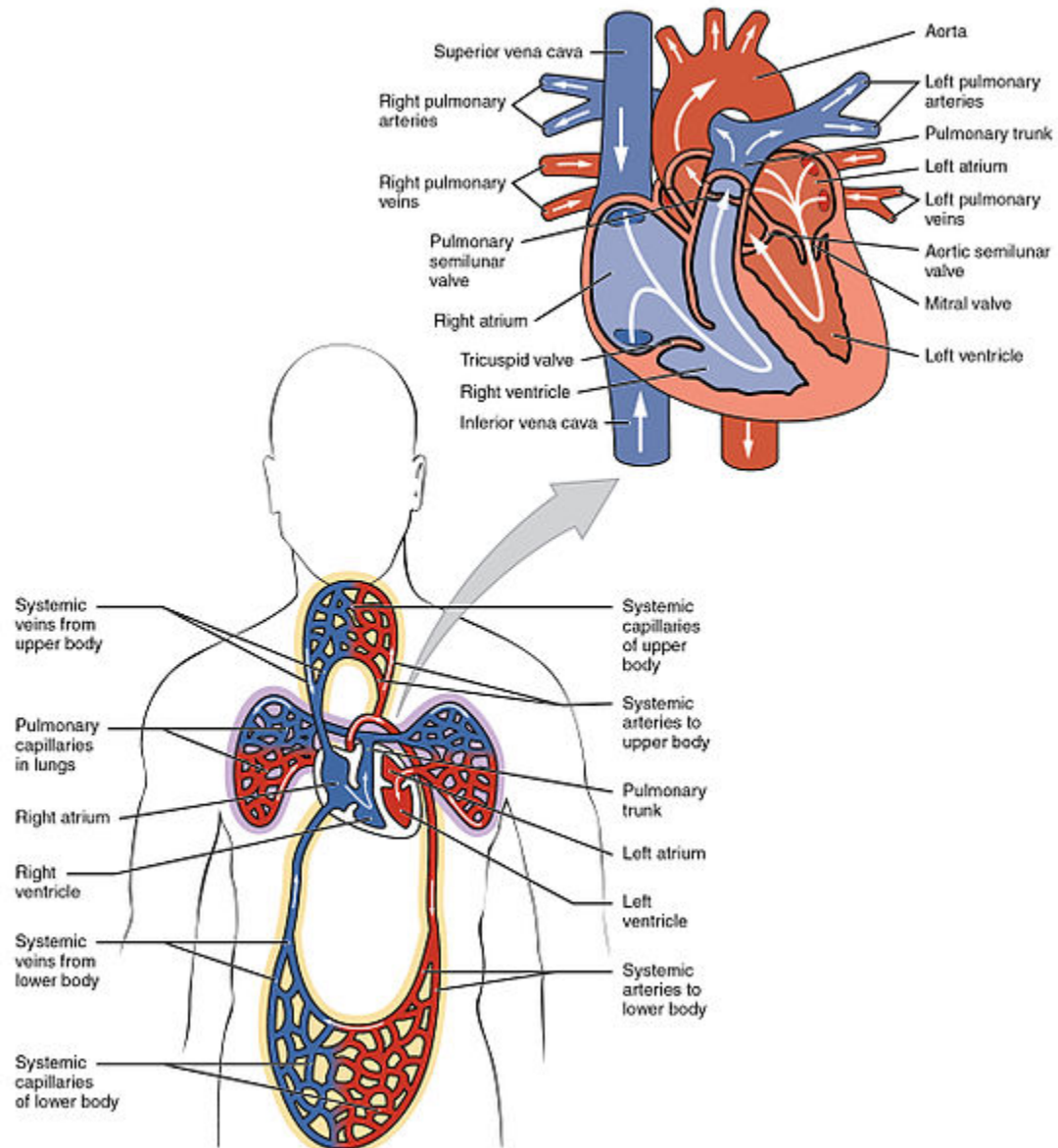


Figure 9.7 Blood Flow Through the Heart and the Pulmonary and Systemic Circuits

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Transportation

The systemic and pulmonary circuits transport blood and its components for physiological processes that occur throughout the body⁴:

- The right ventricle pumps deoxygenated blood through the pulmonary arteries away from the heart to the lungs. (Note this is the only place in the body where arteries carry deoxygenated blood.) Oxygen from air inhaled into the lungs diffuses into the pulmonary capillaries through the thin walls of the alveoli. At the same time, carbon dioxide diffuses out of the pulmonary capillaries into the alveoli and then exhaled out of the body. The pulmonary veins return oxygenated blood to the left atria of the heart, which moves into the left ventricle where it is pumped out to the rest of the body via the aorta to the systemic arteries.
- Nutrients from the foods eaten are absorbed in the small intestine, where they diffuse into the systemic circulation and are transported to the liver through the hepatic portal vein and then throughout the rest of the body.
- Systemic arteries carry oxygenated blood to the liver where it mixes with the nutrient-rich blood coming in from the hepatic portal vein. Wastes and toxins are filtered out of the blood, bile is produced to help remove wastes and break down fats, medications are metabolized, and nutrients are broken down.
- Systemic arteries carry blood to the kidneys, where wastes are filtered out and urine is created.
- Endocrine glands scattered throughout the body release hormones into the bloodstream where they are transported to distant target cells.

Heart Rate

Heart rate (HART RĀT) (**HR**) is the number of heart beats per minute (bpm).

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HR can vary considerably among people based on their age, as well as their fitness level. For an adult, normal resting HR is 60–100 bpm. Although similar to the pulse, the heart rate is auscultated directly using a stethoscope and is a more accurate measurement than the pulse.⁵

Abnormal heart rates are referred to as bradycardia and tachycardia.

Bradycardia (brād-i-KARD-ē-ă) refers to a slow heart rate, less than 60 bpm in an adult. **Tachycardia** (tak-ē-KARD-ē-ă) refers to a fast heart rate, greater than 100 bpm in an adult. Read more about bradycardia and tachycardia in the “[Diseases and Disorders of the Cardiovascular System](#)” section.

Pulse

Each time the heart pumps, ejecting blood forcefully into the circulation, the arteries expand and recoil to accommodate the surge of blood moving through them. This expansion and recoiling of the arterial wall are called the **pulse** (PULS) and allow for the measurement of heart rate. The pulse can be palpated manually by placing the tips of the fingers across an artery that runs close to the body surface, such as the radial artery (on the thumb side of the wrist) or the common carotid artery (in the neck).⁶ These sites and other pulse sites are shown in Figure 9.8⁷ below.

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7. “[2110_Pulse_Sites.jpg](#)” by OpenStax College is licensed under [CC BY 3.0](#)

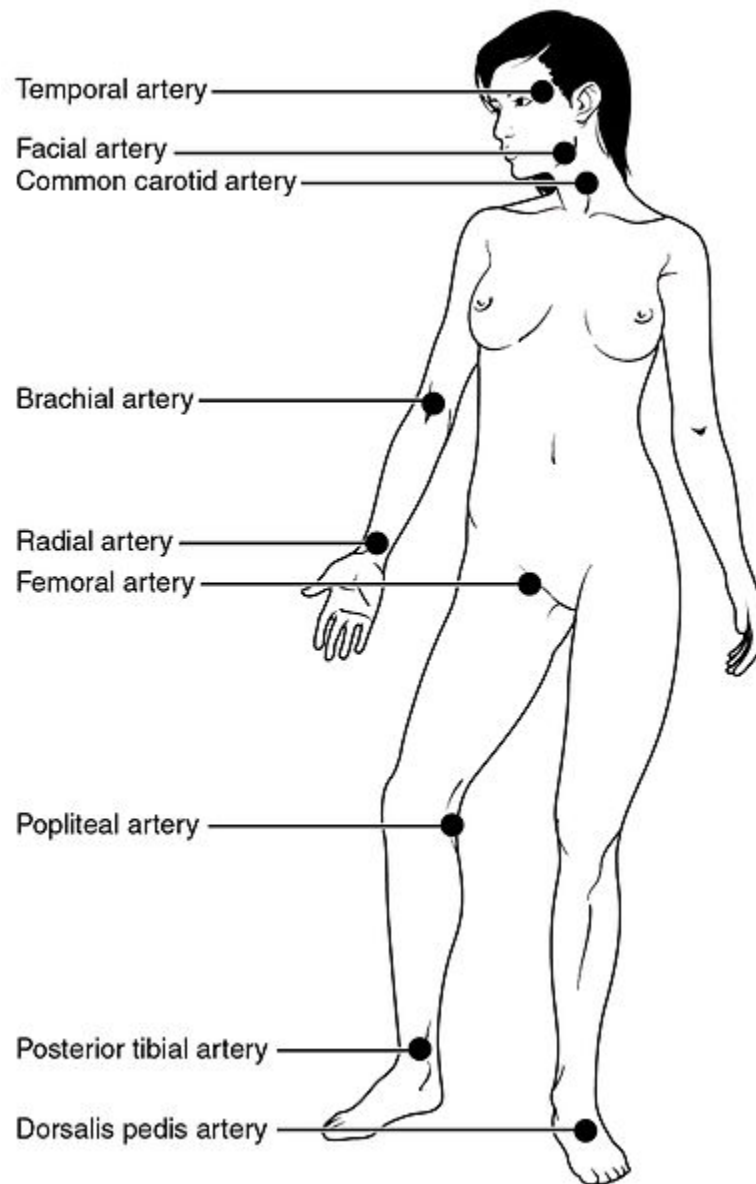


Figure 9.8 Pulse Sites

Both the rate and the strength of the pulse are important clinically. A high pulse rate can be temporarily caused by physical activity, but an extended fast or irregular pulse may indicate a heart condition. The pulse strength indicates the strength of ventricular contraction, cardiac output, and perfusion. **Cardiac output** (KAR-dē-ăk OUT-put) is the amount of blood pumped by the heart per

minute. **Perfusion** (pě-r-FŪ-zhǒn) is the passage of blood through the blood vessels.⁸

If the pulse is strong, then cardiac output is high and perfusion to that site is good. If the pulse is weak, cardiac output is low or perfusion is impaired, and medical intervention may be warranted.

Cardiac Cycle

The period of time that begins with contraction of the atria, continues through ventricular contraction, and ends with ventricular relaxation is known as the cardiac cycle. The phase of the cardiac cycle when ventricles contract and eject blood is called **systole** (SIS-tǒ-lē). The phase of the cardiac cycle where the heart muscles relax, allowing the chambers to fill with blood, is called **diastole** (dī-AS-tǒ-lē).⁹

Blood Pressure

Blood pressure (BLŮD PRESH-ŭr) (**BP**) is the force of the blood against the vessel walls. In clinical practice, blood pressure is typically measured using a **sphygmomanometer** (sfīg-mō-mǎn-ŎM-ět-ěr), commonly called a blood pressure cuff. The cuff is placed over the brachial artery of the patient's upper arm and inflated with air to temporarily **occlude** (ǒ-KLOOD) (block) blood flow and measure blood pressure. Blood pressure is recorded as a ratio of two numbers expressed as systolic pressure over diastolic pressure, measured in millimeters of mercury (mm Hg). For example, 120/80 mm Hg is a normal adult blood pressure. The systolic pressure is the higher value and reflects the

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arterial pressure resulting from the ejection of blood during ventricular contraction called systole. The diastolic pressure is the lower value and represents the arterial pressure of blood during ventricular relaxation called diastole.¹⁰

Low blood pressure, called **hypotension** (hī-pō-TEN-shŏn), has several causes, such as dehydration, vomiting, diarrhea, or medications used to treat hypertension. Treatment for hypotension typically includes fluid replacement. High blood pressure is called **hypertension** (hī-pěr-TEN-shŏn) (**HTN**). Hypertension has a variety of causes, with risk factors such as obesity, lack of exercise, smoking, high salt diet, diabetes, and kidney disease.

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9.6 Diseases and Disorders of the Cardiovascular System

ANEURYSM

An **aneurysm** (AN-yŭ-rizm) is a dilation or bulging of a blood vessel caused by weakened vessel walls. Aneurysms can occur in vessels throughout the body but are more commonly found in arteries due to their increased pressure. Aneurysms can be caused by a variety of factors, including smoking, atherosclerosis (fatty plaque buildup in a vessel), and hypertension.¹ See Figure 9.9² for an illustration of thoracic and abdominal aneurysms.

1. Centers for Disease Control and Prevention. (2021, September 27). *Aortic aneurysm*. Department of Health & Human Services. https://www.cdc.gov/heartdisease/aortic_aneurysm.htm

2. “[Aortic_aneurysm.jpg](#)” by [en:National Institutes of Health](#) is licensed in the [Public Domain](#).

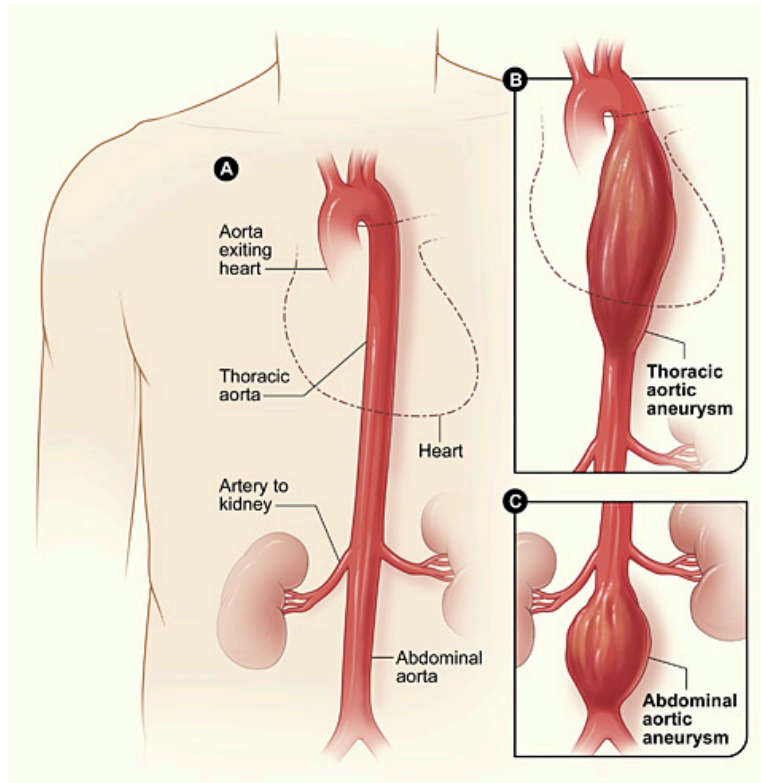


Figure 9.9 Thoracic and Abdominal Aneurysms

Aneurysms are often asymptomatic and detected incidentally during diagnostic tests that are being done for other reasons. The force of blood pumping through the vessel with an aneurysm can split the layers of the artery wall, allowing blood to leak in between them, called a dissection. An aneurysm can burst completely, called a rupture, and cause severe, life-threatening bleeding. Aneurysms are managed with antihypertensive medications or may require surgical repair.³

3. Centers for Disease Control and Prevention. (2021, September 27). *Aortic aneurysm*. Department of Health & Human Services. https://www.cdc.gov/heartdisease/aortic_aneurysm.htm

ARRHYTHMIA

A heart rhythm that follows the regular conduction system of the heart is called **normal sinus rhythm** (SĪ-nūs RITH-ŭm). For example, bradycardia and tachycardia that occurs during normal sinus rhythm have abnormally slow or fast rates but have a regular rhythm.

- **Bradycardia** (brad-ē-KAR-dē-ă) refers to a slow resting heart rate of less than 60 beats per minute. A normal resting heart rate for an adult is 60 to 100 beats per minute (bpm). However, heart rates can vary widely among individuals based on several factors like age, fitness level, overall health, and medication side effects. Physically fit athletes may have a heart rate of 50 to 60 bpm at rest with no symptoms. However, individuals with bradycardia whose heart is not pumping enough blood to sufficiently supply the brain and body tissues with oxygen may have symptoms, such as feeling tired, dizzy, short of breath, or confused. Individuals with symptomatic bradycardia may experience **syncope** (SING-kō-pē), a medical term for a brief lapse in consciousness, commonly referred to as fainting. Bradycardia is a common side effect of many cardiac medications and can also be caused by several cardiac diseases and disorders. Treatment of symptomatic bradycardia includes medications to increase heart rate or surgical implantation of a pacemaker in the heart to maintain a normal heart rate.
- **Tachycardia** (tak-ē-KAR-dē-ă) is a rapid heart rate greater than 100 bpm. Tachycardia can be caused by stress, side effects of medications, and several medical conditions. When the heart beats too rapidly, its chambers do not have time to sufficiently fill with blood, resulting in a decreased amount of oxygenated blood being pumped to body tissues and organs. For this reason, symptoms of tachycardia are similar to symptoms of bradycardia. The individual may also have **palpitations** (pal-pĭ-TĀ-shōnz), a sensation that the heart is racing, pounding, fluttering, or skipping a beat. Treatment is based on the underlying cause and may include medications or surgery.

Arrhythmia (ā-RITH-mē-ă) does not mean an absence of a heartbeat, but rather means the absence of a normal heart rhythm due to disrupted electrical activity of the conduction system. Examples of common arrhythmias are atrial fibrillation, heart block, ventricular tachycardia, and ventricular fibrillation.

- **Atrial fibrillation** (Ā-trē-ăl fīb-rī-LĀ-shŏn) (**A Fib**) is characterized by atrial quivering instead of contracting. A Fib can cause a decrease in the volume of blood propelled with each heartbeat because the ventricles do not completely fill with blood before contracting. A Fib also increases the risk of a cerebrovascular accident (also known as a stroke).
- **Heart block** (hărt blŏk) refers to a disruption in the normal conduction pathway of electrical signals through the atria and ventricles. Heart block can vary in severity from first-degree heart block, which is the least severe and often has no symptoms, to third-degree heart block that can be life-threatening. Symptoms of heart block may include bradycardia, missed heart beats, fatigue, dizziness, chest pain, and shortness of breath.
- **Ventricular tachycardia** (ven-TRĪK-yū-lăr tak-ĭ-KAR-dē-ă) (**V Tach**) refers to a very rapid heartbeat that originates in the ventricles. **Ventricular fibrillation** (ven-TRĪK-yū-lăr fīb-rī-LĀ-shŏn) (**V Fib**) is a disorganized heart rhythm that causes the ventricles to quiver instead of contract. Ventricular tachycardia and ventricular fibrillation are life-threatening arrhythmias that require rapid emergency response and the use of a defibrillator to resolve the abnormal rhythm.

A **defibrillator** (dē-FIB-rī-lā-tŏr) is a device used by trained medical personnel who apply an electrical charge to the heart in an attempt to restart the SA node and establish a normal sinus rhythm. **Automated external defibrillators** (aw-tŏ-măt'-ĕd ĕks-tĕr'năl dē-fīb'-rī-lā-tŏrs) (**AEDs**) are life-saving devices available in public areas to help individuals who are experiencing a **cardiac arrest** (KAR-dē-ăk ār-REST) survive. Cardiac arrest is caused by arrhythmias that cause the heart to suddenly stop pumping blood. The average response time after calling 911 is 8 to 12 minutes, and for each minute defibrillation is delayed, the odds of survival are reduced by approximately 10%, so having access to an AED and knowing how to perform cardiopulmonary

resuscitation (CPR) are critical. CPR refers to repeated compressions of the chest in an attempt to restore blood circulation following a cardiac arrest. While CPR is being performed, special pads are applied to the individual's chest. The AED automatically analyzes the heart's rhythm and, if indicated, delivers an electrical shock to help the heart reestablish an effective rhythm until paramedics arrive. See Figure 9.10⁴ for an image of an AED.



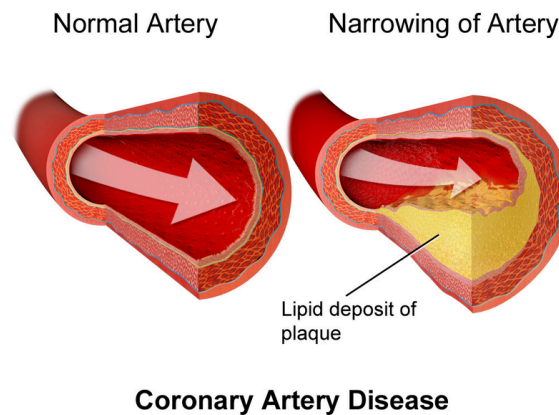
Figure 9.10 Automatic External Defibrillator (AED)

Individuals who have experienced a cardiac arrest due to life-threatening arrhythmias may have an **implantable cardioverter defibrillator** (ĩm-plănt'-ă-bŭl kär'dē-ō-vŭr'-tŏr dē-fīb'-rĩ-lā-tŏr) (**ICD**) surgically placed in their chest. An ICD continuously analyzes the heart rhythm and provides an automatic electric shock to convert a dangerous heart rhythm to a normal heart rhythm.

4. “[Saver_One_AED.jpg](#)” by unknown author via [Anatoliy Smaga](#) is licensed under [CC BY 4.0](#)

ATHEROSCLEROSIS

Atherosclerosis (ă-thĕr-ō-sklĕ-RO-sĭs) refers to hardening and narrowing of arteries due to the buildup of cholesterol and other fats called plaque within the lining of the arteries. Plaque creates inflammation and decreases the amount of blood flow through an artery, also referred to as decreased perfusion. Plaque can also grow so large that it causes a blockage of blood flow in the artery. When this accumulation of plaque occurs in the coronary arteries of the heart, it is called **coronary artery disease** (KOR-ō-nā-rē AR-tĕr-ē dĭ-ZĒZ) (**CAD**) or atherosclerotic heart disease. Read more information about coronary artery disease in a later subsection of this section. See Figure 9.11⁵ for an illustration of the narrowing of a coronary artery by an atherosclerotic plaque.



Coronary Artery Disease
Figure 9.11 Atherosclerotic Plaque

Cerebrovascular disease (sĕr'-brō-VAS-kyū-lăř dĭ-ZĒZ) (**CVD**) occurs when

5. "[Blausen_0259_CoronaryArteryDisease_02.png](#)" by Blausen.com staff (2014). "[Medical gallery of Blausen Medical 2014.](#)" WikiJournal of Medicine is licensed under [CC BY 3.0](#)

arteries in the brain or neck become thick, hard, or full of plaque and blood flow is restricted, which can cause a cerebrovascular accident (commonly known as a stroke). **Peripheral artery disease** (pěr-IF-ěr-ăl AR-těr-ē dĩ-ZĚZ) (**PAD**) occurs when blood vessels are obstructed in peripheral regions of the body, commonly causing pain during activity and possibly causing ulcers in the legs and feet.

A clinician may hear a **bruit** (brwē) when auscultating over an artery if atherosclerosis is present. A bruit sounds like an abnormal blowing, swishing sound. For example, a carotid bruit indicates the individual is at risk for a stroke.

CARDIOMYOPATHY

Cardiomyopathy (kar-dē-ō-my-OP-ă-thē) refers to disease of the heart muscle. When cardiomyopathy occurs, the normal muscle in the heart can thicken, enlarge, stiffen, or thin out. As a result, the heart muscle's ability to pump blood is reduced, which can lead to irregular heartbeats or the backup of blood into the lungs or rest of the body. Cardiomyopathy can be acquired (i.e., developed because of another disorder), inherited, or occur due to an unknown cause. Categories of cardiomyopathy include dilated, hypertrophic, and restrictive.⁶ See Figure 9.12⁷ for an illustration of common types of cardiomyopathy.

6. Centers for Disease Control and Prevention. (2023, February 21). *Cardiomyopathy*. Department of Health & Human Services. <https://www.cdc.gov/heartdisease/cardiomyopathy.htm>

7. “[Major categories of cardiomyopathy.png](#)” by Npatchett is licensed under [CC BY-SA 4.0](#)

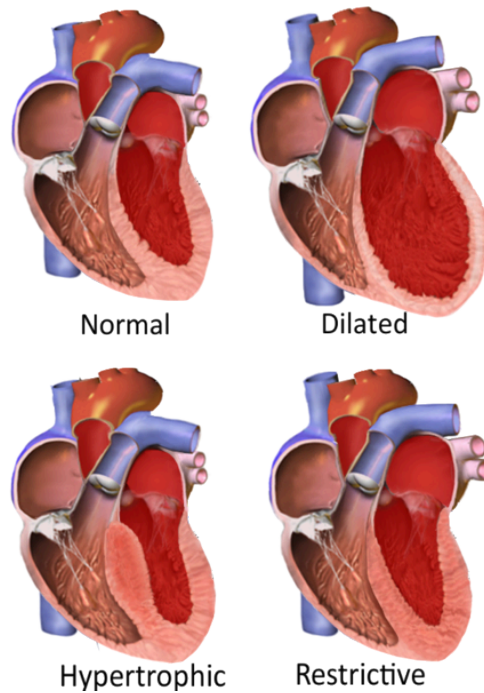


Figure 9.12 Categories of Cardiomyopathy

CONGENITAL HEART CONDITIONS

A **congenital** (kŏn-JĔN-ĭ-tăĭ) condition means it is present at birth. There are several types of congenital heart disorders. Some are caused by openings present in the heart that do not close as they should after birth. See Figure 9.13⁸ for an illustration of common congenital cardiac disorders.

8. [“2009_Congenital_Heart_Defects.jpg”](#) by OpenStax College is licensed under CC BY 3.0

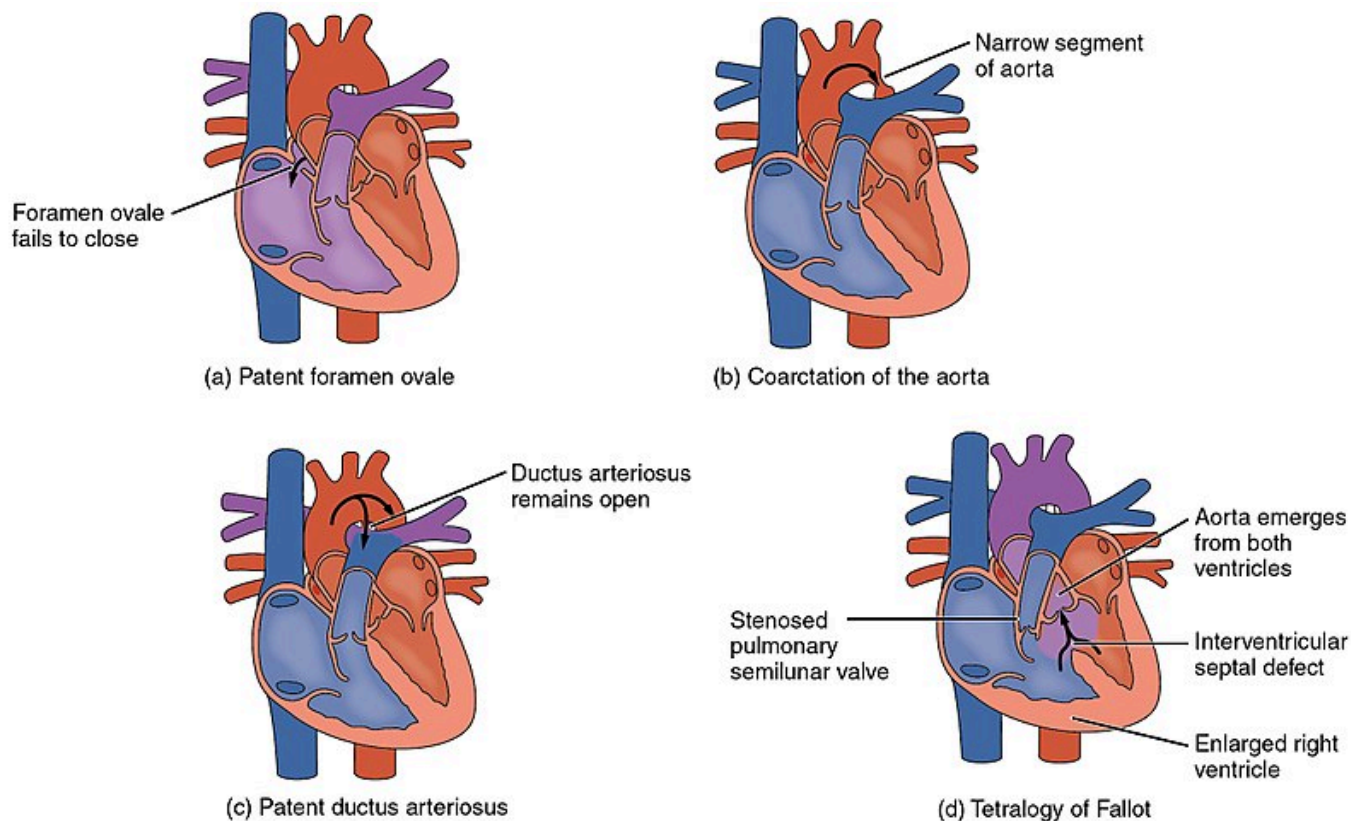


Figure 9.13 Examples of Congenital Heart Disorders

- **Patent ductus arteriosus** (PĀ-těnt DŮK-tŭs är-tēr'-ē-ō-sŭs) occurs when the ductus arteriosus fails to close after birth. The ductus arteriosus is a vessel in the fetal heart that connects the pulmonary trunk and aorta, bypassing the pulmonary circulation.
- **Patent foramen ovale** (PĀ-těnt fŏ-rā'-mĕn ō-vā'-lē) is a hole in the septum between the atria of the heart that does not close at birth.
- **Coarctation** (kō-ark-TĀ-shŏn) of the aorta is a narrowing of the aorta that forces the heart to pump harder to move blood through the aorta.
- **Atrial septal defect** (Ā-trē-ăl SĚP-tăl dī-FĚKT) (**ASD**) refers to an opening that exists in the septum (wall) between the left and right atria.
- **Ventricular septal defect** (ven-TRĪK-yŭ-lăr SĚP-tăl dī-FĚKT) (**VSD**) is an opening that exists in the septum (wall) between the left and right ventricles.

Tetralogy of Fallot (tĕt'ră-lō-jē ōf fă-LŌ) is a serious congenital disorder with

high mortality. It includes several abnormal conditions in the heart that allow unoxygenated blood from the right ventricle to flow into the left ventricle and mix with the blood that is relatively high in oxygen. Symptoms of Tetralogy of Fallot include a heart murmur, dyspnea, low blood oxygen saturation, clubbing of the fingers and toes, difficulty in eating, and failure to grow and develop. A **murmur** (MUR-mŭr) is an abnormal heart sound heard on auscultation by a stethoscope that may sound like a “whooshing” sound. Tetralogy of Fallot is diagnosed by echocardiography. Treatment involves extensive surgical repair.⁹

CORONARY ARTERY DISEASE

Coronary artery disease (KOR-ŏ-nā-rē AR-tēr-ē dĩ-ZĒZ) (**CAD**) occurs when atherosclerosis (i.e., buildup of plaque) in the coronary arteries obstructs the flow of oxygenated blood to the heart muscle. As oxygenated blood flow to the cardiac muscle cells is reduced, referred to as **ischemia** (ĩs-KEE-mē-ă), individuals often experience chest pain called **angina** (an-JĪ-nă). See Figure 9.14¹⁰ for an image of a blockage of coronary arteries on an angiogram.

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10. “[2016_Occluded_Coronay_Arteries.jpg](#)” by OpenStax College is licensed under [CC BY 3.0](#)

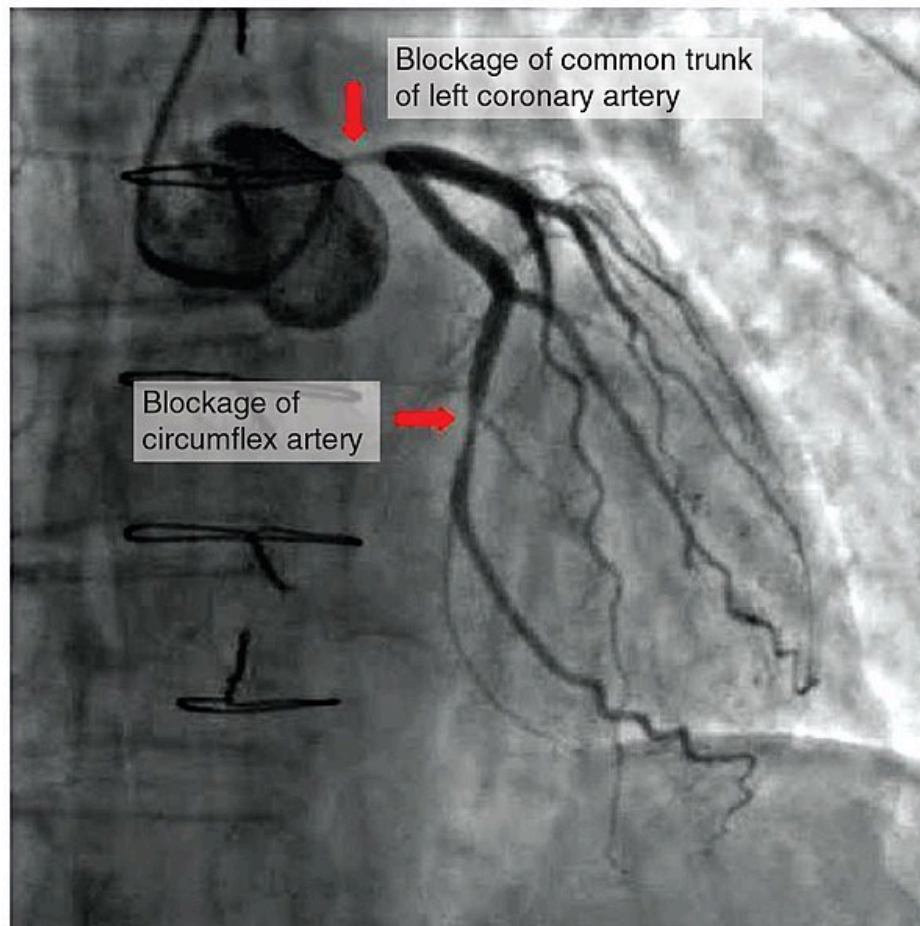


Figure 9.14 Angiogram of Atherosclerotic Coronary Arteries

CAD is progressive and, if left untreated, can cause a myocardial infarction (MI). Risk factors include smoking, family history, hypertension, obesity, diabetes, lack of physical activity, stress, hyperlipidemia, and excessive alcohol use. Treatments may include medication, changes to diet and exercise, angioplasty with insertion of a stent, or coronary artery bypass graft (CABG).¹¹ Read more about these procedures in the “[Medical Specialists](#),”

11. Centers for Disease Control and Prevention. (2023, May 15). *About heart disease*. Department of Health & Human Services. <https://www.cdc.gov/heartdisease/about.htm>

DEEP VEIN THROMBOSIS

A **deep vein thrombosis** (dēp vān THROM-bō-sīs) (**DVT**) is a blood clot in a deep vein that most often occurs in the lower extremities. DVTs can break free and become life-threatening emboli that travel to other areas of the body and cause blockages. For example, a pulmonary embolus (PE) is a medical emergency caused by a DVT that became an embolus and lodged in the lung.

Symptoms of a DVT often include calf pain in one leg with swelling, redness, and warmth of that leg. A DVT is diagnosed with a Doppler ultrasound that identifies altered blood flow in a vessel due to a clot.¹²

EDEMA

Despite the presence of valves within veins that prevent the backflow of blood, over the course of a day, some blood will inevitably pool in the lower limbs, due to the pull of gravity. Any blood that accumulates in a vein will increase the pressure within it. Increased pressure will promote the flow of fluids out of the capillaries and into the interstitial fluid. The presence of excess tissue fluid around the cells leads to a condition called **edema** (e-DE-ma). Medications, such as diuretics, and compression stockings are used to

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help minimize the edema. See Figure 9.15¹³ for an image of a patient with edema.



Figure 9.15 Edema

HEART FAILURE

Heart failure (HART FĀL-yŭr) (**HF**) occurs when the heart loses its effectiveness in pumping blood. When the heart is not pumping effectively, symptoms of fatigue, shortness of breath, edema, or lung congestion can occur. Chronic HF is a progressive disorder that can be represented on a continuum. The continuum ranges from individuals who are at risk for HF but are asymptomatic, to individuals who have end-stage heart failure and require end-of-life care. Treatments may include medication, a low sodium

13. "[Combinpedal.jpg](#)" by [James Heilman, MD](#) is licensed under [CC BY-SA 3.0](#)

diet, and fluid restrictions.¹⁴ See Figure 9.16¹⁵ for an illustration of common symptoms of heart failure.

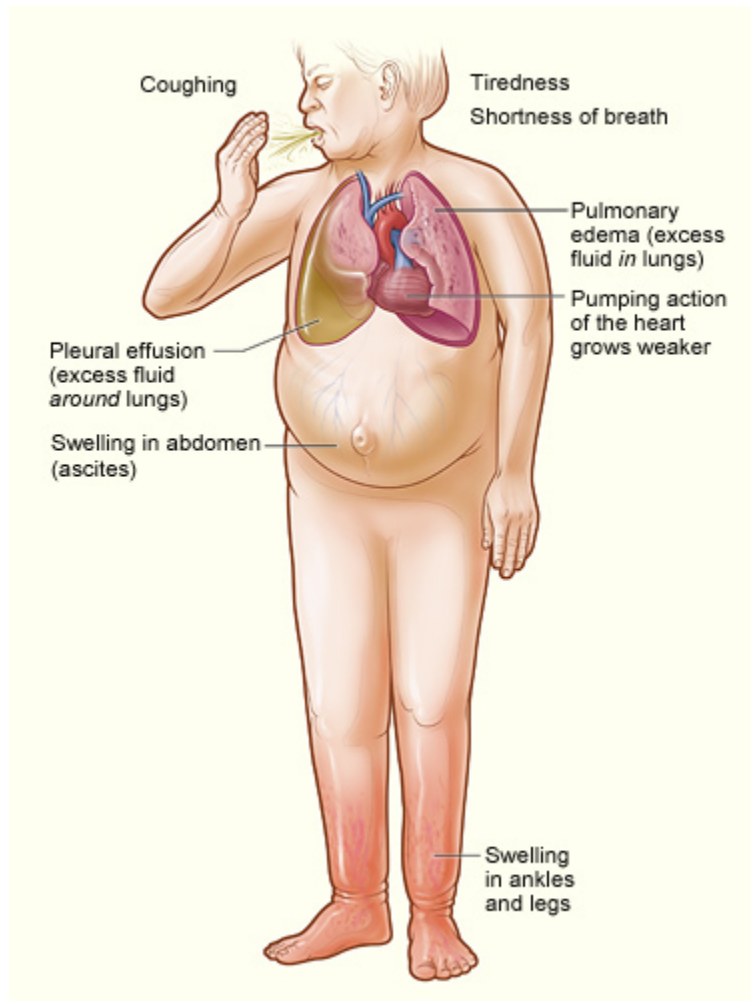


Figure 9.16 Heart Failure

14. Centers for Disease Control and Prevention. (2023, April 14). *Heart disease*. Department of Health & Human Services. <https://www.cdc.gov/heartdisease/about.htm>
15. “Heartfailure.jpg” by National Heart, Lung, and Blood Institute, National Institutes of Health is licensed in the Public Domain.

There are many potential causes of HF, including coronary artery disease (CAD), myocardial infarction (MI), hypertension, valve disorders, and cardiomyopathy. Treatment for heart failure may include medications to eliminate excess fluid, a low salt diet, fluid restrictions, implanted devices that assist the heart to pump blood, and heart transplant surgery.¹⁶

HYPERTENSION

Hypertension (hī-pěr-TEN-shŏn) refers to elevated blood pressure greater than 120/80 mm Hg in an adult. Hypertension is very common, affecting millions of individuals worldwide. See Figure 9.17¹⁷ for an image of a **sphygmomanometer** (sfig-mō-mă-NOM-ět-ěr) used to obtain blood pressure readings.

- ¹⁶. Centers for Disease Control and Prevention. (2023, April 14). *Heart disease*. Department of Health & Human Services. <https://www.cdc.gov/heartdisease/about.htm>
- ¹⁷. “[Grade 1 hypertension.jpg](#)” by [Steven Fruitsmaak](#) is licensed under [CC BY 3.0](#)



Figure 9.17 Sphygmomanometer

Risk factors for developing hypertension include age, ethnicity, family history, and lifestyle factors. Individuals with obesity, diets high in sodium, excessive alcohol intake, chronic stress, and limited physical activity are at higher risk for developing hypertension. Many people with hypertension do not have symptoms, so they are unaware they have the disorder until a complication like a myocardial infarction, stroke, or heart failure occurs. Treatment includes medications and healthy lifestyle changes like adopting a heart-healthy diet, exercising regularly, stopping smoking, getting good sleep, losing weight, and managing stress.¹⁸

MYOCARDIAL INFARCTION

18. National Heart, Lung, and Blood Institute. (2022, March 24). *What is high blood pressure*. National Institutes of Health. <https://www.nhlbi.nih.gov/health/high-blood-pressure>

Myocardial infarction (mī-ō-kar'dē-ăl in-FARK-shŏn) (**MI**), commonly called a heart attack, is caused by blockage of blood flow to the heart tissue, resulting in death of the cardiac muscle cells. **Acute coronary syndrome** (ə-KYŪT KOR-ŏ-nā-rē SĪN-drŏm) (**ACS**) is a general term used for medical situations in which blood supplied to the heart muscle is suddenly insufficient. An MI is commonly caused by atherosclerosis causing a blockage in a coronary artery. It can also occur when a piece of an atherosclerotic plaque breaks off and travels through the coronary arterial system until it lodges in one of the smaller vessels. See Figure 9.18¹⁹ for a depiction of an individual experiencing an MI and the damage occurring to the cardiac muscle as a result of the coronary artery blockage.

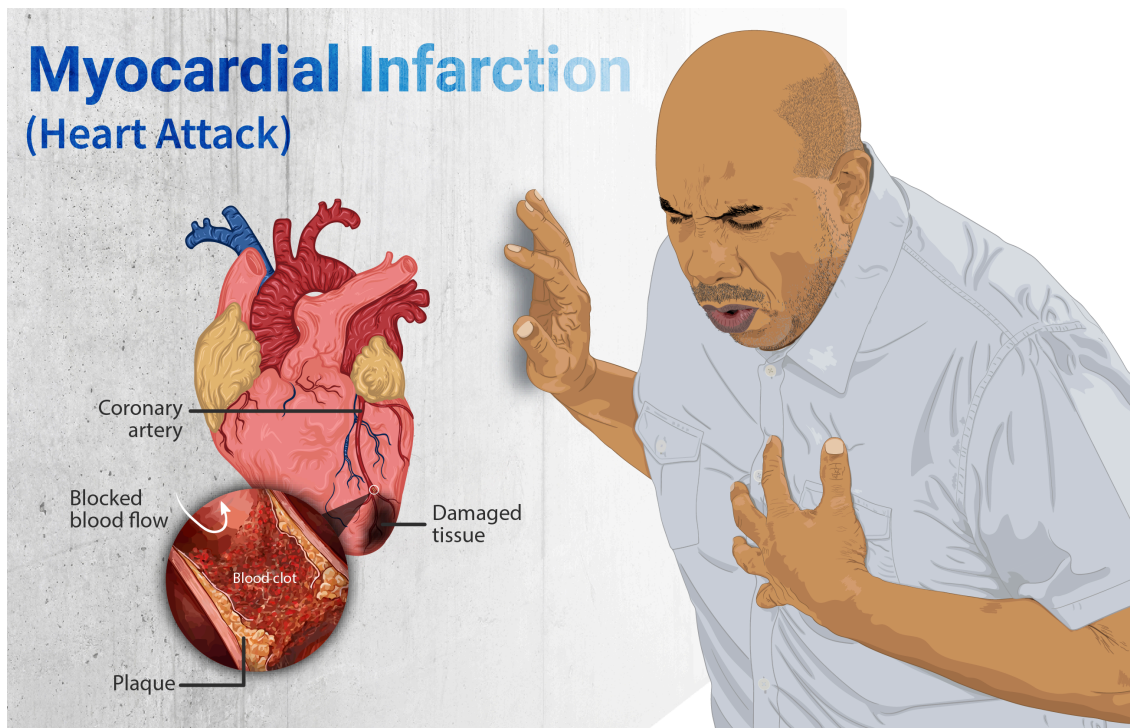


Figure 9.18 Myocardial Infarction

19. “[Depiction of a person suffering from a heart attack \(Myocardial Infarction\).png](https://www.myupchar.com/en)” by <https://www.myupchar.com/en> is licensed under [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

A classic symptom of an MI includes sudden crushing pain beneath the sternum called **angina** (an-JĪ-nă) that may radiate down the left arm. Individuals often describe angina as “it feels as if something is sitting on my chest.” Other common symptoms include dyspnea, diaphoresis, nausea, and light-headedness. **Diaphoresis** (dī-ă-fō-RĒ-sīs) means profuse (excessive) sweating. However, females may not experience these symptoms and only have a feeling similar to indigestion.²⁰

An MI is a medical emergency. The faster the response, the more cardiac muscle cells that can be saved, so anyone who is suspected of having an MI should call 911. An MI is diagnosed with an **electrocardiogram** (ē-lĕk-trō-KĀR-dē-ō-grăġ) (**ECG**) and blood tests called cardiac enzymes. Cardiac enzymes include creatine kinase and cardiac troponin, both of which are released by damaged cardiac muscle cells.²¹

Immediate treatment typically includes administration of oxygen, aspirin (to stop the plaque from growing), and a medication called nitroglycerin (to help dilate the blood vessels to get more oxygenated blood to the cardiac muscle). Based on the results of the ECG and cardiac enzyme tests, the individual may undergo **thrombolysis** (thrŏm-BOL-ĭ-sīs), a procedure that involves administering a clot-dissolving medication to restore blood flow in a coronary artery. An alternative to thrombolysis is **angioplasty** (AN-jee-ŏ-plas-tē) or **coronary artery bypass graft surgery** (KOR-ŏ-nă-rē AR-tēr-ē bĭ-păs graft Sŭr-jĕr-ē) (**CABG**). Read more about these procedures in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to Cardiovascular System](#)” section of this chapter.²²

20. American Heart Association. (n.d.). *Heart attack*. <https://www.heart.org/en/health-topics/heart-attack>

21. American Heart Association. (n.d.). *Heart attack*. <https://www.heart.org/en/health-topics/heart-attack>

22. American Heart Association. (n.d.). *Heart attack*. <https://www.heart.org/en/health-topics/heart-attack>

VALVULAR HEART DISEASE

The heart has four valves that open and close at specific times during the cardiac cycle to control or regulate the blood flowing into and out of the heart. See Figure 9.19²³ for an illustration of the heart valves including the tricuspid, pulmonary, mitral, and aortic. Three of the heart valves (tricuspid, pulmonary, and aortic valves) are composed of three leaflets or flaps that work together to open and close to allow blood to flow forward and not backwards through the opening. The mitral valve (also known as the bicuspid valve) only has two flaps that open and close.

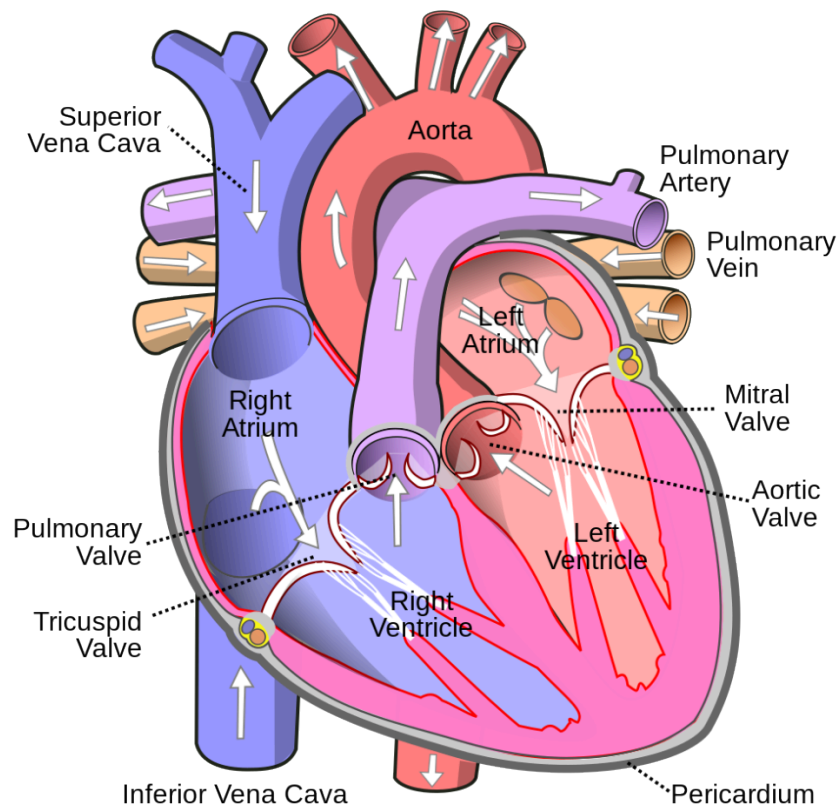


Figure 9.19 Heart Valves

23. “[Diagram of the human heart \(cropped\).svg](#)” by [Wapcaplet](#) is licensed under [CC BY 3.0](#)

Healthy heart valves fully open and close during the heartbeat, but patients with **valvular heart disease** (văl'-vyū-lăr härt dĭ-zēz') have diseased valves that do not fully open and close. Diseased valves that become “leaky” and don’t completely close cause a condition called **regurgitation** (rē-gŭr'-jĭ-tā'-shŭn). When regurgitation occurs, blood flows backwards and not enough blood is pushed forward through the heart. **Aortic insufficiency** (ā-OR-tĭk in-sŭ-FISH-ĕn-sē) (**AI**) is a valvular heart disease that occurs when the aortic valve does not close properly and allows regurgitation of blood back into the left ventricle.

Another type of valve disorder occurs when the opening of the valve is narrowed and stiff, causing it to not open fully when blood is trying to pass through. This disorder is called **stenosis** (stĕ-NŌ-sĭs).²⁴

There are several causes of valvular heart disease, including congenital heart conditions, infections, degenerative conditions (i.e., they wear out with age), and conditions linked to other types of heart disease. A **murmur** (MUR-mŭr), an abnormal heart sound heard on auscultation by a stethoscope, is a classic sign of a valvular heart disorder. Other symptoms include shortness of breath, chest pain, fatigue, dizziness, and palpitations.²⁵

Valvular heart disease is diagnosed by echocardiography. Treatment may include medications to treat the symptoms or surgery to repair or replace the valves.²⁶ Read more about these procedures in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Cardiovascular System](#).”

24. Centers for Disease Control and Prevention. (2019, December 9). *Valvular heart disease*. Department of Health & Human Services. https://www.cdc.gov/heartdisease/valvular_disease.htm
25. Centers for Disease Control and Prevention. (2019, December 9). *Valvular heart disease*. Department of Health & Human Services. https://www.cdc.gov/heartdisease/valvular_disease.htm
26. Centers for Disease Control and Prevention. (2019, December 9). *Valvular heart disease*. Department of Health & Human Services. https://www.cdc.gov/heartdisease/valvular_disease.htm

VARICOSE VEINS

Varicose veins (VAR-i-kōs VĀNZ) are a common condition caused by weak or damaged vein walls and valves. Veins have one-way valves that open and close to keep blood flowing toward the heart. Weak or damaged valves or walls in the veins can cause blood to pool and even flow backward.²⁷ See Figure 9.20²⁸ for an image of varicose veins.

Symptoms include bulging, bluish veins, and a feeling of heaviness or discomfort in the legs and feet. Without treatment, they tend to grow worse over time. The use of compression stockings (commonly known as TED hose), as well as elevating the feet and legs whenever possible, may be helpful in alleviating the symptoms of varicose veins. However, severe cases may require resolution through medical procedures.²⁹

27. National Heart, Lung, and Blood Institute. (2023). *Varicose veins*.
<https://www.nhlbi.nih.gov/health/varicose-veins>

28. “[Varicose_ASV1.jpg](#)” by [Nini00](#) is licensed under [CC BY-SA 3.0](#)

29. National Heart, Lung, and Blood Institute. (2023). *Varicose veins*.
<https://www.nhlbi.nih.gov/health/varicose-veins>



Figure 9.20 Varicose Veins

Procedures used to treat varicose veins include the following³⁰:

- **Endovenous laser ablation** (ĕn'-dō-vē'-nŭs lā'-zōr āb-lā'-shŭn) to close off a varicose vein. A health care provider uses laser or radiofrequency energy to heat the inside of the vein and close it off.
- **Sclerotherapy** (sklĕr-ō-THER-ă-pē) to seal off a varicose vein. The health care provider injects liquid or foam chemicals into the vein to create a plug that seals it shut.
- **Phlebectomy** (flĕ-BĔK-tō-mē) to remove small varicose veins. The health care provider makes small cuts to remove smaller veins near the skin.
- **Surgery** to tie off and remove large varicose veins in a procedure called vein ligation or stripping.

30. National Heart, Lung, and Blood Institute. (2023). *Varicose veins*.

<https://www.nhlbi.nih.gov/health/varicose-veins>

9.7 Medical Specialists, Diagnostic Testing, and Procedures Related to the Cardiovascular System

MEDICAL SPECIALISTS

Cardiology (kă-r-dē-ŏl'ō-jē) is the study of the heart. Specialty roles related to cardiology include cardiologists, cardiovascular surgeons, electrophysiologists, cardiovascular technologists and technicians, cardiovascular perfusionists, cardiac care nurses, cardiology nurse practitioners, and cardiology physician assistants.

Cardiologists

A **cardiologist** (kar-dē-OL-ŏ-jĭst) is a physician who specializes in the diagnosis and treatment of heart disease. Cardiovascular surgeons surgically treat heart disorders. An electrophysiologist is a physician who specializes in the diagnosis and treatment of issues related to the heart's electrical conduction system.

► Read more information about cardiologists on the [American Medical Association's Cardiovascular Disease Specialty web page](#).

Vascular Surgeon

Vascular surgery includes repair and replacement of diseased or damaged blood vessels, removal of plaque from vessels, and insertion of venous catheters, and traditional surgery.¹

Vascular Sonographer

Vascular sonographers use ultrasound machines to produce images of patients' veins and arteries using high-frequency sound waves. Physicians use these images that show the movement of blood through vessels to diagnose and treat various conditions.²

Cardiovascular Technologists and Technicians

Cardiovascular technologists and technicians perform cardiovascular diagnostic tests and procedures such as electrocardiography, stress testing, Holter monitor testing, ambulatory blood pressure (BP) testing, and pacemaker monitoring.

- ▶ Read more about cardiovascular technologist and technician positions on the U.S. Bureau of Labor Statistics [29-2031 Cardiovascular Technologists and Technicians](#) page.

1. Society for Vascular Surgery. (2023). *What is a vascular surgeon?*
<https://vascular.org/patients-and-referring-physicians/common-questions/what-vascular-surgeon>
2. American Registry of Radiologic Technologists. (n.d). *Vascular sonography*.
<https://www.arrt.org/pages/earn-arrt-credentials/credential-options/vascular-sonography>

Cardiovascular Perfusionist

Cardiovascular perfusionists operate circulation equipment that artificially support or temporarily replace a patient's circulatory or respiratory function. An example of such equipment is a heart-lung machine used during some types of coronary artery bypass surgery.

- ▶ Visit the [Mayo Clinic: Cardiovascular Perfusionist web page](#) for more information.

Cardiac Care Nurses

Cardiac care nurses provide care for patients with a variety of heart diseases or conditions in a cardiac care unit (CCU) in hospitals. They administer heart medications, help patients recover from heart surgery, or perform emergency care like assisting in defibrillation.

Cardiology Nurse Practitioners

Cardiology nurse practitioners (NPs) are registered nurses with advanced education and clinical experience to provide care for patients with chronic and acute cardiac diseases. Many cardiology NPs work in private practices, inpatient hospitals, outpatient clinic settings, or multiple practice settings where they assess the health status of patients, prescribe pharmacological and nonpharmacological treatments, and collaborate with an interdisciplinary team.

- ▶ Read more information on "[A Day in the Life of a Cardiology Nurse Practitioner \(NP\)](#)" web page by the American Association of Nurse Practitioners.

Cardiology Physician Assistants

Cardiology physician assistants (PAs) work in collaboration with cardiologists and cardiovascular surgeons. They provide a broad range of medical care to patients with varied clinical duties depending on the subspecialty and setting. PAs take medical histories, perform physical examinations, order and interpret laboratory and diagnostic tests, diagnose illness, develop and manage treatment plans for their patients, prescribe medications, perform procedures, and assist in surgery.

- ▶ Read more information about cardiology PAs on the [“PAs in Cardiology” PDF](#) from the American Academy of Physician Assistants website.

Radiology Technologist

A **radiology technologist** (rā-dē-ŎL-ŏ-jē tĕk-nŎL-ŏ-jĭst), commonly called an X-ray tech, is a health care professional who is specially trained to perform medical imaging like X-rays, CT scans, MRIs, and PET scans. To become a radiology technologist or MRI technologist, a person completes an associate degree and passes a certification exam.

- ▶ Read more information about the occupational outlook for radiology technologists on the [U.S. Bureau of Labor Statistics](#) webpage.

DIAGNOSTIC TESTING

Cardiac Catheterization and Angiogram

Cardiac catheterization (kär'dē-āk kăth-ě-těr-ĭ-ZĀ-shŏn) is a valuable diagnostic procedure in the evaluation and management of cardiovascular disorders. Cardiac catheterization, performed in association with a coronary angiogram, is a diagnostic procedure used to visualize the coronary arteries, heart chambers, and great vessels. It involves the insertion of a thin, flexible tube (catheter) into the blood vessels, usually through the femoral or radial artery, to access the inside of the heart and its surrounding structures.

During a **coronary angiogram** (KOR-ŏ-nā-rē AN-jee-ō-gram), dye is injected into the blood vessels of the heart, and then a series of X-ray images (angiograms) are taken to view the coronary arteries. If a blockage is discovered, an angioplasty can be performed. Read more about angioplasty under the “Procedures” subsection later in this section.

See Figure 9.21³ for an image of a cardiac catheterization procedure showing the image of the patient's coronary arteries and heart chambers displayed on the monitor during the angiogram.

3. [“A cardiac catheterization procedure in the Naval Medical Center San Diego hospital’s cardiac catheterization laboratory.jpg”](#) by Navy Medicine is licensed in the [Public Domain](#).



Figure 9.21 Angiogram and Cardiac Catheterization

Cardiac Stress Test

A **cardiac stress test** (kär'-dē-āk strēs tĕst), also known as an exercise stress test or treadmill test, is a diagnostic procedure used to evaluate the performance and function of the heart during physical activity. It helps identify potential heart problems, such as coronary artery disease (CAD), arrhythmias, and heart valve issues. During a cardiac stress test procedure, a patient is asked to walk on a treadmill or pedal a stationary bicycle to evaluate the heart's function during strenuous activity. In patient circumstances where walking on a treadmill is not appropriate, medication is administered intravenously to mimic the stress on the heart induced by exercise, referred to as a chemical stress test. See Figure 9.22⁴ for an image of a cardiac stress test.

4. [“a-cardiologist-examining-a-patient-undergoing-cardiac-stress-test-8460228”](#) by [Los Muertos Crew](#) via [Pexels](#) is licensed under [CC0](#).



Figure 9.22 Cardiac Stress Testing

Electrocardiogram

An **electrocardiogram** (ē-lĕk-trō-KĀR-dē-ō-grăġm) (**EKG** or **ECG**) is a diagnostic test that records the electrical activity of the heart. It is performed to diagnose a myocardial infarction (MI) or cardiac rhythm abnormalities. See Figure 9.23⁵ for an image of a patient undergoing an ECG.

5. “[ambulance-emergency-medic-health-3592155](#)” by [OsloMetX](#) via [pixabay](#) is licensed under [CC0](#)

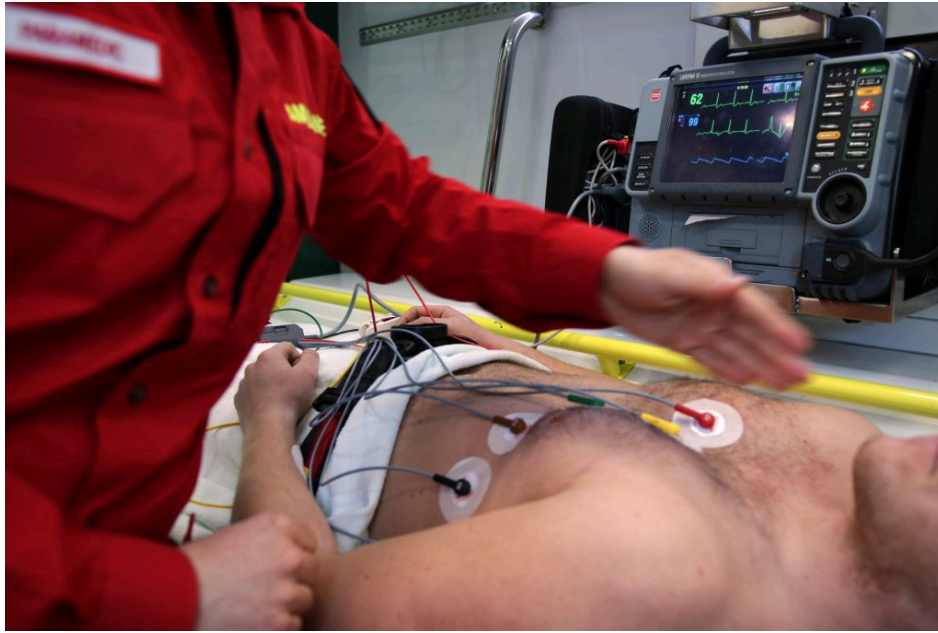


Figure 9.23 ECG Test

During an ECG, surface electrodes are placed on specific anatomical sites on the body to record electrical activity. An example of a 12-lead ECG is presented in Figure 9.24.⁶

6. “12_lead_ECG.jpg” by [Peterhcharlton](#) is licensed under [CC BY 4.0](#)

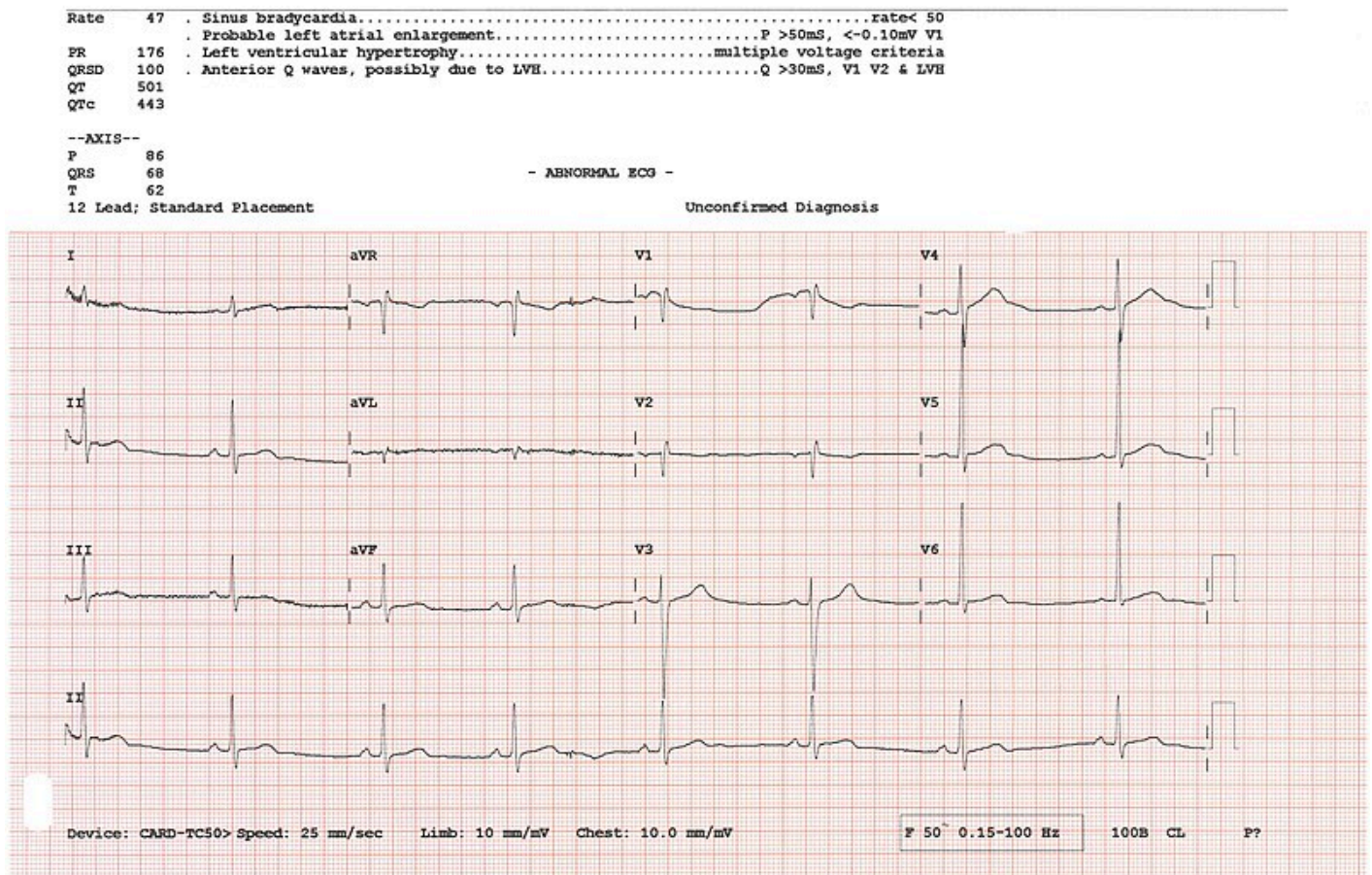


Figure 9.24 ECG Reading

Echocardiogram

An **echocardiogram** (ek-ō-KAR-dē-ō-gram) (**ECHO**) is a noninvasive diagnostic test that uses sound waves (ultrasound) to create real-time images of the heart's structure and function. A trained sonographer or cardiologist applies a gel and a transducer to the patient's chest. The transducer is moved to different areas of the chest to obtain various views of the heart, including the heart chambers, valves, walls, and blood flow patterns. Doppler ultrasound is also used during echocardiography to determine the speed and direction of blood flow through the valves and chambers of the heart. An

echocardiogram is often used to diagnose heart failure and valve disorders impacting the flow of blood through and out of the heart.⁷

A **transesophageal echocardiogram** (trăn-sē-sōf-ă-JĒ-ăl ek-ō-KAR-dē-ō-gram) (**TEE**) uses an ultrasound probe placed in the patient's esophagus to provide a more direct view of heart structures.

Holter Monitor

A **Holter monitor** (HOL-těr MON-ĭ-těr) is a portable device that continuously records a patient's heart rhythm and electrical activity over an extended period, typically 24 to 48 hours. See Figure 9.25⁸ for an illustration of a Holter monitor. Its primary purpose is to detect and document irregularities in the heart's electrical patterns, such as arrhythmias, which may not be captured during brief in-office ECGs. Additionally, patients may activate a trigger on a Holter device to denote the occurrence of cardiac symptoms, such as increased shortness of breath, fatigue, or dizziness. A cardiologist reviews ECG tracings to identify arrhythmias.

7. Johns Hopkins Medicine. (n.d.). *Echocardiogram*.

<https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/echocardiogram>

8. "Holter_Monitor.png" by BruceBlaus is licensed under [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

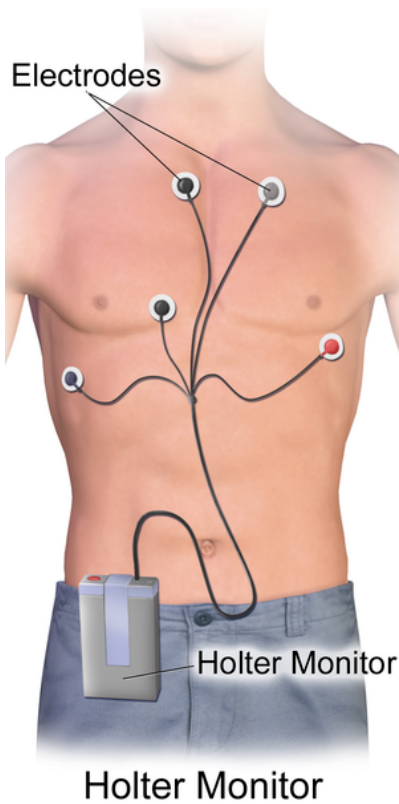


Figure 9.25 Holter Monitor

SPECT Scan

A **single-photon emission computerized tomography scan** (sĭng'-gŭl fō'-tŏn ē-mĭsh'-ŭn kŏm-pyŭ'-tə-rĭzd tŏ-mŏg'-rə-fē skăn) (**SPECT**) analyzes the function of the body's organs, tissues, and bones. For example, a SPECT scan can show how well blood is flowing in the coronary arteries or arteries in the brain. It can also show how completely the heart chambers empty during contractions. A SPECT scan is a type of nuclear imaging test, which means it uses a radioactive substance and a special camera to create 3D pictures. A radioactive substance is administered via **intravenous** (ĭn-tră-VĒ-nŭs) (**IV**) infusion (i.e., into a vein). The SPECT machine is a large circular device containing a camera that detects the radioactive tracer the body absorbs. During the scan, the patient lies on a table while the SPECT machine rotates around them and takes images of their internal organs and other structures.

The pictures are sent to a computer that uses the information to create 3D images of the body.⁹

PROCEDURES

Cardiac Ablation

Cardiac ablation (kär'dē-āk ă-BLĀ-shŏn) uses heat or cold energy to create tiny scars in the heart to block irregular electrical signals and restore a typical heartbeat. This procedure is used to correct various types of arrhythmias. Cardiac ablation is most often done using thin, flexible tubes called catheters inserted through veins or arteries but can also be performed during cardiac surgery.¹⁰

Angioplasty

During a cardiac catheterization, if a blockage is found, an **angioplasty** (AN-jee-ō-plas-tē) may be performed, also referred to as a **percutaneous transluminal coronary angioplasty** (pěr-kyū-TĀ-nē-ŭs trāns-LOO-mĭ-nāl KOR-ŏ-nā-rē AN-jee-ō-plas-tē) (**PTCA**). During an angioplasty, a catheter with a balloon at the tip is inserted into the narrowed coronary artery. The balloon is inflated to widen the artery and improve blood flow. A small mesh device, known as a stent, is often inserted to help keep the coronary artery open after

9. Mayo Clinic. (2022, July 27). *SPECT scan*. <https://www.mayoclinic.org/tests-procedures/spect-scan/about/pac-20384925>

10. Mayo Clinic. (2022, February 22). *Cardiac ablation*. <https://www.mayoclinic.org/tests-procedures/cardiac-ablation/about/pac-20384993>

the procedure is completed. See Figure 9.26¹¹ for an illustration of an angioplasty with stent placement.

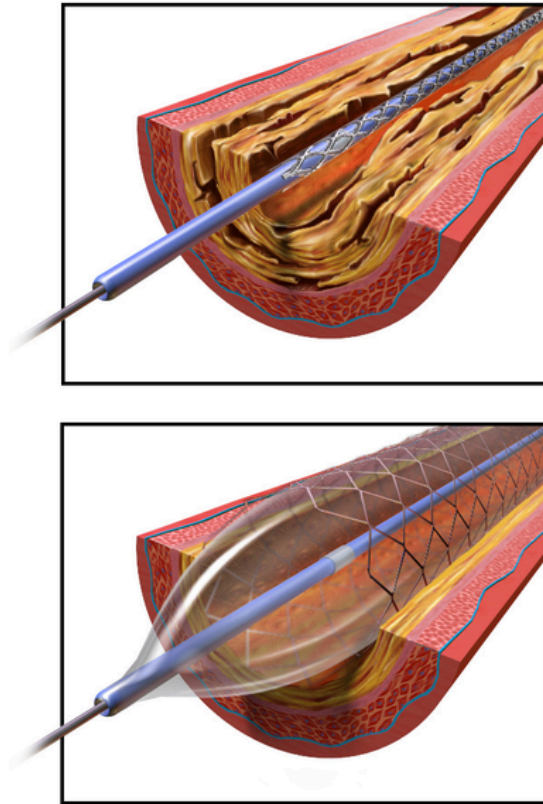


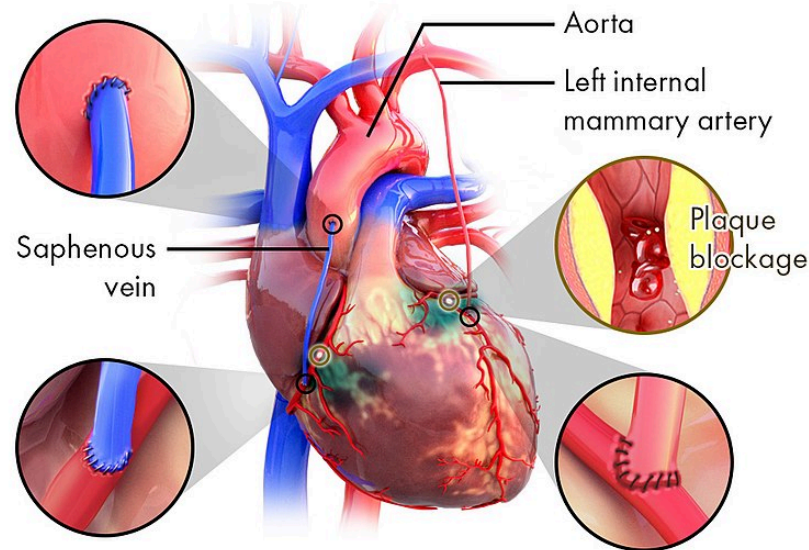
Figure 9.26 Angioplasty with Stent Placement

Coronary Artery Bypass Surgery

Coronary artery bypass (KOR-ō-nā-rē AR-tēr-ē bī-pās) surgery, also called **coronary artery bypass graft** (KOR-ō-nā-rē AR-tēr-ē bī-pās graft) (**CABG**), creates a new path for blood to flow around a blocked or partially blocked coronary artery. The surgery involves taking a healthy blood vessel, often from the chest or leg area, and connecting it underneath the blocked artery to

11. “[Angioplasty - Balloon Inflated with Stent.png](#)” by [BruceBlaus](#) is licensed under [CC BY-SA 4.0](#)

improve blood flow to heart muscle. During surgery, a heart-lung machine may be used to artificially keep oxygenated blood flowing through the patient's body. CABG doesn't cure the heart disease, but it can reduce symptoms and may reduce the risk of heart disease-related death.¹² See Figure 9.27¹³ for an illustration of a CABG.



CORONARY ARTERY BYPASS SURGERY

Figure 9.27 Coronary Artery Bypass Surgery

Heart Transplant

A **heart transplant** (härt träs'-plänt) replaces a patient's failing heart with a donor heart. The failing heart may be a result of end-stage heart failure,

¹². Mayo Clinic. (2022, December 3). *Coronary artery bypass surgery*.
<https://www.mayoclinic.org/tests-procedures/coronary-bypass-surgery/about/pac-20384589>

¹³. "Coronary Artery Bypass Surgery.jpg" by BruceBlaus is licensed under CC BY-SA 4.0

arrhythmias, a congenital heart condition, or other severe heart condition. A healthy heart is donated via organ donation from someone who died. During the transplant procedure, the surgeon removes the patient's failing heart and then connects the donor heart by sewing together the recipient's and donor vena cavae, aorta, pulmonary artery, and left atrium. In patients with congenital heart disease, the surgeon might also transplant the lungs with the heart. For the rest of the patient's life, they are prescribed immunosuppressive and other medications to prevent their body from rejecting the donated heart.¹⁴ See Figure 9.28¹⁵ for an illustration of a heart transplant.

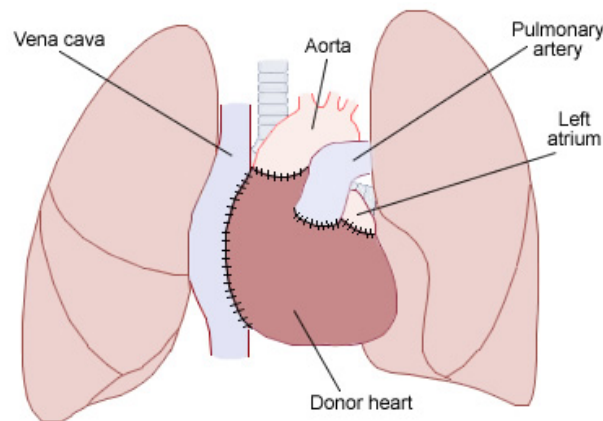


Figure 9.28 Heart Transplant

Pericardiocentesis

Pericardiocentesis (per-ĭ-kar-dē-ō-sen-TĒ-sĭs) is a procedure that involves

14. American Heart Association. (2023, September 19). *Heart transplant*.
<https://www.heart.org/en/health-topics/congenital-heart-defects/care-and-treatment-for-congenital-heart-defects/heart-transplant>
15. “Heart_transplant.jpg” by D Dinneen~commonswiki is licensed under [CC BY-SA 3.0](#)

draining fluid from the pericardial sac around the heart. It involves the cardiologist inserting a needle into the patient's chest until the tip of the needle is inside the pericardium and then draining fluid or placing a drain that can remove fluid slowly over time. Before inserting the needle, the physician and the imaging technician use ultrasound guidance via an echocardiogram to help insert the needle at the specific point needed and prevent injury to the heart.¹⁶ See Figure 9.29¹⁷ for an illustration of pericardiocentesis.

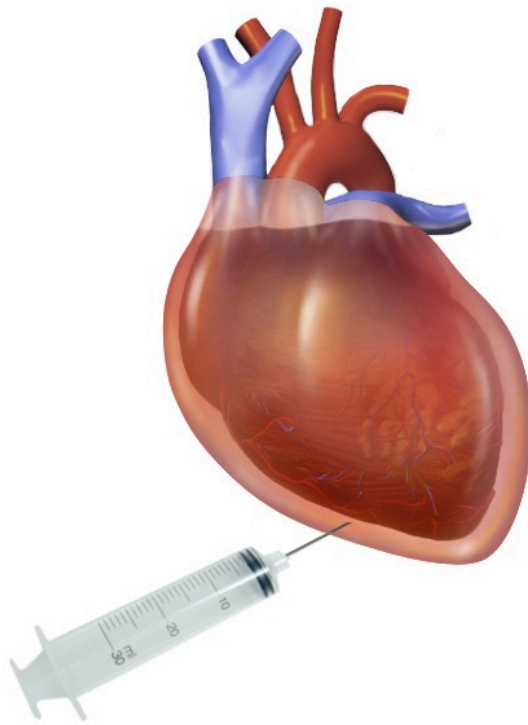


Figure 9.29 Pericardiocentesis

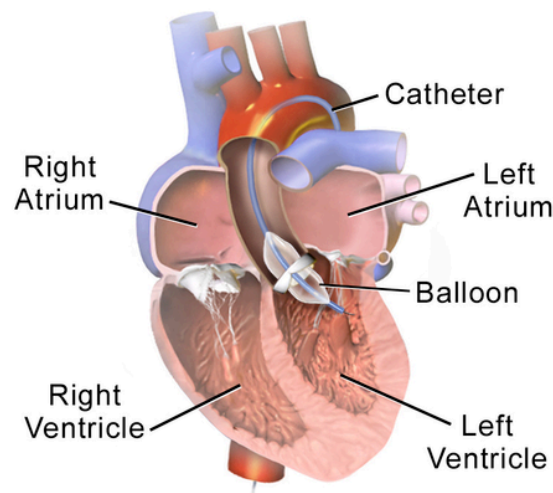
¹⁶. Cleveland Clinic. (2022, February 26). *Pericardiocentesis*.

<https://my.clevelandclinic.org/health/treatments/22613-pericardiocentesis>

¹⁷. “[Pericardiocentesis.jpg](#)” by [Npatchett](#) is licensed under [CC BY-SA 4.0](#)

Valvuloplasty

A **valvuloplasty** (val-VŪ-lō-plas-tē) is a procedure performed by a cardiovascular surgeon to repair a heart valve that has a narrowed opening, referred to as stenosis. Valvuloplasty is performed during a cardiac catheterization. Similar to an angioplasty, a soft, thin tube with a balloon at the tip is inserted into a blood vessel, usually in the groin. The catheter is carefully guided to the narrowed valve in the heart. Once in position, the balloon is inflated to widen the valve, improving blood flow. The balloon is then deflated, and the catheter with balloon is removed.¹⁸ See Figure 9.30¹⁹ for an illustration of a valvuloplasty on the aortic valve.



Balloon Valvuloplasty for Aortic Stenosis

Figure 9.30 Valvuloplasty

¹⁸. Mayo Clinic. (2022, March 18). *Valvuloplasty*. <https://www.mayoclinic.org/tests-procedures/valvuloplasty/pyc-20384961>

¹⁹. “*Valvuloplasty_Aortic.png*” by [BruceBlaus](#) is licensed under [CC BY-SA 4.0](#)

Valve Replacement

If a malfunctioning heart valve can't be repaired, the valve may be surgically replaced, referred to as a **valve replacement** (vălv rē-plās'-měnt). The cardiovascular surgeon removes the heart valve and replaces it with a mechanical valve, or a valve made from cow, pig, or human heart tissue (called a biological valve). Biological valves often need to be replaced because they break down over time. Mechanical valves are more durable but require the patient to take blood-thinning medications for the rest of their life to prevent blood clots.²⁰ See Figure 9.31²¹ for an illustration of valve replacement with a mechanical valve.

20. Mayo Clinic. (2022, December 14). *Heart valve surgery*.

<https://www.mayoclinic.org/tests-procedures/heart-valve-surgery/about/pac-20384901>

21. "Blausen_0056_ArtificialHeartValve.png" by [BruceBlais](#) is licensed under [CC BY 3.0](#)

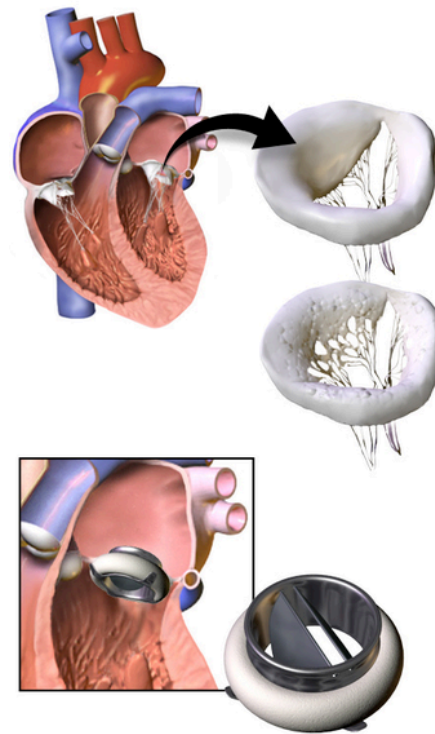


Figure 9.31 Valve Replacement With a Mechanical Valve

9.8 Cardiovascular Learning Activities

Interactive Learning Activity: Label the parts of the heart using this drag and drop activity.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=691#h5p-148>

Interactive Learning Activity: Study cardiovascular system medical terms discussed in this chapter using these flashcards.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=691#h5p-183>

Interactive Learning Activity: Test your knowledge of the cardiovascular system by completing this activity.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=691#h5p-153>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=691#h5p-151>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=691#h5p-58>



Interactive Learning Activity: Practice identifying and defining word parts for terms discussed in this chapter.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=691#h5p-200>

- ▶ You can also print this as a [Chapter 9 Practice Worksheet](#) and check your answers with this [Answer Key PDF](#).

9.9 Glossary

Acute coronary syndrome (ə-KYŪT KOR-ŏ-nā-rē SĪN-drōm) (ACS): A term used to describe a range of conditions associated with sudden, reduced blood flow to the heart, including myocardial infarction. ([Chapter 9.6](#))

Aneurysm (AN-yŭ-rizm): A dilation or bulging of a blood vessel caused by weakened vessel walls, potentially leading to rupture. ([Chapter 9.6](#))

Angina (an-JĪ-nă): Chest pain caused by reduced blood flow to the heart muscle, often associated with coronary artery disease. ([Chapter 9.6](#))

Angioplasty (AN-jee-ō-plas-tē): A procedure to restore blood flow through the artery by inserting and inflating a tiny balloon; it may also involve placing a stent to keep the artery open. ([Chapter 9.6](#), [Chapter 9.7](#))

Aortic insufficiency (ā-OR-tĭk in-sŭ-FISH-ĕn-sē): A condition where the aortic valve does not close tightly, allowing blood to flow backward into the heart. ([Chapter 9.6](#))

Apex (Ā-peks): The inferior tip of the heart, located just to the left of the sternum between the junction of the fourth and fifth ribs. ([Chapter 9.4](#))

Arrhythmia (ā-RITH-mē-ă): An abnormal heart rhythm resulting from variations in the normal sequence of electrical impulses. ([Chapter 9.6](#))

Arterioles (ar-TĒR-ē-ōlz): Small branches of an artery leading into capillaries. ([Chapter 9.4](#))

Artery (AR-tĕr-ē): A blood vessel that carries blood away from the heart, branching into smaller vessels called arterioles. ([Chapter 9.4](#))

Atherosclerosis (ă-thĕr-ō-sklĕ-RO-sĭs): Hardening and narrowing of arteries due to the buildup of cholesterol and other fats, known as plaque, within the lining of the arteries. ([Chapter 9.6](#))

Atrial fibrillation (Ā-trē-ăl fĭb-rĭ-LĀ-shŏn) (A Fib): A common type of arrhythmia characterized by rapid and irregular beating of the atrial chambers of the heart. ([Chapter 9.6](#))

Atrial septal defect (Ā-trē-ăl SĔP-tăl dĭ-FĚKT): A congenital heart defect characterized by an opening in the septum between the left and right atria. ([Chapter 9.6](#))

Auscultation (os-kŭl-TĀ-shŏn): The process of listening to the internal sounds of the body, typically with a stethoscope, used in diagnosing conditions of the heart and lungs. ([Chapter 9.4](#))

Automated external defibrillator (aw-tŏ-māt'-ĕd ěks-tĕr'năl dĕ-fĭb'-rĭ-lā-tŏr) (AED): A portable device used in emergencies to treat sudden cardiac arrest by administering an electric shock. ([Chapter 9.6](#))

Blood pressure (BLŮD PRESĤ-ŭr) (BP): The force of blood against the walls of arteries, typically measured in millimeters of mercury (mm Hg). ([Chapter 9.5](#))

Bradycardia (brad-ĕ-KAR-dĕ-ă): A heart rate that is slower than normal, less than 60 bpm in adults, which can be normal or indicative of an underlying condition. ([Chapter 9.5](#), [Chapter 9.6](#))

Bruit (BRWĒ): An abnormal sound or murmur heard during auscultation of an artery, often due to atherosclerosis or narrowing. ([Chapter 9.6](#))

Capillary (KAP-ĭ-lār-ĕ): A microscopic channel that supplies blood to the tissue cells and connects arterioles with venules. ([Chapter 9.4](#))

Cardiac ablation (kār'dĕ-ăk ă-BLĀ-shŏn): A procedure used to destroy problematic heart tissue that causes irregular heartbeats. ([Chapter 9.7](#))

Cardiac arrest (KAR-dĕ-ăk ăr-REST): A sudden cessation of heart function, often due to arrhythmias. ([Chapter 9.6](#))

Cardiac catheterization (kār'dĕ-ăk kăth-ĕ-tĕr-ĭ-ZĀ-shŏn): A diagnostic procedure in which a catheter is inserted into a large blood vessel that leads to the heart. ([Chapter 9.7](#))

Cardiac output (KAR-dĕ-ăk OUT-put): The amount of blood pumped by the heart per minute. ([Chapter 9.5](#))

Cardiac stress test (kār'-dĕ-ăk strĕs tĕst): A test that measures the heart's ability to respond to external stress in a controlled clinical environment. ([Chapter 9.7](#))

Cardiologist (kar-dĕ-OL-ŏ-jĭst): A physician who specializes in the diagnosis and treatment of heart diseases and conditions. ([Chapter 9.7](#))

Cardiology (kār-dĕ-ŏl'ŏ-jĕ): The study of the heart and its functions in health and disease. ([Chapter 9.7](#))

Cardiomyopathy (kar-dĕ-ŏ-my-OP-ă-thĕ): A group of diseases that affect the heart muscle, leading to impaired cardiac function. ([Chapter 9.6](#))

Cerebrovascular disease (sěr'-brō-VAS-kyū-lār dī-ZĒZ) (CVD): A group of conditions affecting the blood vessels and blood supply to the brain, including stroke. ([Chapter 9.6](#))

Coarctation (kō-ark-TĀ-shŏn): A congenital condition characterized by the narrowing of the aorta, leading to reduced blood flow. ([Chapter 9.6](#))

Congenital (kŏn-JĒN-ĭ-tāl): A conditions present at birth, which can include a variety of heart disorders. ([Chapter 9.6](#))

Coronary angiogram (KOR-ŏ-nā-rē AN-jee-ō-gram): A procedure that uses X-ray imaging to see the heart's blood vessels. ([Chapter 9.7](#))

Coronary artery bypass (KOR-ŏ-nā-rē AR-těr-ē bī-pās): A type of surgery that improves blood flow to the heart. ([Chapter 9.7](#))

Coronary artery bypass graft surgery (KOR-ŏ-nā-rē AR-těr-ē bī-pās graft Sŭr-jěr-ē) (CABG): A surgical procedure used in coronary artery disease where blood flow is rerouted around a blocked artery. ([Chapter 9.6](#))

Coronary artery disease (KOR-ŏ-nā-rē AR-těr-ē dī-ZĒZ) (CAD): A condition where plaque buildup occurs in the coronary arteries, leading to reduced blood flow to the heart muscle. ([Chapter 9.6](#))

Deep vein thrombosis (dēp vān THROM-bō-sīs) (DVT): A blood clot in a deep vein, usually in the legs, which can be life-threatening if it dislodges and travels to the lungs. ([Chapter 9.6](#))

Defibrillator (dē-FIB-rī-lā-tŏr): A device used to deliver an electric shock to the heart to restore a normal rhythm. ([Chapter 9.6](#))

Diaphoresis (dī-ă-fŏ-RĒ-sīs): Excessive sweating, commonly associated with some cardiovascular events like a myocardial infarction. ([Chapter 9.6](#))

Diastole (dī-AS-tŏ-lē): The phase of the cardiac cycle when the heart muscles relax and the chambers fill with blood. ([Chapter 9.5](#))

Echocardiogram (ek-ō-KAR-dē-ō-gram): A sonographic imaging test that uses sound waves to produce images of the heart. ([Chapter 9.7](#))

Edema (e-DĒ-mă): Swelling caused by excess fluid trapped in the body's tissues, often occurring in the legs and ankles. ([Chapter 9.6](#))

Electrocardiogram (ē-lĕk-trō-KĀR-dē-ō-grām) (EKG or ECG): A test that measures the electrical activity of the heartbeat to show abnormalities in the heart rhythm and structure. ([Chapter 9.6](#), [Chapter 9.7](#))

Endovenous laser ablation (ĕn'-dō-vē'-nŭs lā'-zŏr ăb-lā'-shŭn): A minimally

invasive procedure used to treat varicose veins using laser energy. ([Chapter 9.6](#))

Heart block (härt blök): A condition where the electrical signals in the heart are partially or completely blocked. ([Chapter 9.6](#))

Heart failure (HART FĀL-yŭr) (HF): A condition where the heart can't pump blood efficiently to meet the body's needs, leading to symptoms like shortness of breath and edema. ([Chapter 9.6](#))

Heart rate (HART RĀT) (HR): The number of heartbeats per minute, with normal resting HR for an adult being 60–100 bpm. ([Chapter 9.5](#))

Heart transplant (härt trāns'-plānt): A surgical procedure to replace a diseased and nonfunctioning heart with a healthy heart from a donor. ([Chapter 9.7](#))

Holter monitor (HOL-tĕr MON-ĭ-tŏr): A portable device worn to continuously monitor the heart's rhythms and electrical activity. ([Chapter 9.7](#))

Hypertension (hī-pĕr-TEN-shŏn) (HTN): Elevated blood pressure, typically defined as greater than 120/80 mm Hg in adults. ([Chapter 9.5](#), [Chapter 9.6](#))

Hypotension (hī-pō-TEN-shŏn): Abnormally low blood pressure. ([Chapter 9.5](#))

Implantable cardioverter defibrillator (ĭm-plānt'-ă-bŭl kār'dē-ō-vŭr'-tŏr dē-fĭb'-rĭ-lā-tŏr) (ICD): A device implanted in the chest to monitor heart rhythms and provide appropriate electrical therapy to correct arrhythmias. ([Chapter 9.6](#))

Inferior vena cava (VĒ-nă KĀ-vă): A large vein that carries deoxygenated blood from the lower body to the heart. ([Chapter 9.4](#))

Intravenous (ĭn-tră-VĒ-nŭs) (IV): Pertaining to within a vein, often referring to the administration of medications or fluids. ([Chapter 9.4](#), [Chapter 9.7](#))

Ischemia (ĭs-KEE-mē-ă): A condition where blood flow and oxygen are restricted or reduced in a part of the body, often due to narrowed or blocked arteries. ([Chapter 9.6](#))

Murmur (MUR-mŭr): A sound heard during heartbeat that may be a normal or an abnormal finding, often caused by turbulent blood flow. ([Chapter 9.6](#))

Myocardial infarction (mī-ŏ-kar'dē-ăl in-FARK-shŏn) (MI): Commonly known as a heart attack, caused by blockage of blood flow to the heart tissue resulting in death of cardiac muscle cells. ([Chapter 9.4](#), [Chapter 9.6](#))

Normal sinus rhythm (Sĭ-nŭs RITH-ŭm) (NSR): The regular, natural rhythm of the heart, characterized by coordinated electrical activity. ([Chapter 9.6](#))

Occlude (ŏ-KLOOD): To block or close a blood vessel or passage. ([Chapter 9.5](#))

Palpitations (pal-pĭ-TĀ-shŏnz): A sensation where an individual feels that their heart is racing, pounding, fluttering, or skipping a beat. ([Chapter 9.6](#))

Patent ductus arteriosus (PĀ-tĕnt DŮK-tŭs ār-tēr'-ē-ō-sŭs): A congenital heart defect where the ductus arteriosus fails to close after birth, allowing blood to flow between the aorta and pulmonary artery. ([Chapter 9.6](#))

Patent foramen ovale (PĀ-tĕnt fŏ-rā'-mĕn ō-vā'-lē): A congenital heart defect where a hole in the septum between the heart's atria does not close at birth. ([Chapter 9.6](#))

Percutaneous transluminal coronary angioplasty (pĕr-kyū-TĀ-nē-ŭs trāns-LOO-mĭ-nāl KOR-ŏ-nā-rē AN-jee-ō-plas-tē) (PTCA): A procedure to open up blocked coronary arteries, allowing blood to circulate unobstructed to the heart muscle. ([Chapter 9.7](#))

Perfusion (pĕr-FŪ-zhŏn): The passage of blood through the blood vessels to supply organs and tissues. ([Chapter 9.5](#))

Pericardiocentesis (per-ĭ-kar-dē-ō-sen-TĒ-sĭs): A procedure to remove fluid from the sac surrounding the heart. ([Chapter 9.7](#))

Peripheral artery disease (pĕr-IF-ēr-āl AR-tēr-ē dĭ-ZĒZ) (PAD): A condition characterized by narrowed arteries in the peripheral parts of the body, often leading to pain and muscle cramps. ([Chapter 9.6](#))

Phlebectomy (flĕ-BĚK-tŏ-mē): A surgical procedure to remove varicose veins. ([Chapter 9.6](#))

Pulse (PULS): The rhythmic expansion and recoil of arteries resulting from heart contraction; can be felt over arteries close to the body's surface. ([Chapter 9.5](#))

Regurgitation (rē-gŭr'-jĭ-tā'-shŭn): The backward flow of blood through a heart valve, indicating that the valve isn't closing properly. ([Chapter 9.6](#))

Sclerotherapy (sklĕr-ō-THER-ă-pē): A procedure used to treat varicose veins and spider veins by injecting a solution directly into the vein. ([Chapter 9.6](#))

Single-photon emission computerized tomography scan (sĭng'-gŭl fŏ'-tŏn ē-mĭsh'-ŭn kŏm-pyū'-tə-rĭzd tŏ-mŏg'-rə-fē skăn) (SPECT): A type of nuclear

medicine scan that provides detailed images of internal organs, including the heart. ([Chapter 9.7](#))

Sphygmomanometer (sfĭg-mō-măn-ŎM-ět-ěr): An instrument used to measure blood pressure, commonly referred to as a blood pressure cuff. ([Chapter 9.5](#), [Chapter 9.6](#))

Stenosis (stě-NŌ-sĭs): The abnormal narrowing of a passage in the body, such as a blood vessel or a heart valve. ([Chapter 9.6](#))

Stethoscope (STETH-ŏ-skōp): An instrument used to listen to heart and lung sounds, referred to as auscultation. ([Chapter 9.4](#))

Superior vena cava (VĒ-nă KĀ-vă): A large vein that carries deoxygenated blood from the upper body to the heart. ([Chapter 9.4](#))

Syncope (SING-kŏ-pē): A temporary loss of consciousness or fainting, often related to insufficient blood flow to the brain. ([Chapter 9.6](#))

Systole (SIS-tŏ-lē): The phase of the cardiac cycle in which the ventricles contract and eject blood. ([Chapter 9.5](#))

Tachycardia (tak-ē-KAR-dē-ă): A condition where the heart rate is faster than normal, over 100 bpm in adults. ([Chapter 9.5](#), [Chapter 9.6](#))

Tetralogy of Fallot (tět'ră-lŏ-jē ōf fă-LŌ): A serious congenital heart condition that includes four heart defects, leading to mixed blood flow and reduced oxygenation. ([Chapter 9.6](#))

Thrombolysis (thrŏm-BOL-ĭ-sĭs): A treatment to dissolve dangerous clots in blood vessels, improve blood flow, and prevent damage to tissues and organs. ([Chapter 9.6](#))

Transesophageal echocardiogram (trăn-sē-sŏf-ă-JĒ-ăl ek-ŏ-KAR-dē-ŏ-gram): An imaging test that uses sound waves to create detailed pictures of the heart via the esophagus. ([Chapter 9.7](#))

Valve replacement (vălv rē-plăs'-mĕnt): A surgical procedure to replace one or more of the heart's valves with either an artificial or a biological valve. ([Chapter 9.7](#))

Valvular heart disease (văl'-vyū-lăř hărt dĭ-zēz'): A condition in which one or more of the heart's valves do not function properly, affecting blood flow within the heart. ([Chapter 9.6](#))

Valvuloplasty (val-VŪ-lŏ-plas-tē): A procedure to repair a narrowed heart valve. ([Chapter 9.7](#))

Varicose veins (VAR-i-kōs VĀNZ): Enlarged, swollen, and twisting veins, often appearing blue or dark purple as a result of faulty valves in the veins. ([Chapter 9.6](#))

Veins (VĀNZ): Blood vessels that return blood to the heart, including the inferior vena cava and superior vena cava. ([Chapter 9.4](#))

Ventricular fibrillation (ven-TRĪK-yū-lăř fĭb-rĭ-LĀ-shŏn) (V Fib): A life-threatening heart rhythm where the ventricles quiver, instead of contracting, resulting in no cardiac output. ([Chapter 9.6](#))

Ventricular septal defect (ven-TRĪK-yū-lăř SĚP-tăł dĭ-FĚKT): A congenital heart defect where an opening exists in the septum between the left and right ventricles. ([Chapter 9.6](#))

Ventricular tachycardia (ven-TRĪK-yū-lăř tak-ĭ-KAR-dē-ă) (V Tach): A life-threatening rapid heart rhythm that originates from the ventricles. ([Chapter 9.6](#))

Venules (VEN-yoolz): Small veins that receive blood from capillaries and transport it to larger veins. ([Chapter 9.4](#))

PART X

CHAPTER 10 BLOOD TERMINOLOGY

10.1 Blood Introduction

Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the blood
- Identify meanings of key word components of the blood
- Categorize diagnostic, therapeutic, procedural, or anatomic terms related to the blood
- Use terms related to the blood
- Use terms related to the diseases and disorders of the blood

Introduction

Hematology (hēm-ă-TŌL-ō-jē) is the study of blood, blood components, and blood-forming organs and their impact on an individual's health and well-being. The hematology system consists of the blood, the bone marrow, and accessory organs, including the spleen and the liver. Blood components consist of erythrocytes (red blood cells), leukocytes (white blood cells), thrombocytes (platelets), and clotting factors.

In the “Cardiovascular System Terminology” chapter, we learned how the heart serves as a pump to transport blood throughout the body via a network of arteries and veins. This chapter will discuss how components in the blood carry oxygen. The chapter will also discuss how the blood components participate in the immune response and how they help stop bleeding by forming a clot when there is an injury. Immune system function will be

further discussed in the “[Lymphatic & Immune Systems Terminology](#)” chapter.

This chapter will review common word components related to the hematology system to assist learners in analyzing, building, and defining medical terms. Other terms, whose definitions cannot be easily built from word components, will be described in context based on the anatomy and physiology of the hematology system and common diseases and disorders. Medical specialists, diagnostic tests, and procedures related to the hematology system will also be discussed.

View the following YouTube video¹ overview about blood:

 [Blood, Part 1 – True Blood: Crash Course Anatomy & Physiology #29](#)

1. CrashCourse. (2015, August 3). *Blood, Part 1 – True blood: Crash Course Anatomy & Physiology #29* [Video]. YouTube. All rights reserved.
<https://youtu.be/HQWlcSp9SIs?si=bCZ164OINAy4ESqc>

10.2 Word Components Related to Blood

This section will describe common word components related to the hematology system. These word components help build definitions for many medical terms. Other common prefixes are described in [Chapter 1.3](#), and common suffixes are described in [Chapter 1.5](#).

PREFIXES RELATED TO THE HEMATOLOGY SYSTEM

- **a-**: Absence of, without
- **endo-**: Within, in
- **epi-**: On, upon, over
- **hyper-**: Above, excessive
- **hypo-**: Below, deficient
- **inter-**: Between
- **pan-**: All, total
- **peri-**: Surrounding, around
- **poly-**: Many, much

WORD ROOTS WITH A COMBINING VOWEL RELATED TO THE HEMATOLOGY SYSTEM

- **chrom/o**: Color
- **coagul/o**: Clotting
- **cyt/o**: Cell
- **eosin/o**: Red, dawn, rosy
- **erythr/o**: Red
- **fibrin/o**: Fibrin
- **hem/o**: Blood
- **hemat/o**: Blood
- **hepat/o**: Liver
- **is/o**: Same, equal
- **isch/o**: Deficiency, blockage
- **leuk/o**: White
- **lymph/o**: Lymph, lymph tissue
- **mon/o**: One, single
- **myel/o**: Bone marrow, spinal cord
- **neutr/o**: Neutral; neither base nor acid
- **phag/o**: Eat, swallow
- **phleb/o**: Vein
- **plasm/o**: Plasma
- **poikil/o**: Varied, irregular
- **therm/o**: Heat
- **thromb/o**: Clot
- **splen/o**: Spleen
- **ven/o**: Vein

SUFFIXES RELATED TO THE HEMATOLOGY

SYSTEM

- **-ac:** Pertaining to
- **-apheresis:** Removal, carrying away
- **-ar:** Pertaining to
- **-blast:** Immature cell, embryonic
- **-centesis:** Surgical puncture to aspirate fluid
- **-cyte:** Cell
- **-cytosis:** Abnormal condition of cells (increase in cells)
- **-ectomy:** Excision, surgical removal
- **-emia:** In the blood
- **-genic:** Producing, originating, causing
- **-globin:** Protein
- **-ia:** Condition of, diseased state, abnormal state
- **-ic:** Pertaining to
- **-ism:** State of
- **-itis:** Inflammation
- **-logist:** Specialist who studies and treats
- **-logy:** Study of
- **-lysis:** Loosening, dissolution, separating
- **-megaly:** Enlarged, enlargement
- **-oid:** Resembling
- **-oma:** Tumor
- **-osis:** Abnormal condition
- **-ous:** Pertaining to
- **-pathy:** Disease
- **-penia:** Abnormal reduction in number
- **-pexy:** Surgical fixation, suspension
- **-phage:** Eat, swallow
- **-plasty:** Surgical repair
- **-poiesis:** Formation
- **-rrhage** or **-rrhagia:** Excessive flow
- **-stasis:** Stop, stopping, controlling

- **-tomy**: Cut into, incision
- **-us**: No meaning

10.3 Examples of Blood Terms Easily Defined By Their Word Components

Here are examples of common medical terms related to the hematology system that can be easily defined by breaking the terms into their word components.

Hematologist

1. Break down the medical term into word components:
Hemat/o/logist
2. Label the word components: **Hemat** = WR; **o** = CV; **logist** = S
3. Define the word components: **Hemat** = blood; **logist** = specialist who studies and treats
4. Create a final definition of the medical term: **A specialist who studies and treats diseases of the blood**

Hemostasis

1. Break down the medical term into word components:
Hem/o/stasis
2. Label the word components: **Hem** = WR; **o** = CV; **stasis** = S

3. Define the word components: **Hem** = blood; **stasis** = stopping
4. Create a final definition of the medical term: **Stopping blood (bleeding)**

Leukocytopenia

1. Break down the medical term into word components:
Leuk/o/cyt/o/penia
2. Label the word components: **Leuk** = WR; **o** = CV; **cyt** = WR; **o** = CV; **penia** = S
3. Define the word components: **Leuk** = white (blood cell); **cyt** = cell; **penia** = abnormal reduction in number
4. Create a final definition of the medical term: **Abnormal reduction of white blood cells**



Interactive Learning Activity: Practice defining and pronouncing terms related to blood by breaking them into word parts.



An interactive HSP element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=4383#h5p-177>

- ▶ You can also print these flashcard activities as a [Chapter 10](#)

▶ [Student Companion Worksheet](#) and check your answers with this [Answer Key](#).

10.4 Anatomy of the Hematology System

The hematology system consists of the blood and the bone marrow that create the cellular elements of the blood, as well as accessory organs, including the spleen and the liver.

BLOOD

Blood is made of formed elements (cells) and plasma. The formed elements include **erythrocytes** (ě-r-ĭ-thrō-sĭtz), **leukocytes** (LOO-kō-sĭtz), and **thrombocytes** (THRŌM-bō-sĭtz), all suspended in a liquid called plasma. In diagnostic reports, erythrocytes are referred to as red blood cells (RBCs), leukocytes are referred to as white blood cells (WBCs), and thrombocytes are referred to as platelets.

When a blood sample is taken from a patient and sent to the laboratory for analysis, the sample is centrifuged to separate the components of blood from one another so they can be measured. As the heaviest elements in blood, red blood cells (RBCs) settle at the very bottom of the tube. RBCs make up about 45% of the volume of the blood, measured in a blood test called hematocrit. **Hematocrit** (hē-MAT-ō-krit) (**HCT**) is the ratio of the volume of red blood cells to the total volume of blood. The normal hematocrit for men is 40 to 54%, and for women it is 36 to 48%.¹

1. Billett, H. H. (1990). Hemoglobin and hematocrit. In Walker, H. K., Hall, W. D., & Hurst, J. W. (Eds), *Clinical Methods: The history, physical, and laboratory*

Above the RBC layer in a centrifuged sample is a layer of white blood cells (WBCs) and platelets, which together make up less than 1% of the sample of whole blood. Above this buffy layer is **plasma** (PLAZ-mă), the liquid part of blood. Plasma is a pale, straw-colored fluid that constitutes 55% of a blood sample. Plasma is mostly water with dissolved proteins, including albumin, immunoglobulins, and clotting factors. It also contains nutrients, electrolytes, and cellular wastes. Plasma suspends RBCs, WBCs, and platelets, enabling them to circulate throughout the body within the cardiovascular system.² See Figure 10.1³ for an illustration of the composition of blood in a blood sample.

examinations (3rd ed., Chapter 151). Butterworths.

<https://www.ncbi.nlm.nih.gov/books/NBK259/>

2. This work is a derivative of *Anatomy & Physiology* by [OpenStax](#) and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/details/books/anatomy-and-physiology-2e>
3. “1913_ABO_Blood_Groups.jpg” by [Alan Sved](#) is licensed under [CC BY-SA 4.0](#).

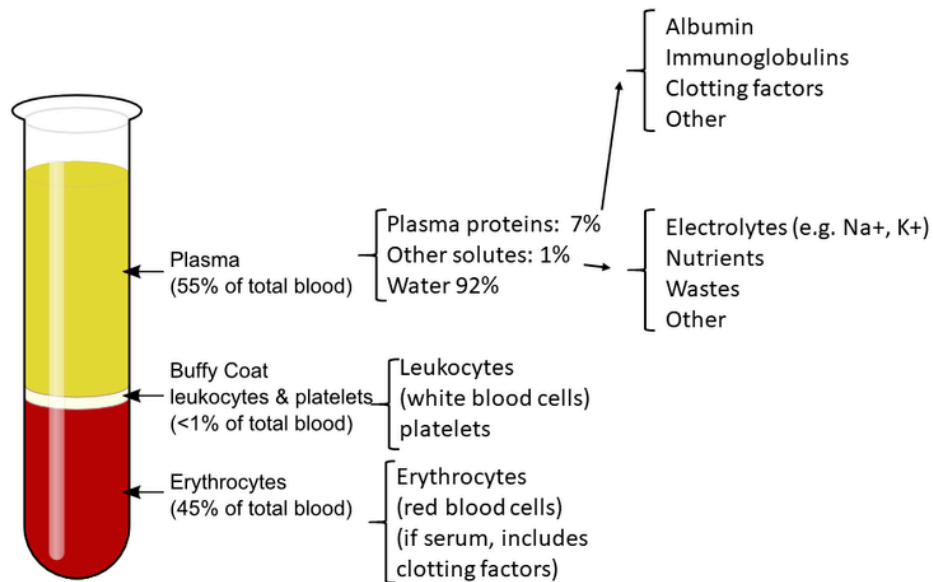


Figure 10.1 Composition of a Blood Sample

Phlebotomy (flĕ-BOT-ŏ-mĕ) refers to the opening or puncture of a vein in order to withdraw a blood sample for analysis. **Hemolysis** (hĕ-MOL-ĭ-sĭs) refers to the breaking down of red blood cells due to the mishandling of blood samples during routine blood collection and transport.

Bone Marrow

Formation of the formed elements of the blood takes place primarily in the red bone marrow. **Bone marrow** (bŏn MĀR-ŏ) is the soft tissue inside bones that produces red blood cells (RBC), white blood cells (WBC), and platelets. Red bone marrow is primarily located in flat bones such as the sternum, skull, and pelvis.⁴

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In the red bone marrow, stem cells are undifferentiated and have the remarkable capacity to become any type of cell. As these stem cells differentiate, they require specific growth factors for specialization. For example, **erythropoietin** (ĕr-ĭ-thrō-poi-Ē-tin) (**EPO**) is a hormone that stimulates the production of erythrocytes (red blood cells) that is produced by the kidneys.⁵ During a stem cell transplant, donated healthy stem cells are provided to a patient and, if successful, take over production of their blood cells in their bone marrow. Read more about stem cell transplants in the [“Medical Specialists, Diagnostic Testing, and Procedures Related to Blood.”](#)

Red Blood Cells

Red blood cells (rĕd blŭd sĕls) (**RBCs**) transport oxygen and carbon dioxide between tissues and the lungs. RBCs are packed with **hemoglobin** (HĒM-ō-glō-bin) (**Hgb**), a protein molecule that carries oxygen. For this reason, deficiency in RBCs results in symptoms related to decreased oxygenation of the body's tissues and organs.⁶ See Figure 10.2⁷ for an illustration of RBCs containing hemoglobin that carries oxygen molecules.

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7. [“Figure_39_04_01.jpg”](#) by CNX OpenStax is licensed under [CC BY 4.0](#)

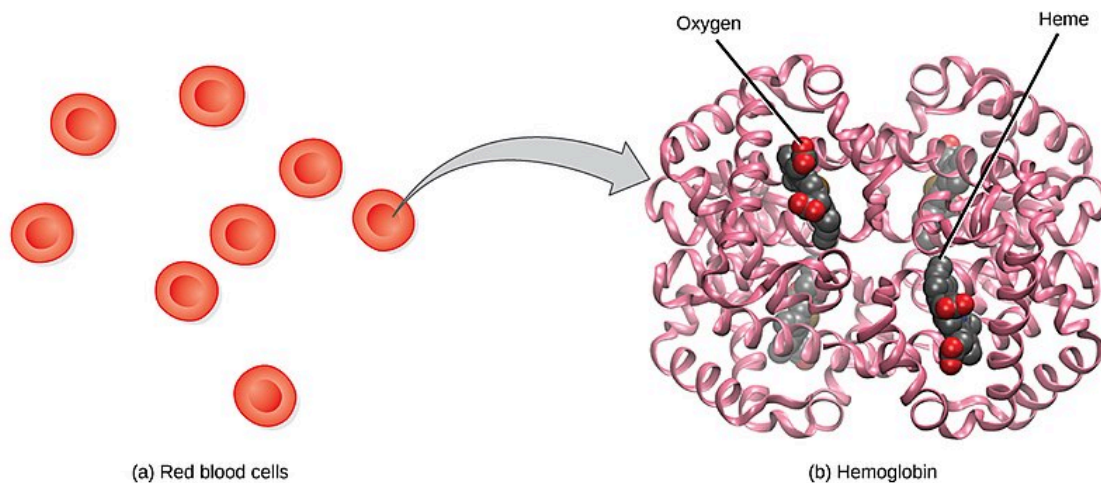


Figure 10.2 Red Blood Cells

Production of RBCs in the red bone marrow occurs at the staggering rate of more than 2 million cells per second. For this production to occur, raw materials, including iron, folic acid, and B12, must be present in adequate amounts. RBCs live only 120 days on average and must be continually replaced.⁸

Old RBCs and hemoglobin are broken down by white blood cells in a process called phagocytosis. When hemoglobin breaks down, a yellow substance called **bilirubin** (bil-ĭ-ROO-bin) is released. If the body cannot adequately metabolize bilirubin, a symptomatic yellow discoloration called jaundice occurs in the skin, mucus membranes, and eyes.⁹

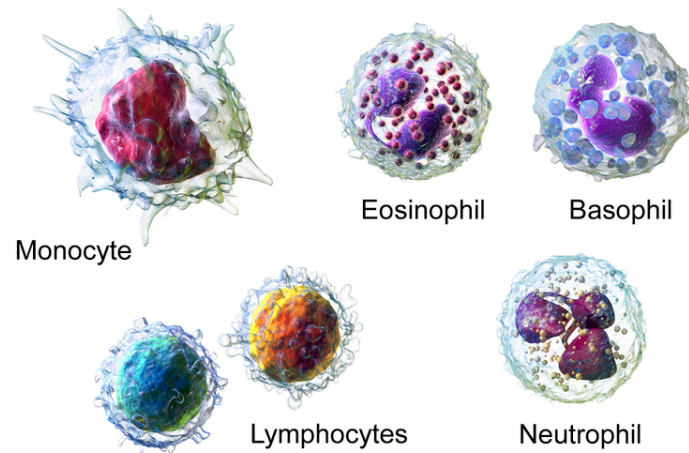
White Blood Cells

White blood cells (wīt blūd sĕls) (**WBCs**), also called leukocytes, provide

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immune functions and defenses against disease. WBCs protect the body against invading microorganisms, as well as its own cells that have mutated DNA, and they also clean up cellular debris. There are five main types of WBCs called **neutrophils** (NŪ-trō-filz), **lymphocytes** (LĪM-fō-sītz), **monocytes** (MON-ō-sītz), **eosinophils** (ē-ō-SIN-ō-filz), and **basophils** (BAS-ō-filz).¹⁰ See Figure 10.3¹¹ for an illustration of these types of WBCs.



White Blood Cells

Figure 10.3 Types of White Blood Cells

Table 10.4 summarizes the main functions of the different types of WBCs.

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11. “[Blausen_0909_WhiteBloodCells.png](#)” by Blausen.com staff (2014). “[Medical gallery of Blausen Medical 2014.](#)” *WikiJournal of Medicine* is licensed under [CC BY 3.0](https://creativecommons.org/licenses/by/3.0/)

Table 10.4. Types of WBCs and Functions¹²

Type of WBC	Percentages in Total WBC Count	Function
Neutrophils	40 -70%	Engulf and destroy bacteria during acute bacterial infections and inflammation.
Lymphocytes	20-45%	Important role in adaptive immunity with the production of antibodies.
Monocytes	2-10%	Transformed into macrophages in acute infections to clear debris and pathogens.
Eosinophils	1-6%	Defend against parasites and cause allergic reactions by releasing histamine and other chemicals.
Basophils	0.5-1%	Release histamine and other inflammatory mediators during an allergic reaction.

Platelets

Platelets (PLĀT-lĭtz), also called thrombocytes, help form a clot when there is bleeding. Platelets serve a critical function in **hemostasis** (hē-mō-STĀ-sĭs), the process by which the body seals a broken blood vessel and prevents further blood loss. During hemostasis, platelets become activated and create a

¹². American Society of Hematology. (n.d.). *Blood basics*.

<https://www.hematology.org/education/patients/blood-basics>

platelet plug.¹³ See Figure 10.4¹⁴ for an illustration of platelets and activated platelets. Hemostasis and blood clot formation are further discussed in the [“Physiology of the Hematology System.”](#)

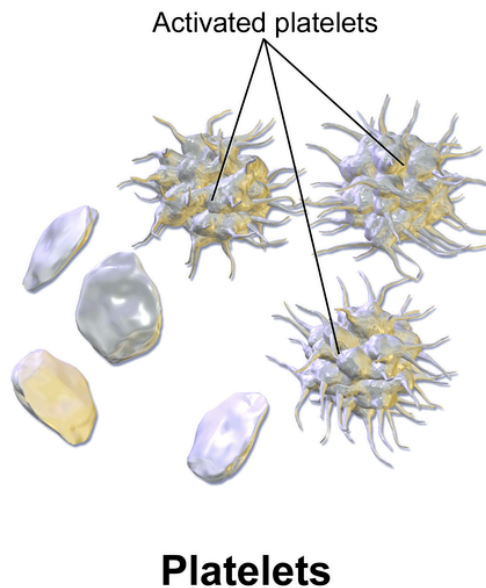


Figure 10.4 Platelets and Activated Platelets

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¹⁴. “[Blausen_0740_Platelets.png](#)” by Blausen.com staff (2014). “[Medical gallery of Blausen Medical 2014.](#)” *WikiJournal of Medicine* is licensed under [CC BY 3.0](#)

ACCESSORY ORGANS

The spleen and liver are accessory organs for blood production and clotting regulation.

Spleen

The **spleen** (splēn) produces and stores WBCs, filters and stores RBCs and platelets, and plays a role in the filtration and destruction of old RBCs. There are two types of tissue in the spleen: white pulp and red pulp. White pulp, the lymphatic tissue of the spleen, produces some WBCs, although most WBCs are produced in the red bone marrow. Red pulp serves as a storage site for RBCs and platelets. The spleen also filters antigens and plays a role in the destruction of old RBCs and the breakdown of hemoglobin.¹⁵ See Figure 10.5¹⁶ for an illustration of the location of the spleen.

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16. “[Diagram showing the position of the spleen CRUK_417.svg](#)” by [Cancer Research UK uploader](#) is licensed under [CC BY-SA 4.0](#)

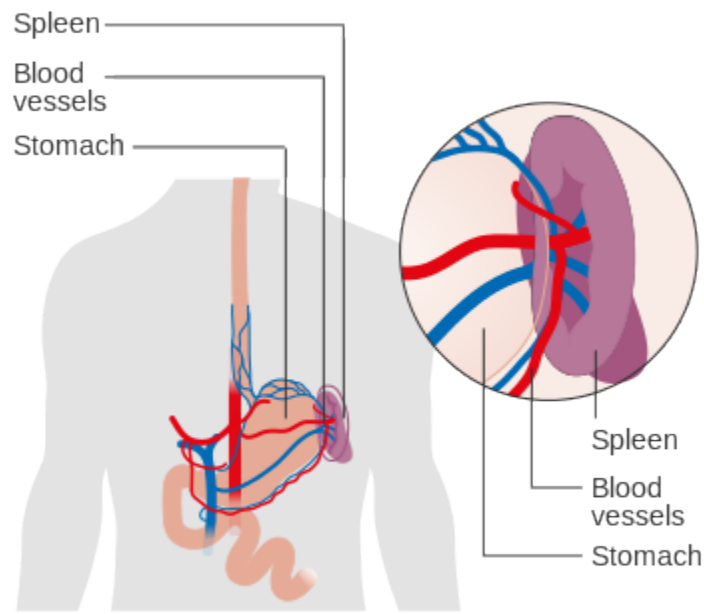


Figure 10.5 Spleen

Because the spleen serves as a reservoir for blood, injury to the spleen can result in excessive, life-threatening bleeding called **hemorrhage** (HEM-ŏ-rāj). For this reason, patients who have experienced blunt abdominal trauma undergo rapid diagnostic testing to check for and rapidly treat splenic damage and prevent hemorrhage.

Enlargement of the spleen, called **splenomegaly** (sple-nō-MĒG-ă-lē), can occur due to a variety of reasons, such as systemic infection, sickle cell disease, or cancer. Patients who undergo **splenectomy** (splē-NEK-tŏ-mē), the removal of the spleen, experience reduced immune function and have an increased risk of infection.¹⁷

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Liver

The **liver** (LIV-ěr) serves as a storage site for blood and blood cells. It also produces prothrombin and other clotting factors. See Figure 10.6¹⁸ for an illustration of the location of the liver.

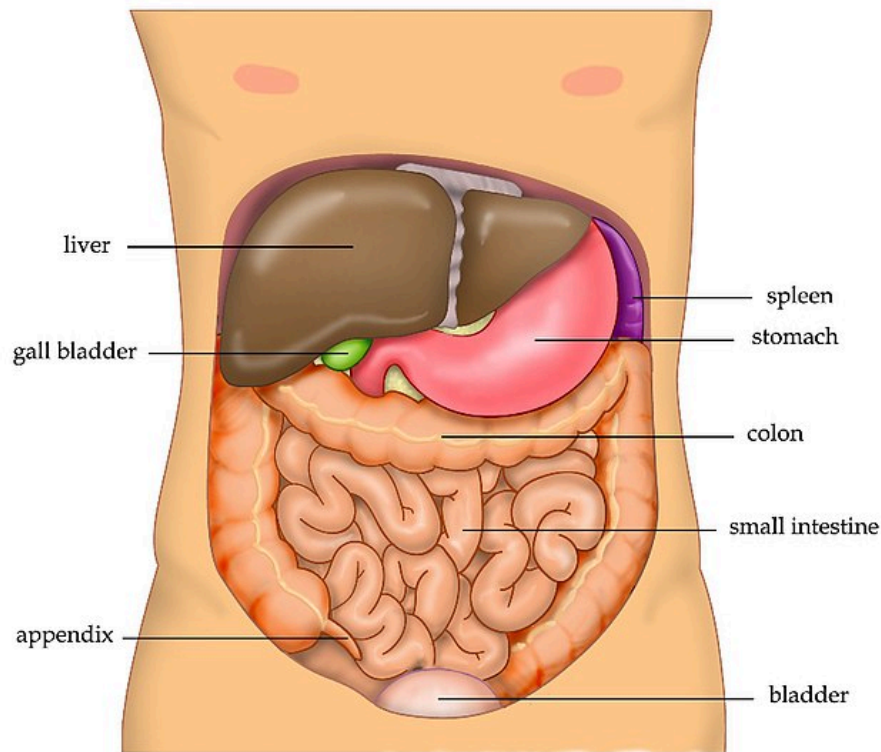


Figure 10.6 Liver

The liver also plays a significant role in the breakdown of hemoglobin. The liver receives bilirubin from the breakdown of RBCs, where it undergoes a chemical change called conjugation so it can be filtered and excreted by the kidneys. If the liver becomes impaired and cannot adequately metabolize

18. "[Anatomy_Abdomen_Tiesworks.jpg](#)" by [Tvanbr](#) is licensed in the [Public Domain](#).

bilirubin, jaundice occurs.¹⁹ **Jaundice** (JAWN-dis) refers to yellowish discoloration of the skin and eyes.

Enlargement of the liver is called **hepatomegaly** (hep-a-tō-MĒG-ă-lē). Hepatomegaly can be caused by liver disease, cancer, and excess alcohol intake.

BLOOD TYPES

There are four blood types called A, B, AB, and O. These blood types are genetically determined for every individual. Each type is determined by the presence or absence of specific antigens called “A” or “B” on the individual’s red blood cells.²⁰

Based on the presence or lack of A or B antigens on an individual’s red blood cells, antibodies are present in their blood that recognize these antigens as foreign and stimulate their immune response. For example, an individual with Type A blood has an A antigen on their RBC but has antibodies to the B antigen in their blood. For this reason, if an individual requires a blood transfusion, it is vital for the donated blood to be compatible with their blood type or a life-threatening reaction will occur.²¹ A **blood transfusion** (blūd tran-SFŪ-zhǒn) is a procedure that enables the transfer of

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blood products from one person to another. Figure 10.7²² shows the different blood types and associated antigens and antibodies, as well as their compatible blood types.

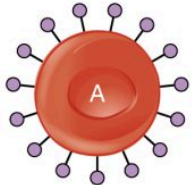
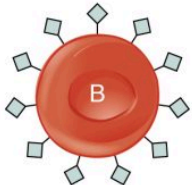
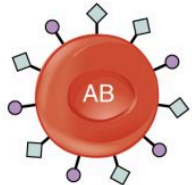
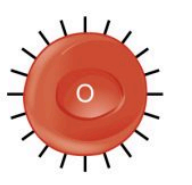
	Blood Type			
	A	B	AB	O
Red Blood Cell Type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red blood Cell	 A antigen	 B antigen	 A and B antigens	None
Blood Types Compatible in an Emergency	A, O	B, O	A, B, AB, O (AB ⁺ is the universal recipient)	O (O is the universal donor)

Figure 10.7 Blood Types

Rh Blood Group

In addition to the A, B, AB, or O blood type, individuals may have another antigen on their red blood cells called **Rh factor** (Är äch FAK-tör). Individuals who have the antigen on their RBCs are described as **Rh positive** (Är-äch

22. “1913_ABO_Blood_Groups.jpg” by OpenStax College is licensed under [CC BY 3.0](#)

PŌZ-ĭ-tĭv) (**Rh+**), and those who lack the antigen are described as **Rh negative** (Ār-āch NĚG-ă-tĭv) (**Rh-**). When identifying a patient's blood type, the Rh factor is designated by adding the word positive or negative to the ABO type. For example, A positive (A+) means A blood type with the Rh antigen present, and AB negative (AB-) means AB blood type without the Rh antigen. Individuals receiving blood transfusions must receive donated blood that matches their Rh type, or a serious, life-threatening reaction will occur.²³

During pregnancy, the fetus can be significantly affected if the mother has a different Rh factor. If an Rh- mother conceives a Rh+ baby, her Rh antibodies can cross the placenta and destroy the fetal RBCs. This condition is known as **hemolytic disease of the newborn** (hē-mō-LĭT-ik dĩ-zēz əv thə NŪ-bôrn) and can be so severe that without treatment the fetus may die in the womb or shortly after birth. A medication known as **RhoGAM** (RŌ-găm) can temporarily prevent the development of Rh antibodies in an Rh- mother, thereby averting this potentially serious disease for the fetus if it is Rh+. RhoGAM is administered to Rh- mothers during weeks 26–28 of pregnancy and within 72 hours following birth.²⁴

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10.5 Physiology of the Hematology System

FUNCTIONS OF BLOOD

The primary functions of blood are the transportation of oxygen, carbon dioxide, nutrients, and hormones, as well as moving cellular wastes so they can be eliminated from the body. Other functions of blood include thermoregulation, defense against infection, and hemostasis.¹

Transportation

The blood transports oxygen, carbon dioxide, nutrients, electrolytes, and hormones. Oxygen from the air you breathe diffuses into the blood in the lungs and then moves to the heart where it is pumped out to the tissues of the body. From the tissues, blood picks up carbon dioxide and moves it to the lungs for removal by exhalation.

Nutrients from the foods you eat are absorbed in the digestive tract. Most of these travel in the bloodstream to the liver, where they are metabolized and released back into the bloodstream for delivery to body cells. Various waste products are also picked up from the cells in the blood and then transported to the kidneys and liver for excretion from the body in the form of urine or bile.

Finally, endocrine glands scattered throughout the body release hormones

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into the bloodstream, where they are transported to distant target cells they affect.

Thermoregulation

Body temperature is regulated via a negative-feedback loop referred to as thermoregulation. For example, if you exercise on a hot day, your rising core body temperature triggers several mechanisms, including the increased transportation of blood from your core to the surface of your body, which is typically cooler. As blood passes through the vessels of the skin, heat is dissipated to the environment, and the blood returning to your core is cooler. In contrast, on a cold day, blood is diverted away from the skin to maintain a warm core. In extreme cold, if the extremities are not protected adequately, this process can result in frostbite.

Defense Against Infection

Many types of WBCs protect the body from infection by microorganisms that enter the body. Other WBCs seek out and destroy internal threats, such as cells with mutated DNA that could multiply to become cancerous. Read more about the function of WBCs in the “[Lymphatic and Immune Systems Terminology](#)” chapter.

Hemostasis

When damage occurs to blood vessels that results in bleeding, platelets and clotting factors form a clot to stop the bleeding, referred to as **hemostasis** (hē-mō-STĀ-sīs). There are three steps to the hemostasis process: vascular spasm called vasoconstriction, the formation of a platelet plug, and blood clotting called **coagulation** (kō-ag-yū-LĀ-shōn). Failure of any of these steps will result in hemorrhage. Figure 10.8² summarizes the steps of hemostasis.

2. “[1909_Blood_Clotting.jpg](#)” by OpenStax College is licensed under [CC BY 3.0](#)

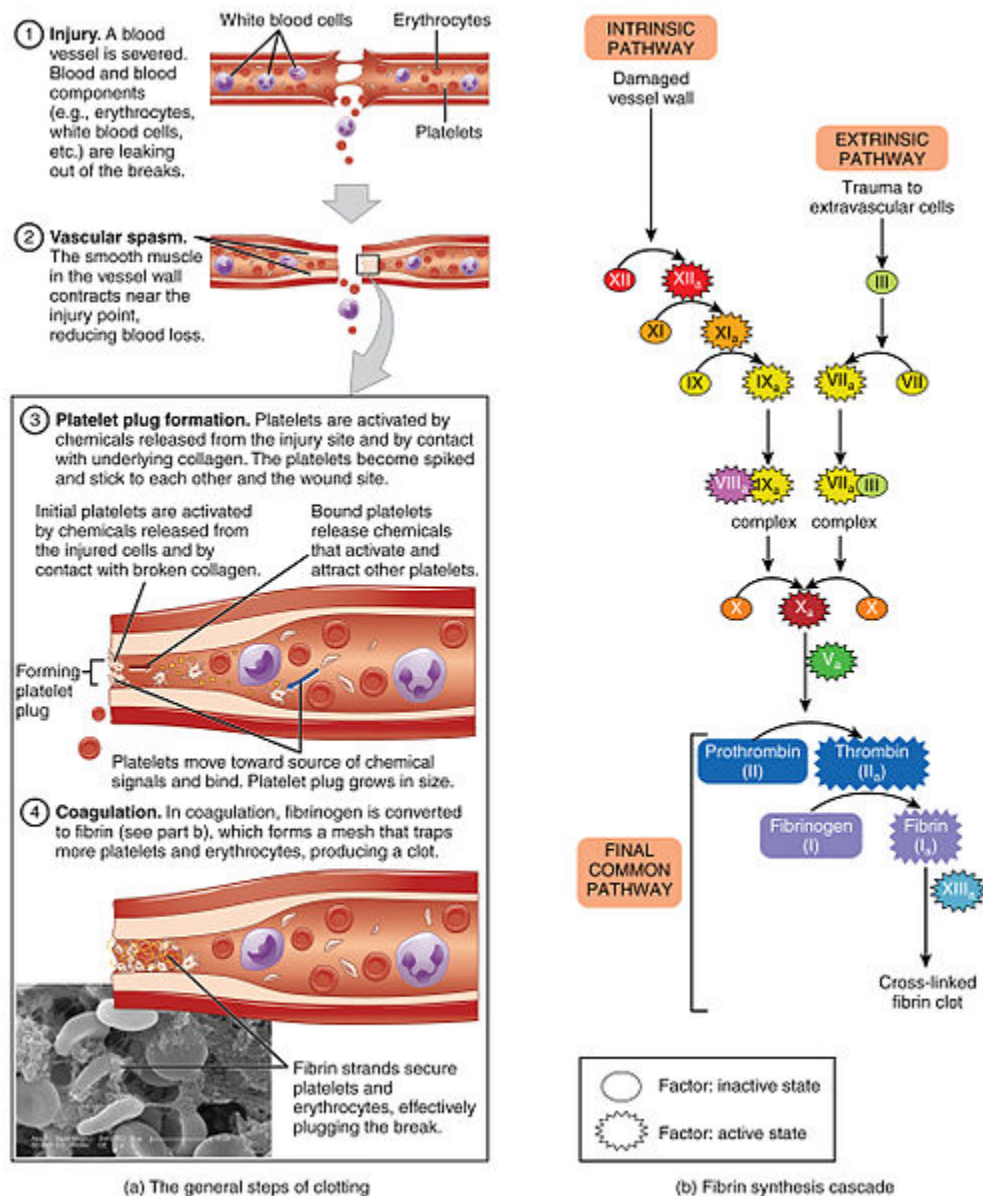


Figure 10.8 Hemostasis

During hemostasis, a protein called **fibrin** (fī-brin) is produced to form a blood clot.

Fibrinolysis (fī-brī-NŌL-ĭ-sīs) is the process in which a clot is degraded in a healing vessel. An **anticoagulant** (an-tī-kō-AG-yū-lănt) is a substance or medication that prevents coagulation. Examples of commonly prescribed anticoagulant medications are warfarin and heparin.

Three commonly performed blood tests related to blood clotting are **prothrombin time** (PRŌ-thrŏm-bĭn tīm) (**PT**), **international normalized ratio**

(ĭn-tĕr-NASH-ŭ-năl NÔR-mă-līzd RĀ-shiō) (**INR**), and **partial thromboplastin time** (pär-shăl thrŏm-bō-PLAS-tĭn tīm) (**PTT**). PT measures the time it takes for plasma to clot. INR is a standardized measurement of PT, so a normal reference range can be used for all individuals. PTT measures a specific group of clotting factors. These tests may be performed to diagnose clotting disorders or monitor patients who are receiving anticoagulants.³

3. MedlinePlus [Internet]. Bethesda (MD): National Library of Medicine (US); [updated 2022, Sep. 21]. Prothrombin time test and INR (PT/INR); [cited 2023, Nov. 5]. <https://medlineplus.gov/lab-tests/prothrombin-time-test-and-inr-ptinr/>

10.6 Diseases and Disorders of the Blood

Anemia (ā-NĒ-mē-ă) is a blood disorder in which there is a deficiency of red cells and/or hemoglobin. Anemia is diagnosed when a blood test shows a hemoglobin value of less than 13.5 gm/dL in a man or less than 12.0 gm/dL in a woman. The lack of RBCs and hemoglobin causes a decreased amount of oxygen to be delivered to body tissues, resulting in commonly occurring symptoms of fatigue, weakness, shortness of breath, palpitations, and pale skin. See Figure 10.9¹ for an illustration of common symptoms of anemia.

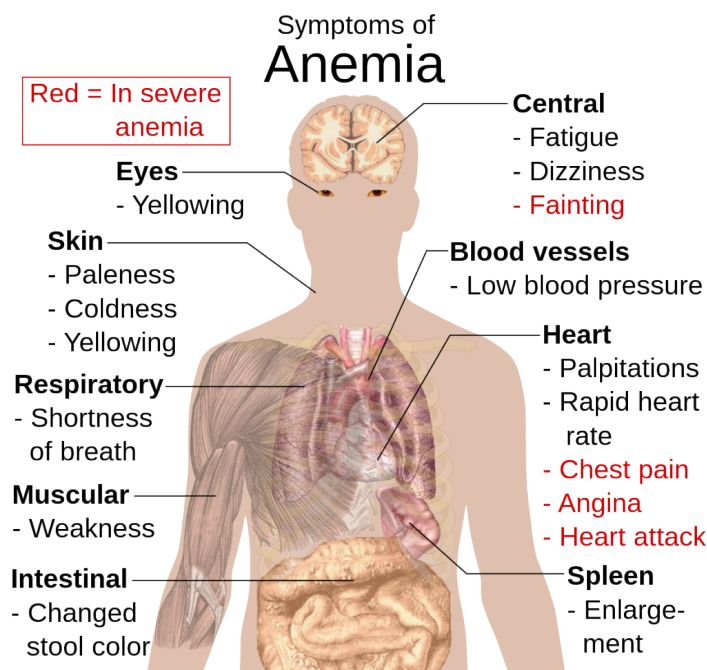


Figure 10.9 Anemia Symptoms

1. "Symptoms_of_anemia.svg.png" by Mikael Häggström is licensed in the Public Domain

There are three basic causes of anemia: blood loss, decreased RBC production, and excessive destruction of RBCs. In addition to these causes, various diseases and cancers can also cause anemia.²

Anemia from Blood Loss

Anemia from blood loss can result from excessive bleeding from wounds or other lesions, such as ulcers and gastrointestinal cancer. Excessive menstruation and blood loss during childbirth can also cause this type of anemia.

Faulty or Decreased RBC Production

Iron deficiency anemia (īrŏn dē-Fĭ-shĕn-sē ā-NĒ-mē-ă) is the most common type of anemia. It is caused by a lack of dietary iron needed for the sufficient production of hemoglobin.

Sickle cell anemia (SĭK-l sĕl ā-NĒ-mē-ă) is genetic disorder that causes red blood cells to assume a sickle (i.e., crescent) shape that can block blood flow and cause serious problems in organs throughout the body. See Figure 10.10³ for an image of a sickled red blood cell.

2. American Society of Hematology. (n.d.). *Anemia*. <https://www.hematology.org/education/patients/anemia>

3. “[Eritrociti.jpg](#)” by EM Unit, UCL Medical School, Royal Free Campus, Wellcome Images is licensed under [CC BY 4.0](#)



Figure 10.10 Sickled Red Blood Cell in Sickle Cell Anemia

Aplastic anemia (ā-PLAS-tĭk ā-NĒ-mē-ă) is a bone marrow condition causing an insufficient production of RBCs. This condition can be inherited, or it can be caused by radiation, medication, chemotherapy, or infection.

Other Types of Anemia

Megaloblastic anemia (mě-gŭh-lō-plă-stĭk ā-NĒ-mē-ă) involves a deficiency of vitamin B12 and/or folate, often due to inadequate dietary intake.

Pernicious anemia (pĕr-nĭsh-ē-ŭs ā-NĒ-mē-ă) is caused by poor absorption of vitamin B12 in the gastrointestinal tract. **Thalassemia** (thal-ă-SĒM-ē-ă) is an inherited condition typically occurring in individuals from the Middle East, the Mediterranean, Africa, and Southeast Asia in which maturation of the RBCs does not proceed normally. **Pancytopenia** (pan-sĭ-tō-PĒN-ē-ă) is reduction of all types of blood components, including red and white blood cells and platelets.⁴

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HEMATOMA

A **hematoma** (hēm-ă-TŌ-mă) is a collection (or pooling) of blood outside the blood vessel caused by an injury. Trauma is the primary cause of a hematoma. Trauma can be the result of a car accident, fall, broken bones, gunshot wound, or head injury. People with bleeding disorders or those taking anticoagulant medication are at higher risk for developing hematomas from injuries. Symptoms of a hematoma include redness, warmth, swelling, inflammation, and pain and require medical treatment.⁵

Hematomas differ from bruises. A bruise, also known as a **contusion** (kon-TU-zhun), occurs when the small veins and capillaries under the skin break, releasing blood into the surrounding tissue. Bruises are dark blue or purple tender patches that appear on the skin within a few hours after injury.⁶

HEMOPHILIA

Hemophilia (hē-mō-FĒL-ē-ă) is a genetic disorder in which blood doesn't clot normally due to deficient or abnormal clotting factors. Patients with

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5. MercyHealth. (n.d.). *Bruise or hematoma*. <https://www.mercy.com/health-care-services/primary-care-family-medicine/conditions/bruise-hematoma>

6. MercyHealth. (n.d.). *Bruise or hematoma*. <https://www.mercy.com/health-care-services/primary-care-family-medicine/conditions/bruise-hematoma>

hemophilia can bleed excessively and hemorrhage from even minor internal and external injuries.⁷

HEMORRHAGE

Hemorrhage (HEM-ŏ-rāj) is excessive bleeding that cannot be controlled by hemostasis. A hemorrhage is a medical emergency.

LEUKEMIA

Leukemia (lū-KĒM-ē-ă) is cancer of the bone marrow, the body's blood-forming tissues. It includes an abundance of nonfunctional leukocytes (i.e., white blood cells), reducing the individual's ability to fight off infection.⁸ Leukemia is diagnosed with a bone marrow biopsy. Treatment may include chemotherapy and a bone marrow/stem cell transplant.

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LEUKOCYTOSIS

Leukocytosis (lū-kō-sī-TŌ-sīs) is excessive leukocyte (white blood cell) production. Although leukocyte counts are high, the cells themselves are often nonfunctional, leaving the individual at increased risk for infection.⁹

LEUKOPENIA

Leukopenia (lū-kō-PĒN-ē-ă) is a condition in which too few leukocytes (white blood cells) are produced, which impact the individual's ability to fight off disease.¹⁰

LYMPHOMA

Lymphoma (lim-FŌ-mă) is a type of cancer in which masses of malignant lymphocytes (white blood cells) collect in lymph nodes, the spleen, the liver, and other tissues. As in leukemia, the malignant leukocytes do not function properly, and the patient is vulnerable to infection. Two main types of lymphoma are Hodgkin lymphoma and non-Hodgkin lymphoma. Hodgkin

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lymphoma progresses slowly and responds well to treatment if found early. Non-Hodgkin lymphoma can progress quickly and may require aggressive treatment. Symptoms of lymphoma include swollen lymph nodes, fever, drenching night sweats, weight loss, and fatigue. Treatment may include chemotherapy, radiation therapy, and immunotherapy.¹¹

POLYCYTHEMIA

Polycythemia (pol-ē-sī-THĒM-ē-ă) refers to an elevated RBC count. A mild form of polycythemia is normal for people living at high altitudes because their bodies create a greater number of red blood cells to carry oxygen due to decreased pressure of oxygen at high altitudes. Some elite athletes even train at high elevations specifically to induce this phenomenon. However, a bone marrow disease called **polycythemia vera** (pol-ē-sī-THĒM-ē-ă vee-ruh) causes an excessive production of immature RBCs and other blood components, increasing the viscosity of blood. **Viscosity** (vīs-KOS-ĭ-tē) refers to the state of being thick, sticky, and easily coagulable.¹²

11. Medline Plus. (2023). *Hodgkin lymphoma*. <https://medlineplus.gov/hodgkinlymphoma.html>

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THROMBOSIS, THROMBUS, AND EMBOLUS

Thrombosis (thrŏm-BŌ-sīs) is the formation of a thrombus. A **thrombus** (THROM-būs) is a collection of platelets, red blood cells, and white blood cells trapped within a mass of fibrin strands, commonly referred to as a “blood clot.” While the formation of a clot is a normal step in hemostasis, the development of a thrombus can cause decreased blood flow in a blood vessel or a life-threatening obstruction of a blood vessel in the heart or brain.¹³

When a portion of a thrombus breaks free from the vessel wall and travels through the bloodstream, it is referred to as an **embolus** (ĒM-bŏ-lūs). An embolus that is carried through the bloodstream can be large enough to block a vessel critical to a major organ. When it becomes trapped, an embolus is called an **embolism** (ĒM-bŏ-līzm). In the heart, brain, or lungs, an embolism can cause a life-threatening heart attack, stroke, or pulmonary embolism.¹⁴

Thrombolysis (thrŏm-BŎL-ī-sīs) refers to the dissolution of a clot. Medications like tissue plasminogen activator (tPA), commonly referred to as “clot busters,” are used to dissolve severe clots causing heart attacks, strokes, or pulmonary embolism.

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THROMBOCYTOSIS

Thrombocytosis (thrŏm-bō-sī-TŌ-sīs) refers to an abnormally high number of platelets (thrombocytes) in the blood, which can cause thrombosis.

THROMBOCYTOPENIA

Thrombocytopenia (thrŏm-bō-sī-tō-PĒN-ē-ă) refers to an insufficient number of platelets, causing ineffective blood clotting and the potential for excessive bleeding.¹⁵ Common symptoms of thrombocytopenia include bleeding gums, blood in the urine or stool, or petechiae and purpura. Petechiae and purpura are red or purple spots on the skin caused by microscope hemorrhages that do not turn lighter in color when pressure is applied. See Figure 10.11¹⁶ for an image of petechiae and purpura.

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16. “[Purpura.jpg](#)” by [User:Hektor](#) is licensed under [CC BY-SA 3.0](#)

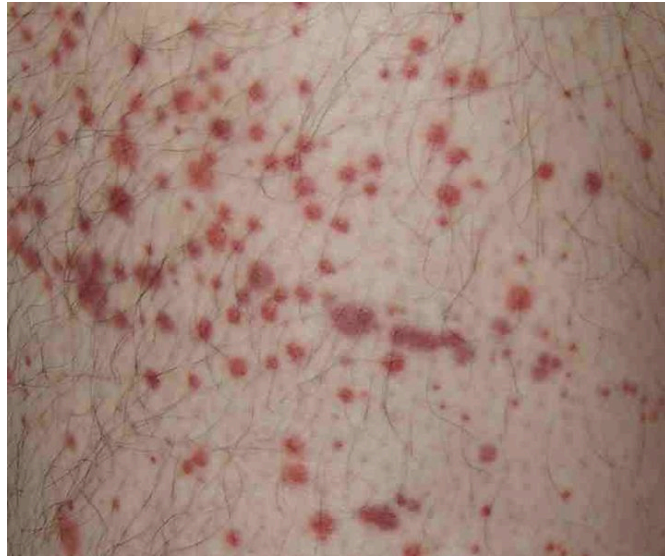


Figure 10.11 Petechiae and Purpura

10.7 Medical Specialists, Diagnostic Testing, and Procedures Related to Blood

MEDICAL SPECIALISTS

Hematologist

A **hematologist** (hē-mā-TŌL-ō-jist) is a physician who specializes in diagnosing and treating blood disorders.

- ▶ To learn more about a career as a hematologist, visit the [American Medical Association's specialty profile on hematology.](#)

Phlebotomist

A **phlebotomist** (flě-BOT-ō-mist) is medical professional trained to withdraw blood or perform blood transfusions. After the blood is collected, it is analyzed by a medical laboratory technician.

- ▶ Read more about a career as a phlebotomist at Cleveland Clinic's web page titled [Phlebotomist](#).

Medical Laboratory Technologist/Scientist/Assistant

Medical laboratories employ a variety of individuals in technical positions. Specialized positions are as follows:

- **Medical technologist** (Měd-ĭ-căl Těk-nŏl-ŏ-jist) **(MT)**: A medical professional who tests and analyzes blood, other body fluids, and tissue samples.
- **Medical laboratory scientists** (Měd-ĭ-căl LĂB-ŏr-ă-tŏr-ē Sĭ-ĚN-tĭsts) **(MLS)**: A medical professional who performs complex analyses of tissue, blood, and other body fluids.
- **Medical laboratory assistants** (Měd-ĭ-căl LĂB-ŏr-ă-tŏr-ē ă-Sĭs-tănts) **(MLA)**: A medical professional who assists in receiving, preparing, testing, and processing specimen samples.

- ▶ Read more information about these careers at the American Society for Medical Laboratory Science's web page called [What is a Medical Laboratory Professional?](#)

DIAGNOSTIC TESTING AND PROCEDURES

Apheresis

In traditional blood donation, a unit of whole blood is taken from a donor and sent to a laboratory, where it is separated into its four components: red blood cells, white blood cells, platelets, and plasma. The components are stored and administered to patients who need blood products transfused after surgery, after a severe injury/trauma, or to treat a severe disease or hematological condition. In contrast, during **apheresis** (ăf-ě-RĒ-sīs), a specific component is removed from a donor's blood, and the remaining components are returned to the donor while they are still connected to the machine.¹

Donor apheresis takes longer than a whole blood donation but is easy and painless and has many benefits. For example, an apheresis double red-cell donation (called erythropheresis) separates red blood cells and returns the remaining “non-targeted” plasma and platelets to the volunteer donor. This allows for the collection of twice as many red blood cells from one donation as they would in a whole-blood donation. As another example, a platelet apheresis donation can provide as many platelets as those obtained in four to six whole-blood donations.² See Figure 10.12³ for an image of an erythropheresis machine.

1. Yale Medicine. (n.d.). *Apheresis*. <https://www.yalemedicine.org/conditions/apheresis>
2. Yale Medicine. (n.d.). *Apheresis*. <https://www.yalemedicine.org/conditions/apheresis>
3. “Fenwal Erythropheresis machine for plasmapheresis.jpg” by Elwood P. Dowd is licensed under [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)



Figure 10.12 Erythropheresis Machine

Blood Product Transfusion

A **blood product** (blŭd prah-DUHKT) is any therapeutic substance derived from human blood. Types of blood products include whole blood, packed red blood cells (PRBCs), individual factor concentrates, fresh frozen plasma (FFP), platelet concentrates, and cryoprecipitate (i.e., plasma rich in proteins). Transfusion of blood products is a common procedure with nearly 16 million blood components transfused each year in the United States.⁴ Nurses

4. American Red Cross. (n.d.). *Importance of the blood supply*. <https://www.redcrossblood.org/donate-blood/how-to-donate/how-blood-donations-help/blood-needs-blood->

typically provide blood transfusions after they are prescribed by a health care provider.

In severe cases of symptomatic, severe anemia (i.e., dyspnea or chest pain) or hemoglobin levels less than 7 g/dL, transfusions of red blood cells are prescribed to rapidly increase hemoglobin levels. See Figure 10.13⁵ for an illustration of a bag of red blood cells. Note the blood type (i.e., A, B, AB, or O) and the Rh factor positive or negative) are indicated on the label to compare with the patient's lab results. Health care agencies have strict safety procedures that nurses and other health care personnel follow when providing a blood transfusion to prevent the administration of incompatible blood to a patient.

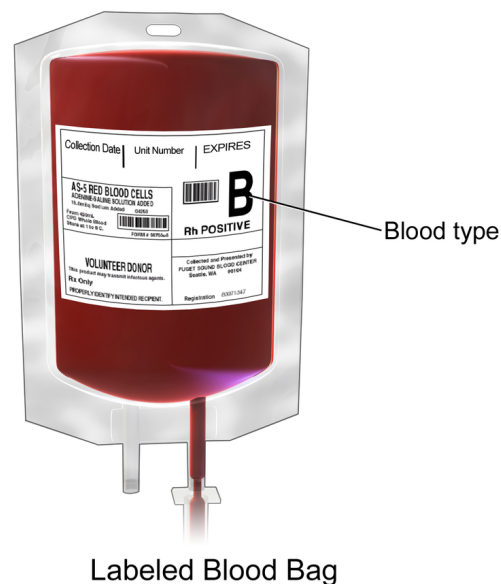


Figure 10.13 Labeled Bag of Red Blood Cells

[supply.html#:~:text=Facts%20About%20Blood%20Needs&text=Approximately%2029%2C000%20units%20of%20red,each%20year%20in%20the%20U.S](#)

5. “[Blausen_0086_Blood_Bag.png](#)” by Blausen.com staff (2014) at “[Medical gallery of Blausen Medical 2014](#).” *WikiJournal of Medicine* is licensed under [CC BY 3.0](#)

Bone Marrow Aspiration and Biopsy

Bone marrow aspiration (BŌn MĂR-rōw ă-spĭ-RĀ-shŏn) involves the extraction of a small sample of liquid bone marrow from the center of a patient's bone. Common sites for bone marrow aspiration include the pelvic bone and sternum. The procedure is typically performed after local anesthesia is administered, and then the provider inserts a needle into the bone marrow space and draws out a liquid sample. The aspiration allows for laboratory analysis of the cellular components of the bone marrow (i.e., red blood cells, white blood cells, and platelets). Bone marrow aspiration is helpful for determining the presence of severe blood disorders, such as leukemia, and is also used to monitor disease progression or treatment effectiveness.⁶

Bone marrow biopsy (BŌn MĂR-rōw BĪ-ŏp-sē) involves obtaining a small core of bone and marrow tissue from the bone marrow space. The procedure is often performed in conjunction with bone marrow aspiration.

See Figure 10.14⁷ for an illustration of a bone marrow biopsy.

6. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Bone marrow aspiration; [reviewed 2022, Apr 9; cited 2023, Nov 5]. <https://medlineplus.gov/ency/article/003658.htm>

7. “[Blausen_0097_BoneMarrowBiopsy.png](#)” by [Blausen Medical Communications, Inc.](#) is licensed under [CC BY 3.0](#)

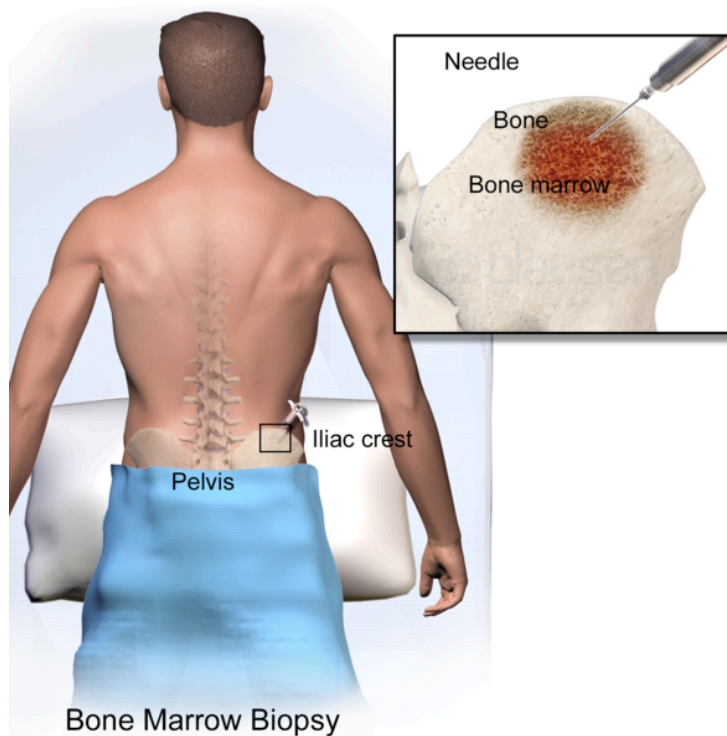


Figure 10.14 Bone Marrow Biopsy

In contrast to the bone marrow aspiration procedure, the provider uses a larger needle during bone marrow biopsy to remove a cylindrical section of both the bone and marrow. See Figure 10.15⁸ for an image of a bone marrow biopsy needle. Bone marrow biopsy provides a comprehensive evaluation of the bone marrow, allowing for a closer assessment of the bone marrow's cellular density, structure, and the presence of any abnormal or diseased cells. It helps diagnose a wider range of conditions, including non-hematological disorders like metastatic cancers and immune diseases that may infiltrate the bone marrow.⁹

8. [“Multi_Purpose_Bone_Marrow_Biopsy_Needle.jpg”](#) by [Thirteen Of Clubs](#) from Minneapolis is licensed under [CC BY-SA 2.0](#)

9. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.;



Figure 10.15 Bone Marrow Biopsy Needle

Bone Marrow Transplant/Stem Cell Transplant

Bone marrow transplant (BŌn MÄR-rōw TRÄNS-plänt), also called **stem cell transplant** (STĚM Sěl TRÄNS-plänt), is a potentially curative treatment for severe hematological diseases like sickle cell disease, as well as cancer like leukemia. It typically involves the administration of chemotherapy to destroy the patient's existing bone marrow and then replacing the bone marrow with healthy stem cells donated from a compatible donor. If successful, transplantation can be curative and result in the patient's bone marrow taking over the production of healthy red blood cells, white blood cells, and platelets. However, patients undergoing this procedure with donated stem

c1997-2023. Bone marrow biopsy; [reviewed 2022, Apr 9; cited 2023, Nov 5].
<https://medlineplus.gov/ency/article/003934.htm>

cells must take immunosuppressive medication for the remainder of their lives.¹⁰

Complete Blood Count

A **complete blood count** (kõm-PLĒT BLŮD kownt) (**CBC**) is a blood test performed in a laboratory that provides a comprehensive assessment of various blood components, including RBCs, WBCs, platelets, hematocrit (HCT), and hemoglobin (Hgb). These parameters help evaluate the overall health of the hematological system and can indicate anemia, infection, or other blood disorders. A **CBC with differential** (CBC wĭth Dĭf-ě-REN-shǎl) includes an additional measurement of the different types of white blood cells (i.e., neutrophils, lymphocytes, monocytes, eosinophils, and basophils). See Figure 10.16¹¹ for an illustration of CBC with differential test results indicated behind a tube of drawn blood.

10. National Cancer Institute. (2023, October 5). *Stem cell transplants in cancer treatment*. National Institutes of Health. <https://www.cancer.gov/about-cancer/treatment/types/stem-cell-transplant>

11. “[Complete blood count and differential.jpg](#)” by SpicyMilkBoy is licensed under [CC BY-SA 4.0](#)

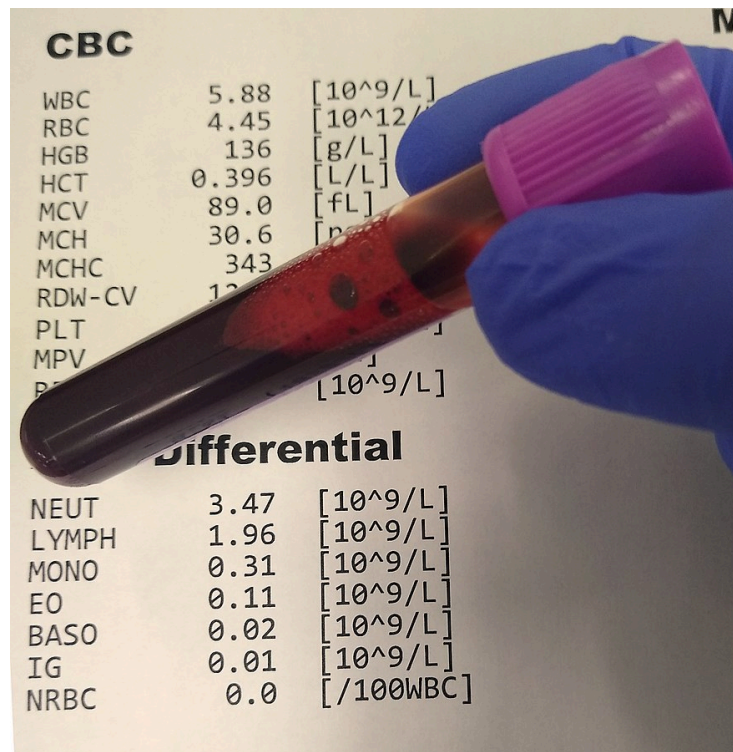


Figure 10.16 CBC With Differential Test Results

10.8 Blood Learning Activities

Interactive Learning Activity: Study medical terms related to the blood that are discussed in this chapter using these flashcards.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=368#h5p-184>

Interactive Learning Activity: Review terms related to the blood.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=368#h5p-59>



Interactive Learning Activity: Practice identifying and defining word parts for terms discussed in this chapter.



An interactive H5P element has been excluded from this version

of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=368#h5p-201>

- ▶ You can also print this as a [Chapter 10 Practice Worksheet](#) and check your answers with this [Answer Key PDF](#).

10.9 Glossary

Anemia (ā-NĒ-mē-ă): A blood disorder characterized by a deficiency of red blood cells and/or hemoglobin, leading to decreased oxygen delivery to body tissues and symptoms like fatigue, weakness, shortness of breath, and pale skin. ([Chapter 10.6](#))

Anticoagulant (ăn-tī-kō-AG-yū-lănt): A substance or medication that prevents or reduces coagulation of blood, thereby prolonging the clotting time. ([Chapter 10.5](#))

Apheresis (ăf-ě-RĒ-sīs): A procedure where a specific component of blood is removed from a donor, and the remaining components are returned to the donor. ([Chapter 10.7](#))

Aplastic anemia (ā-PLAS-tĭk ā-NĒ-mē-ă): A bone marrow condition causing insufficient production of red blood cells. ([Chapter 10.6](#))

Basophils (bā-sō-fĭls): The least common type of white blood cell, playing a role in inflammatory responses, particularly those involving allergic reactions. ([Chapter 10.4](#))

Bilirubin (bĭl-ĭ-rōō-bĭn): A yellow compound that occurs in the normal catabolic pathway that breaks down heme in vertebrates. High levels in the bloodstream can lead to jaundice. ([Chapter 10.4](#))

Blood product (blŭd prah-DUHKT): Components of blood, such as red blood cells, white blood cells, platelets, and plasma, used for transfusions. ([Chapter 10.7](#))

Blood transfusion (blŭd tran-SFŪ-zhŏn): A procedure that enables the transfer of blood products from one person to another. ([Chapter 10.4](#))

Bone marrow (bŏn MAR-ŏ): The soft, spongy tissue found inside bones, responsible for the production of blood cells. ([Chapter 10.4](#))

Bone marrow aspiration (BŌn MĂR-rŏw ă-spĭ-RĀ-shŏn): The extraction of a small sample of liquid bone marrow for laboratory analysis to diagnose severe blood disorders like leukemia. ([Chapter 10.7](#))

Bone marrow biopsy (BŌn MĂR-rŏw Bĭ-ŏp-sē): Obtaining a core of bone

and marrow tissue for examining the bone marrow space, often performed with bone marrow aspiration. ([Chapter 10.7](#))

Bone marrow transplant (BŌn MĀR-rōw TRĀNS-plānt): A treatment for severe hematological diseases or cancers like leukemia, involving the replacement of a patient's bone marrow with healthy stem cells from a donor. ([Chapter 10.7](#))

CBC with differential (CBC wĭth Dĭf-ě-REN-shǎl): A CBC test that includes an additional measurement of the different types of white blood cells, such as neutrophils, lymphocytes, monocytes, eosinophils, and basophils. ([Chapter 10.7](#))

Coagulation (kō-ag-yū-LĀ-shǒn): The process of blood clotting, an essential part of hemostasis, involving the transformation of blood from a liquid to a gel to stop bleeding. ([Chapter 10.5](#))

Complete blood count (kǒm-PLĒT BLŮD kownt) (CBC): A blood test that provides a comprehensive assessment of various blood components, including red and white blood cells, platelets, hematocrit, and hemoglobin. ([Chapter 10.7](#))

Contusion (kon-TU-zhun): A bruise that occurs when small veins and capillaries under the skin break, releasing blood into the surrounding tissue. ([Chapter 10.6](#))

Embolism (ĒM-bǒ-lĭzm): A condition where an embolus becomes trapped in a blood vessel, potentially causing a heart attack, stroke, or pulmonary embolism. ([Chapter 10.6](#))

Embolus (ĒM-bǒ-lŭs): A piece of a thrombus that has broken free and travels through the bloodstream, potentially causing blockage in blood vessels of major organs. ([Chapter 10.6](#))

Eosinophils (ē-ō-sĭn-ō-fĭls): White blood cells involved in the response to allergic reactions, asthma, and infection with parasites. ([Chapter 10.4](#))

Erythrocytes (ě-rĭth-rō-sĭts): Red blood cells, which are responsible for carrying oxygen from the lungs to the body's tissues and carbon dioxide as a waste product, away from the tissues and back to the lungs. ([Chapter 10.4](#))

Erythropoietin (ě-rĭth-rō-poi-Ē-tĭn) (EPO): A hormone produced by the kidneys that promotes the formation of red blood cells by the bone marrow. ([Chapter 10.4](#))

Fibrin (FĪ-brin): A fibrous protein formed during blood clotting, essential for the formation of a stable blood clot. ([Chapter 10.5](#))

Fibrinolysis (fī-brī-NŌL-ĭ-sĭs): The process that breaks down fibrin in blood clots, playing a crucial role in preventing blood clots from growing and becoming problematic. ([Chapter 10.5](#))

Hematocrit (hē-măt-ō-krit) (HCT): A blood test that measures the percentage of the volume of whole blood that is made up of red blood cells. ([Chapter 10.4](#))

Hematologist (hē-mā-TŌL-ō-jist): A physician who specializes in the diagnosis and treatment of blood disorders. ([Chapter 10.7](#))

Hematology (hēm-ă-TŌL-ō-jē): The study of blood, blood components, and blood-forming organs, focusing on their role in health and disease. ([Chapter 10.1](#))

Hematoma (hēm-ă-TŌ-mă): A collection or pooling of blood outside the blood vessel caused by an injury. ([Chapter 10.6](#))

Hemoglobin (hē-mō-glō-bĭn) (Hgb): A protein in red blood cells that carries oxygen from the lungs to the rest of the body and returns carbon dioxide from the body to the lungs. ([Chapter 10.4](#))

Hemolysis (hē-MOL-ĭ-sĭs): The destruction or breakdown of red blood cells, leading to the release of hemoglobin into the surrounding fluid. ([Chapter 10.4](#))

Hemolytic disease of the newborn (hē-mō-LĪT-ik dĩ-zēz əv thə NŪ-bôrn): A condition occurring when an Rh-negative mother's immune system attacks Rh positive fetal red blood cells, potentially leading to fetal death without treatment. ([Chapter 10.4](#))

Hemophilia (hē-mō-FĒL-ē-ă): A genetic disorder in which blood doesn't clot normally due to deficient or abnormal clotting factors. ([Chapter 10.6](#))

Hemorrhage (HEM-ŏ-rāj): Excessive bleeding that cannot be controlled by hemostasis and is considered a medical emergency. ([Chapter 10.4](#), [Chapter 10.6](#))

Hemostasis (hē-mō-STĀ-sĭs): The process of blood clot formation at the site of vessel injury. It involves three steps: vascular spasm, formation of a platelet plug, and blood clotting (coagulation). ([Chapter 10.4](#), [Chapter 10.5](#))

Hepatomegaly (hep-ăt-ō-MĚG-ă-lē): Enlargement of the liver, which can be caused by liver disease, cancer, and excess alcohol intake. ([Chapter 10.4](#))

International normalized ratio (ĩn-těr-NASH-ũ-năl NÔR-mă-lĩzd RĂ-shiō) (INR): A calculation based on the PT used to ensure test results from different labs are comparable; it's particularly important for patients on anticoagulant medication like warfarin. ([Chapter 10.5](#))

Iron deficiency anemia (ĩrŃn dē-Fĩ-shěn-sē ā-NĒ-mē-ă): The most common type of anemia, caused by a lack of dietary iron needed for sufficient production of hemoglobin. ([Chapter 10.6](#))

Jaundice (JAWN-dis): A yellowish discoloration of the skin and eyes, usually caused by impaired liver function that affects the metabolism of bilirubin. ([Chapter 10.4](#))

Leukemia (lũ-KĒM-ē-ă): Cancer of the bone marrow and the body's blood-forming tissues, characterized by an abundance of nonfunctional leukocytes (white blood cells). ([Chapter 10.6](#))

Leukocytes (lũ-kō-sĩts): White blood cells, which are part of the immune system and help the body to fight infection and other diseases. ([Chapter 10.4](#))

Leukocytosis (lũ-kō-sĩ-TŌ-sĩs): Excessive leukocyte (white blood cell) production, often with nonfunctional cells, leading to increased risk of infection. ([Chapter 10.6](#))

Leukopenia (lũ-kō-PĒN-ē-ă): A condition where too few leukocytes (white blood cells) are produced, impacting the individual's ability to fight off disease. ([Chapter 10.6](#))

Liver (LIV-ěr): A vital organ that plays multiple roles in digestion, metabolism, and hemostasis, including the production of bile and the storage of blood and blood cells. ([Chapter 10.4](#))

Lymphocytes (lĩm-fō-sĩts): A subtype of white blood cells found in the lymphatic system, playing a large role in the immune response. ([Chapter 10.4](#))

Lymphoma (lĩm-FŌ-mă): A type of cancer where masses of malignant lymphocytes (white blood cells) collect in lymph nodes, the spleen, the liver, and other tissues. ([Chapter 10.6](#))

Medical laboratory assistants (mēd-ĩ-căl LĂB-Ńr-ă-tŃr-ē ă-Sĩs-tănts) (MLA): Professionals who assist in preparing, testing, and processing specimen samples. ([Chapter 10.7](#))

Medical laboratory scientists (mēd-ĩ-căl LĂB-Ńr-ă-tŃr-ē Sĩ-ĒN-tĩsts) (MLS):

Professionals who perform complex analyses of tissue, blood, and other body fluids. ([Chapter 10.7](#))

Medical technologist (měd-ĭ-căl Těk-nŏl-ŏ-jist) (MT): A medical professional who tests and analyzes blood, other body fluids, and tissue samples. ([Chapter 10.7](#))

Megaloblastic anemia (mě-gŭh-lŏ-plă-stĭk ā-NĒ-mē-ă): Involves a deficiency of vitamin B12 and/or folate, often due to inadequate dietary intake. ([Chapter 10.6](#))

Monocytes (mŏn-ŏ-sĭts): A type of white blood cell that engulfs and digests cellular debris, foreign substances, microbes, and cancer cells. ([Chapter 10.4](#))

Neutrophils (nŭ-trŏ-fĭls): A type of white blood cell that helps heal damaged tissues and resolve infections. ([Chapter 10.4](#))

Pancytopenia (păn-sĭ-tŏ-PĒ-nē-ă): A reduction of all types of blood components including red and white blood cells, and platelets. ([Chapter 10.6](#))

Partial thromboplastin time (păr-shăl thrŏm-bŏ-PLAS-tĭn tĭm) (PTT): A blood test that measures a specific group of clotting factors and is used to diagnose clotting disorders or monitor patients on anticoagulants. ([Chapter 10.5](#))

Pernicious anemia (pěr-nĭsh-ē-ŭs ā-NĒ-mē-ă): Caused by poor absorption of vitamin B12 in the gastrointestinal tract. ([Chapter 10.6](#))

Phlebotomist (flě-BOT-ŏ-mist): A medical professional trained to withdraw blood or perform blood transfusions. ([Chapter 10.7](#))

Phlebotomy (flě-BOT-ŏ-mē): The practice of drawing blood from a vein, typically for laboratory testing or blood donation. ([Chapter 10.4](#))

Plasma (plăz-mă): The liquid component of blood in which the blood cells and other components are suspended. It plays a vital role in maintaining blood pressure and regulating body temperature. ([Chapter 10.4](#))

Platelets (PLĀT-lĭts): Also known as thrombocytes, these are small, colorless cell fragments in the blood whose main function is to react to bleeding from blood vessel injury by clumping, thereby initiating a blood clot. ([Chapter 10.4](#))

Polycythemia (pol-ē-sĭ-THĒM-ē-ă): Refers to an elevated red blood cell count, which can be a normal response to living at high altitudes. ([Chapter 10.6](#))

Polycythemia vera (pol-ē-sĭ-THĒM-ē-ă vee-ruh): A bone marrow disease

causing excessive production of immature red blood cells and other blood components, increasing blood viscosity. ([Chapter 10.6](#))

Prothrombin time (PRŌ-thrŏm-bĭn tĭm) (PT): A blood test that measures how long it takes blood to clot, used to check for bleeding problems or the effects of anticoagulants. ([Chapter 10.5](#))

Red blood cells (rĕd blŭd sĕls) (RBCs): Cells in the blood that carry oxygen from the lungs to the rest of the body and return carbon dioxide from the body to the lungs for exhalation. ([Chapter 10.4](#))

Rh factor (Ār āch FAK-tŏr): An antigen found on red blood cells; individuals can be Rh positive (Rh+) if they have the antigen or Rh negative (Rh-) if they lack it. ([Chapter 10.4](#))

Rh negative (Ār-āch NĚG-ă-tĭv) (Rh-): Individuals who lack the Rh factor antigen on their red blood cells. ([Chapter 10.4](#))

RhoGAM (RŌ-gām): A medication administered to Rh negative mothers during pregnancy and after birth to prevent the development of Rh antibodies, thereby averting hemolytic disease of the newborn in Rh positive fetuses. ([Chapter 10.4](#))

Rh positive (Ār-āch PŌZ-ĭ-tĭv) (Rh+): Individuals who have the Rh factor antigen present on their red blood cells. ([Chapter 10.4](#))

Sickle cell anemia (SĪK-l sĕl ā-NĚ-mĕ-ă): A genetic disorder that causes red blood cells to assume a sickle shape, which can block blood flow and cause serious problems in organs throughout the body. ([Chapter 10.6](#))

Spleen (splĕn): An organ that serves as a storage site for red blood cells (RBCs) and platelets, filters antigens, and plays a role in the destruction of old RBCs and the breakdown of hemoglobin. ([Chapter 10.4](#))

Splenectomy (splĕ-NEK-tŏ-mĕ): Surgical removal of the spleen, which can lead to reduced immune function and an increased risk of infection. ([Chapter 10.4](#))

Splenomegaly (splĕ-nŏ-MĚG-ă-lĕ): Enlargement of the spleen, which can occur due to various reasons such as systemic infection, sickle cell disease, or cancer. ([Chapter 10.4](#))

Stem cell transplant (STĚM Sĕl TRĂNS-plănt): Another term for bone marrow transplant, involving the replacement of diseased bone marrow with healthy stem cells. ([Chapter 10.7](#))

Thalassemia (thal-ă- SĒM-ē-ă): An inherited condition typically occurring in individuals from specific regions, characterized by abnormal maturation of red blood cells. ([Chapter 10.6](#))

Thrombocytes (thrōm-bō-sītz): Also known as platelets, these are blood cells responsible for blood clotting. ([Chapter 10.4](#))

Thrombocytopenia (thrōm-bō-sī-tō-PĒ-nē-ă): A condition where there is an insufficient number of platelets, leading to ineffective blood clotting and potential for excessive bleeding. ([Chapter 10.6](#))

Thrombocytosis (thrōm-bō-sī-TŌ-sīs): A condition characterized by an abnormally high number of platelets in the blood, which can lead to thrombosis. ([Chapter 10.6](#))

Thrombolysis (thrōm-BŎL-ī-sīs): The process of dissolving a blood clot, often achieved with medications like tissue plasminogen activator (tPA). ([Chapter 10.6](#))

Thrombosis (thrōm-BŎ-sīs): The formation of a thrombus, a blood clot, within a blood vessel, potentially causing obstruction of blood flow. ([Chapter 10.6](#))

Thrombus (THROM-būs): A blood clot composed of platelets, red and white blood cells, and fibrin strands, potentially leading to decreased blood flow or life-threatening obstruction in blood vessels. ([Chapter 10.6](#))

Viscosity (vīs-KOS-ī-tē): Refers to the state of being thick, sticky, and easily coagulable, as seen in conditions like polycythemia vera. ([Chapter 10.6](#))

White blood cells (wīt blūd sēls) (WBCs): Cells of the immune system involved in protecting the body against both infectious disease and foreign invaders. ([Chapter 10.4](#))

PART XI

CHAPTER 11 LYMPHATIC & IMMUNE SYSTEMS TERMINOLOGY

11.1 Lymphatic & Immune Systems Introduction

Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the lymphatic and immune systems
- Identify meanings of key word components of the lymphatic and immune systems
- Categorize diagnostic, therapeutic, procedural, or anatomic terms related to the lymphatic and immune systems
- Use terms related to the lymphatic and immune systems
- Use terms related to the diseases and disorders of the lymphatic and immune systems

Introduction to the Lymphatic and Immune Systems

The lymphatic system is a network of organs, lymph nodes, lymph ducts, and lymph vessels that produce and transport lymph from tissue spaces to the bloodstream. The lymphatic system is a major part of the body's immune system.¹

1. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.;

This chapter will review common word components related to the lymphatic and immune systems to assist learners in analyzing, building, and defining medical terms. Other terms, whose definitions cannot be easily built from word components, will be described in context based on the anatomy and physiology of the lymphatic and immune systems and common diseases and disorders. Because the lymphatic system shares organs with a number of other body systems, the disorders discussed near the end of this chapter mainly focus on disorders of the immune system. Medical specialists, diagnostic tests, and procedures related to the lymphatic and immune systems will also be discussed.

View the following YouTube video² for an overview of the
 lymphatic system: [Lymphatic System: Crash Course A&P #44](https://www.youtube.com/watch?v=l7orwMgTQ5I&feature=youtu.be)

c1997-2023. Lymph system; [reviewed 2022, Jul 25; cited 2023, Nov 5].
<https://medlineplus.gov/ency/article/002247.htm>

2. CrashCourse. (2015, November 30). *Lymphatic system: Crash Course A&P #44* [Video]. YouTube. All rights reserved.
<https://www.youtube.com/watch?v=l7orwMgTQ5I&feature=youtu.be>

11.2 Word Components Related to the Lymphatic and Immune Systems

This section will describe common word components related to the lymphatic and immune systems. These word components help build definitions for many medical terms. Other common prefixes are described in [Chapter 1.3](#), and common suffixes are described in [Chapter 1.5](#).

PREFIXES RELATED TO THE LYMPHATIC AND IMMUNE SYSTEMS

- **a-**: Absence of, without
- **an-**: Absence of, without
- **ana-**: Up, upward or back, backward
- **brady-**: Slow
- **inter-**: Between
- **pan-**: All

WORD ROOTS RELATED TO THE LYMPHATIC AND IMMUNE SYSTEMS

- **aden/o**: Gland

- **immun/o**: Immune, immunity
- **lymph/o**: Lymph, lymph tissue
- **lymphaden/o**: Lymph gland, lymph node
- **myel/o**: Bone marrow, spinal cord
- **phag/o**: To eat
- **splen/o**: Spleen
- **thym/o**: Thymus gland
- **tox/o**: Poison

SUFFIXES RELATED TO THE LYMPHATIC AND IMMUNE SYSTEMS

- **-ac**: One affected with
- **-apheresis**: Withdrawal or removal
- **-cyte**: Cell
- **-ectomy**: Excision, cut out
- **-itis**: Inflammation
- **-logist**: Specialist who studies and treats
- **-logy**: Study of
- **-megaly**: Enlarged, enlargement
- **-oid**: Resembling
- **-oma**: Tumor, swelling
- **-osis**: Abnormal condition
- **-pathy**: Disease
- **-penia**: Decrease, deficiency
- **-poiesis**: Formation, production
- **-rrhaphy**: Suturing

11.3 Examples of Lymphatic and Immune Systems Terms Easily Defined By Their Word Parts

Here are examples of common medical terms related to the lymphatic and immune systems that can be easily defined by breaking the terms into their word components.

Immunologist

1. Break down the medical term into word components:
Immun/o/logist
2. Label the word components: **Immun** = WR; **o** = CV; **logist** = S
3. Define the word components: **Immun** = immune system; **logist** = specialist who studies and treats
4. Create a final definition of the medical term: **A specialist who studies and treats immune system disorders**

Splenectomy

1. Break down the medical term into word components:

Splen/ectomy

2. Label the word components: **Splen** = WR; **ectomy** = S
3. Define the word components: **Splen** = spleen; **ectomy** = cut out
4. Create a final definition of the medical term: **Surgical removal of the spleen**

Lymphadenopathy

1. Break down the medical term into word components:
Lymphaden/o/pathy
2. Label the word components: **Lymphaden** = WR; **o** = CV; **pathy** = S
3. Define the word components: **Lymphaden** = lymph node; **pathy** = disease
4. Create a final definition of the medical term: **Disease of a lymph node (i.e., swelling of a lymph node due to infection)**



Interactive Learning Activity: Practice pronouncing and defining medical terms related to the lymphatic and immune systems by breaking them down into word parts.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=4771#h5p-179>

- ▶ You can also print these flashcard activities as a [Chapter 11 Student Companion Worksheet](#) and check your answers with this [Answer Key](#).

11.4 Anatomy of the Lymphatic and Immune Systems

ANATOMY OF THE LYMPHATIC AND IMMUNE SYSTEMS

The **lymphatic system** (lĭmf-ă-TĭK sĭs-tŭm) is the system of vessels, cells, and organs that transports fluid called lymph to the bloodstream and also filters pathogens from the blood. The **immune system** (ĭ-MŪN SĭS-tĕm) is the complex collection of cells and organs that destroys or neutralizes pathogens that would otherwise cause infection, disease, or death. The lymphatic system, for most people, is associated with the immune system to such a degree that the two systems are virtually indistinguishable.¹

Lymph Vessels

Lymph capillaries are interlaced in **interstitial space** (in-tĕr-STISH-ăĭ spās), the space between individual cells in the tissues. Interstitial fluid enters the lymphatic capillaries and becomes lymph. **Lymph** (limf) is a clear-to-white fluid that transports immune system cells, as well as dietary lipids and fat-

1. This work is a derivative of Open Stax Anatomy and Physiology 2e at <https://openstax.org/books/anatomy-and-physiology-2e/pages/21-1-anatomy-of-the-lymphatic-and-immune-systems>

soluble vitamins absorbed in the small intestine called **chyle** (kīl).² See Figure 11.1³ for an image of lymph capillaries.

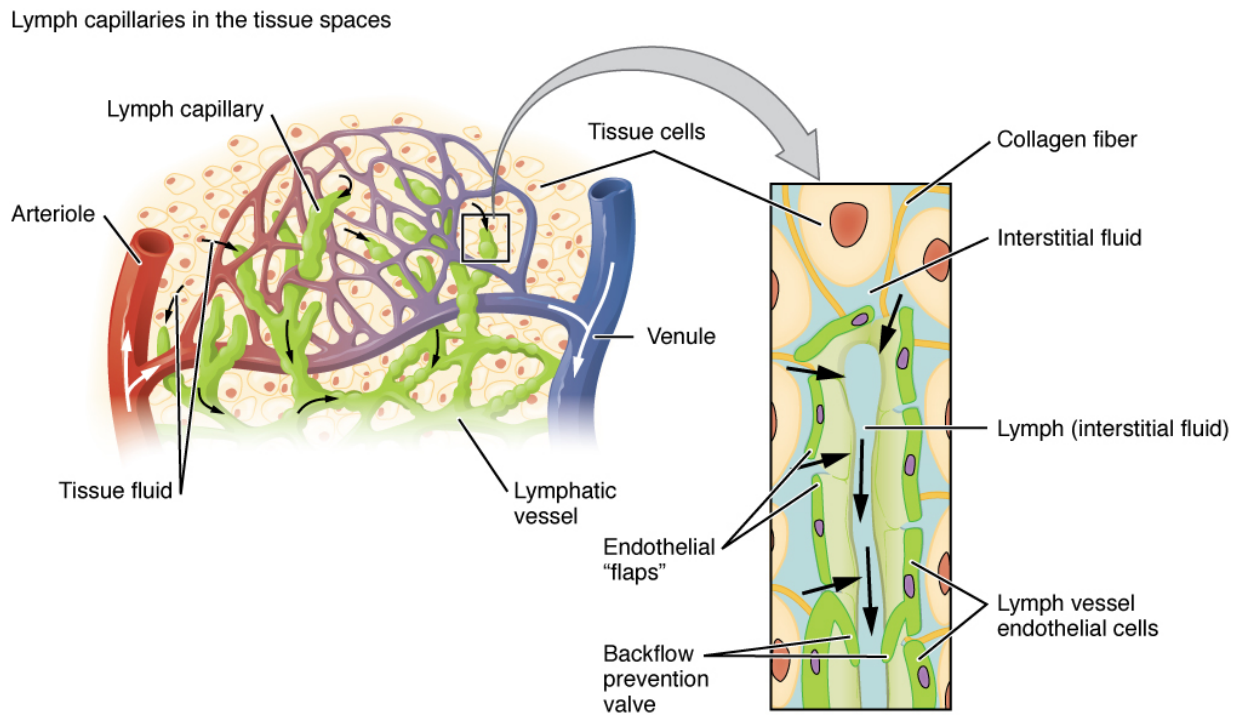


Figure 11.1 Lymph Capillaries

Lymph capillaries empty into larger lymphatic vessels that become larger and larger until they ultimately empty into the bloodstream at the left and right subclavian veins.

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3. "2202_Lymphatic_Capillaries.jpg" by OpenStax College is licensed under CC BY 3.0

Lymph Nodes

Immune system cells not only use lymphatic vessels to make their way from interstitial space into the circulation, but also use lymph nodes as major staging areas for the development of critical immune responses. **Afferent lymphatic vessels** (AF-ě-rěnt lim-FAT-ik VES-ěls) are vessels that lead into a lymph node, and **efferent lymphatic vessels** (EF-ě-rěnt lim-FAT-ik VES-ěls) are vessels that lead out of a lymph node.⁴

Lymph nodes (limf nōdz) are small, bean-shaped organs located throughout the lymphatic system. Lymph nodes store immune system cells (B cells and T cells) that help the body fight infection and also filter the lymph fluid to remove foreign material such as bacteria and cancer cells. Lymph nodes are also the sites of adaptive immune responses that are discussed in the “[Physiology of the Lymphatic and Immune Systems](#).”

Lymph travels through the lymph nodes near the groin, armpits, neck, chest, and abdomen. Humans have about 500–600 lymph nodes throughout the body.⁵ See Figure 11.2⁶ for an illustration of lymph vessels and nodes.

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6. “lymphaticimage-972×1024.jpg” by J. Gordon Betts, et al. is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

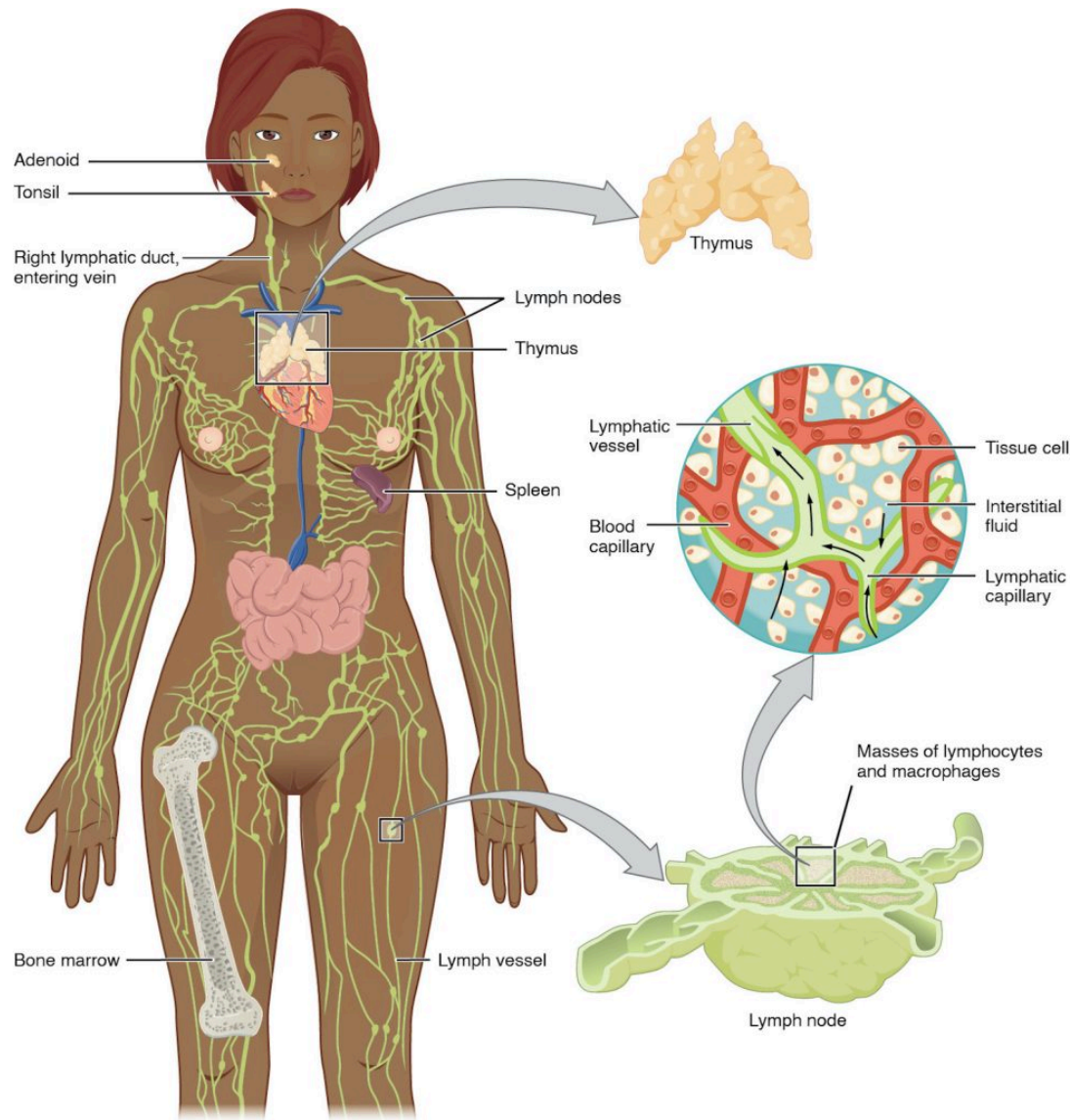


Figure 11.2 Anatomy of the Lymphatic System

A major distinction between the lymphatic and cardiovascular systems is that lymph is not actively pumped by the heart but is forced through the vessels by the contraction of skeletal muscles during body movements and breathing. One-way valves in lymphatic vessels keep the lymph moving toward the heart.⁷

When the lymphatic system is damaged in some way, such as by being blocked by cancer cells or destroyed by injury, lymph “backs up” from the lymph vessels into interstitial spaces. This inappropriate accumulation of fluid, referred to as **lymphedema** (limf-e-DẼ-ma), can cause serious medical consequences.

Primary Lymphoid Organs: Bone Marrow and Thymus

The primary lymphoid organs are the bone marrow and thymus gland. The lymphoid organs are where lymphocytes mature, proliferate, and are selected to attack pathogens.

A **lymphocyte** (lim-fa- SĪT) is a type of white blood cell that fights infection. There are two main types of lymphocytes: B cells and T cells. **B cells** (B sĕls) produce antibodies that are used to attack invading bacteria, viruses, and toxins. **T cells** (T sĕls) destroy the body’s own cells that have been taken over by viruses or become cancerous.⁸

Recall that all blood cells, including lymphocytes, are formed in the red bone marrow. The B cell undergoes nearly all of its development in the bone marrow, whereas the immature T cell, called a thymocyte, leaves the bone marrow and matures in the thymus gland. The **thymus gland** (THĪ-mŭs gland) is an organ found in the space between the sternum and the aorta of the heart (refer to Figure 11.2).⁹

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8. National Human Genome Research Institute. (2023, November 6). *Lymphocyte*. <https://www.genome.gov/genetics-glossary/Lymphocyte>
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Secondary Lymphoid Organs

Lymphocytes develop and mature in the primary lymphoid organs, but they mount immune responses from the secondary lymphoid organs. Secondary lymphoid organs include the spleen, tonsils, and lymph nodes.¹⁰

Spleen

The **spleen** (splēn) is sometimes called the “filter of the blood.” As discussed in the “[Anatomy of the Hematology System](#)” in the “Blood Terminology” chapter, the spleen stores and filters red blood cells and also produces white blood cells and antibodies to fight infection.

Tonsils

The **tonsils** (TON-sĭls) are lymphoid nodules located along the inner surface of the pharynx (throat) and are important in developing immunity to oral pathogens. There are five tonsils, including the pharyngeal tonsil (also called the adenoid) located behind the nasal cavity in the nasopharynx, two palatine tonsils located at the back of the mouth in the oropharynx, and two lingual tonsils attached to the tongue. See Figure 11.3¹¹ for an illustration of the palatine tonsils. Swelling or enlargement of the tonsils is an indication of an active immune response to infection. A major function of tonsils is to help children’s bodies recognize, destroy, and develop immunity to common environmental pathogens so that they will be protected in their later lives. However, tonsils are often removed for individuals who have recurring throat

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11. “[Throat_with_Tonsils_0011J.jpeg](#)” by [Klem](#) is licensed under [CC BY 3.0](#)

infections because swollen tonsils can interfere with breathing and/or swallowing.¹²

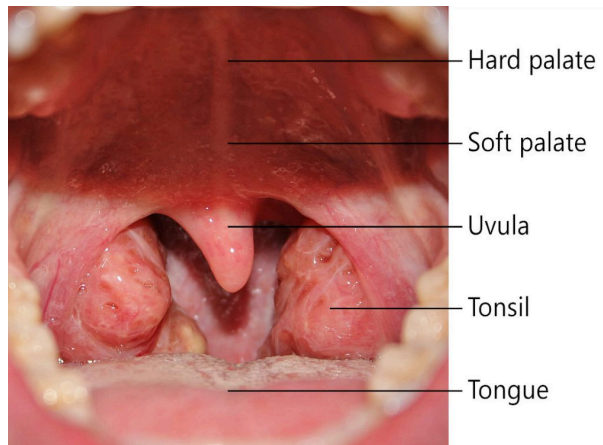


Figure 11.3 Location of the Palatine Tonsils

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11.5 Physiology of the Lymphatic and Immune Systems

IMMUNE RESPONSE

There are two basic processes in which the human body defends against microorganisms that cause infection, referred to as a nonspecific, innate immune response and a specific, adaptive immune response.

Innate Immune Response

The nonspecific, **innate immune response** (ĭn-NĀT i-MŪN ri-SPONS) refers to defenses that target invading pathogens in a nonspecific manner. It is called “innate” because it is present from the moment we are born. **Pathogens** (PĀTH-ō-jĕnz) refer to bacteria, viruses, or other microorganisms that can cause infection and disease. The innate immune response includes physical barriers, inflammation, and fever.¹

Physical Barriers

Physical barriers are the body’s basic defenses against infection. These physical barriers are also referred to as the body’s first line of defense. They include intact skin and mucous membranes, as well as mucus and enzymes,

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that physically destroy and/or remove pathogens and debris from areas of the body where they might cause harm or infection. Other examples of physical barriers include tears, acidity in the urine and reproductive tracts, and sebum (the protective oil secreted through hair follicles onto the skin).²

Internal Defenses

Internal defenses are also referred to as the body's second line of defense. These work to protect the body if a pathogen gets past the physical barriers and into the body. Examples of internal defenses include phagocytosis, inflammatory response, and fever.³

PHAGOCYTOSIS

Phagocytosis (făg-ō-sī-TŌ-sīs) refers to the process of cells engulfing and destroying pathogens (i.e., “cells eating”). Monocytes are a type of white blood cell that are macrophages (big eaters). Macrophages “eat up” damaged cells, pathogens, and debris. Another type of white blood cell called neutrophils are also called phagocytes, but as they “clean up,” they become toxic and die,

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creating pus. Neutrophils are typically the first cells on site to a new infection.⁴ See Figure 11.4⁵ for an image of phagocytosis.

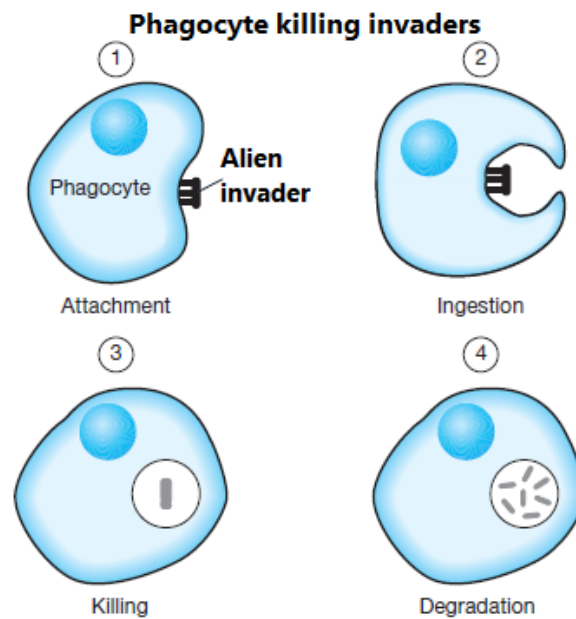


Figure 11.4 Phagocytosis

INFLAMMATORY RESPONSE

Inflammation (in-flă-MĀ-shŏn) is characterized by heat, redness, pain, and swelling. Although inflammation is often perceived as a negative consequence of injury or disease, it is an important process that recruits immune defenses to eliminate pathogens, remove damaged and dead cells, and initiate repair mechanisms.⁶

4. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Immune response; [reviewed 2022, Jan 23; cited 2023, Nov 7]. <https://medlineplus.gov/ency/article/000821.htm>

5. "phagocytes.png" by [zzzi zeth](#) is licensed in the Public Domain.

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During the **inflammatory response** (ĩn-FLĂM-ă-tör-ē ri-SPONS), the damaged cells release chemicals, including **histamine** (HIS-tă-mēn). These chemicals cause redness, heat, and increased permeability of blood vessels so fluid leaks into tissues, causing swelling. These chemicals also attract phagocytes and lymphocytes.⁷ See Figure 11.5⁸ for an image of inflammation.



Figure 11.5 Inflammation

FEVER

Fever (FĒ-vör), also referred to as pyrexia, is part of the inflammatory response that extends beyond the site of infection and affects the entire body, resulting in an overall increase in body temperature. Health care providers generally consider a fever to be 100.4°F (38°C) or higher. Fever enhances the innate

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8. [“Tickbite_Inflammation_2482a.jpg”](#) by [Túrelío](#) is licensed under [CC BY-SA 3.0-de](#)

immune response by stimulating white blood cells to kill pathogens. The rise in body temperature also inhibits the growth of many pathogens.⁹

View the following supplementary YouTube video¹⁰ on
 nonspecific innate immunity: [Immune System, Part 1: Crash Course Anatomy & Physiology #45](#)

Adaptive Immune Response

The **adaptive immune response** (ă-dăp-tīv ĭ-mūn rĭ-spōns) is activated when the nonspecific, innate immune response is insufficient to control an infection. The adaptive immune response requires the body's exposure to a pathogen to recognize it as a threat in order for it to respond. Exposure can be through direct contact or via immunization. After the adaptive immune system has been exposed to a pathogen, it develops memory cells to recognize this pathogen in the future and quickly mount a defense.¹¹

A **lymphocyte** (LIM-fō-sīt), a specific type of white blood cell, plays a key role

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10. CrashCourse. (2015, December 8). *Immune system, Part 1: Crash Course Anatomy & Physiology #45* [Video]. YouTube. All rights reserved. https://youtu.be/GIJK3dwCWCw?si=YFX4Rpb4U8a_dyPS

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in the adaptive immune response. There are two main groups of lymphocytes called B cells and T cells, both of which are formed in **bone marrow** (bōn MAR-ō). B cells mature in the bone marrow, and T cells mature in the thymus, the rationale for being called “B” cells and “T” cells. B cells are involved in humoral immunity (i.e., immune functions in the blood and other fluids in the body), and T cells are involved in cell-mediated defenses (i.e., fighting invaders within cells).¹²

HUMORAL IMMUNITY: B CELLS

Humoral immunity (HYŌŌ-mör-äl ĭ-mū-nĭ-tē) refers to the function of B cells and their production of antibodies. B cells originate and develop in the bone marrow and then migrate in body fluids through the lymph nodes, spleen, and blood to seek out and destroy pathogens in the interstitial spaces. B cells make plasma cells that produce Y-shaped proteins called **antibodies** (ANT-i-bod-ēz) that destroy pathogens based on their antigens. **Antigens** (ĀN-tĭ-jĕnz) are markers that tell the immune system whether something in the body is harmful or not. Antigens are found on viruses, bacteria, cancer cells, and even normal cells of the body. Each antigen has a unique shape that the immune system reads like a nametag to know whether or not it belongs in that person’s body. Antibodies are very specific to the antigens they recognize and destroy. They fit onto the antigen like a key to a lock.¹³

When a B cell finds an abnormal cell with an antigen that it has antibodies for, it binds to it and responds by cloning itself into many B cells and differentiating into plasma cells, which release thousands of antibodies per second to attack the pathogen. Some B cells become memory B cells that are

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13. Cleveland Clinic. (2022, August 16). *Antigen*. <https://my.clevelandclinic.org/health/diseases/24067-antigen>

involved in immunological memory to ensure a stronger and faster antibody response if the body is exposed to the same antigen in the future.

View the following supplementary YouTube video¹⁴ on
 adaptive immunity: [Immune System, Part 2: Crash Course Anatomy & Physiology #46](https://youtu.be/2DFN4IBZ3rI?feature=shared)

Passive Immunity

Passive immunity (PĀS-iv im-Ū-nīt-ē) is a type of immunity obtained by receiving antibodies produced by someone else. For example, infants have passive immunity because they are born with antibodies they received through the placenta from their mother. However, these antibodies are unable to create effector cells or memory cells, so it won't remember an antigen if it gets infected again. These antibodies disappear between 6 and 12 months of age. Breast milk also contains antibodies, so babies who are breastfed have passive immunity for a longer period of time.¹⁵

Passive immunization can also be transferred via an injection of antibodies formed by another person or animal. There are five classes of antibodies comprised of the following immunoglobulins: IgG, IgM, IgA, IgD, and IgE. Immunoglobulins provide immediate protection against an antigen, but do not provide long-lasting protection. For example, Hepatitis B Immune

14. CrashCourse. (2015, December 8). *Immune system, Part 2: Crash Course Anatomy & Physiology #46* [Video]. YouTube. All rights reserved. <https://youtu.be/2DFN4IBZ3rI?feature=shared>

15. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Immune response; [reviewed 2022, Jan 23; cited 2023, Nov 7]. <https://medlineplus.gov/ency/article/000821.htm>

Globulin (HBIG) is administered to individuals who have been exposed to hepatitis B as passive immunization to help fight the infection.¹⁶

CELL-MEDIATED RESPONSE: T CELLS

When nonspecific, innate immunity and humoral immunity are not effective in defending against pathogens or abnormal cells, the body responds with a **cell-mediated response** (Sĕl-mĕd-ē-āt-ed rĭ-spŏns) using lymphocyte T cells to destroy the abnormal cells. There are two major types of T cells called helper T cells and killer T cells¹⁷:

- Helper T cells use chemical messengers to activate the adaptive immune response. They stimulate B cells to make antibodies and help develop the killer T cells.
- Killer T cells, also called natural killer (NK) cells or cytotoxic cells, directly kill cells that have been invaded by a virus or are otherwise abnormal. They also clone themselves into many effector T cells and create memory T cells for immunological memory of the antigen.

See Figure 11.6¹⁸ for a comparison of the function of B cells and cytotoxic T cells. The purple cell is an invading virus. The B cells release antibodies to fight the virus and protect the body's cells from being invaded by the virus. The

16. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Immune response. <https://medlineplus.gov/ency/article/000821.htm>

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18. “General Effector Mechanisms of B and T Cells.png” by מרתה כסלו is licensed under CC BY-SA 4.0

cytotoxic T cells recognize body cells that have been infected by the virus and destroy them.

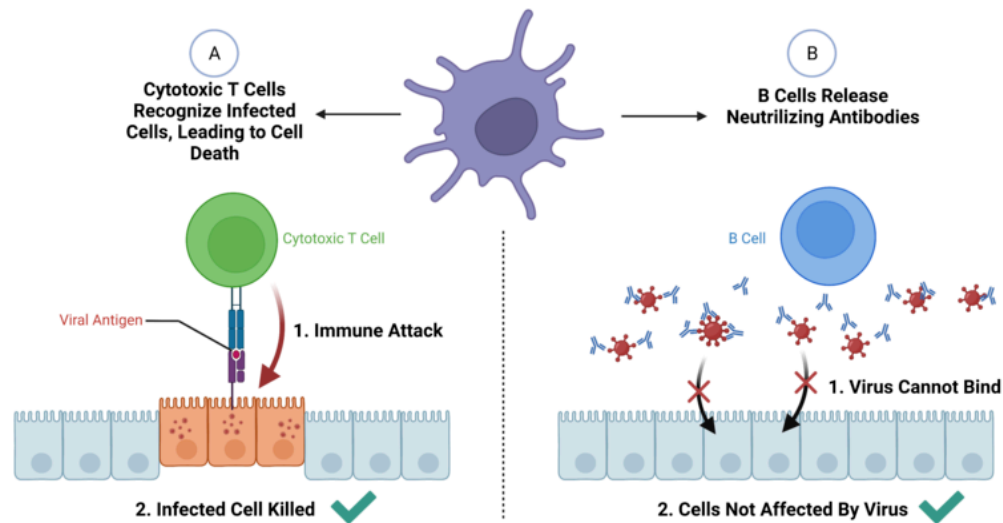


Figure 11.6 Functions of Cytotoxic T Cells and B Cells

Chemical messaging occurs during the immune response and includes cytokines. **Cytokines** (Sĭ-tō-kīnz) are proteins secreted by cells that act as chemical messengers in immune responses. When a pathogen enters the body, the first immune cell to notice the pathogen is like the conductor of an orchestra. That cell directs all the other immune cells by creating and sending out messages (cytokines) to the rest of the organs or cells in the body to respond to and initiate inflammation.¹⁹

See Figure 11.7²⁰ for an illustration of innate immunity and specific adaptive

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20. "2211 Cooperation Between Innate and Immune Responses.jpg" by OpenStax is licensed under CC BY 3.0

immunity using an example of a pathogen entering the body through the nose.

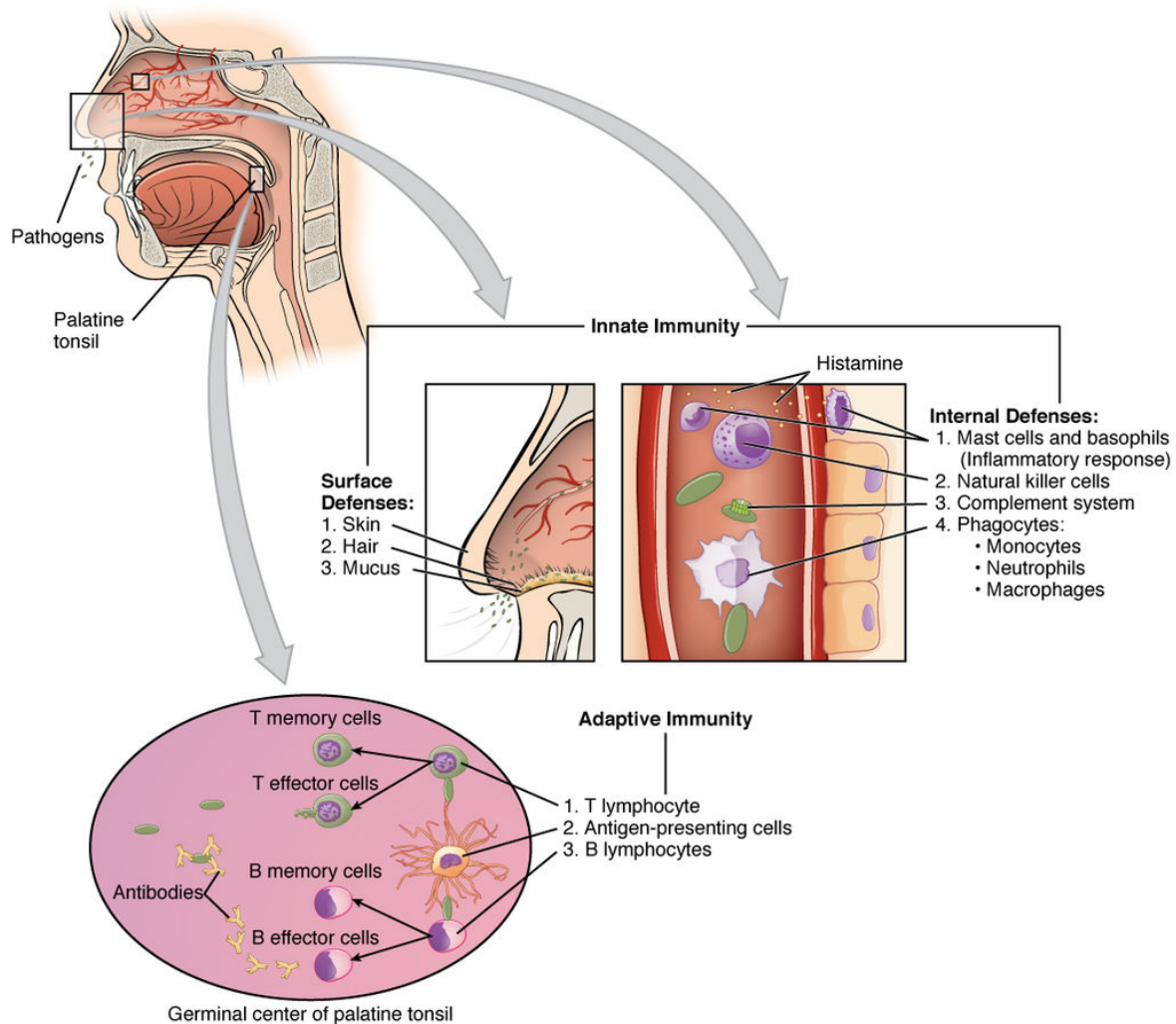


Figure 11.7 Innate Immunity and Specific Adaptive Immunity



View the following YouTube video²¹ on cell-mediated

21. CrashCourse. (2015, December 21). *Immune system, Part 3: Crash*



immune response: [Immune System, Part 3: Crash Course Anatomy & Physiology #47](#)

IMMUNOLOGICAL MEMORY

Immunological memory (im-yŭ-NOL-ŏ-jē- kăl MEM-ŏ-rē) refers to the ability of the adaptive immune response to mount a stronger and faster immune response upon reexposure to a pathogen. Memory B and T cells for each specific pathogen are created that provide long-term protection from reinfection with that pathogen. On reexposure, these memory cells facilitate an efficient and quick immune response. For example, when an individual recovers from chicken pox, the body develops a memory of the varicella-zoster virus that will specifically protect it from reinfection if exposed to the virus again.²²

Acquired immunity refers to immunity that develops with exposure to various antigens as an individual's immune system builds a defense. However, pathogens can mutate and change the shape of their antigens so the

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https://youtu.be/rd2cf5hValM?si=sd_XWq6Mn2Sm_Kt1

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immune system can no longer recognize or defend against it.²³ For example, influenza viruses mutate frequently, requiring annual influenza vaccination.

IMMUNIZATION

Immunization (ĩm-yū-nĩ-zā-shŏn)²⁴ is a method to trigger an individual's acquired immune response and prevent future disease. A vaccine is an agent administered by injection, orally, or by nasal spray that provides active acquired immunity to a particular infectious disease. Small doses of a viral antigen are given to activate immunological memory. Memory cells allow the body to react quickly if exposed to the recognized antigen and efficiently defend against the virus.²⁴

STRESS AND THE IMMUNE SYSTEM

Hormones released during the stress response (also known as the “fight or flight” response by the sympathetic nervous system) include epinephrine, cortisol, and corticosteroids. These hormones suppress T cell immune response, which can result in a weakened immune system. Additionally, long-term stress is associated with an increase in stress-related diseases like hypertension and coronary artery disease.²⁵

23. Cleveland Clinic. (2022, August 16). *Antigen*. <https://my.clevelandclinic.org/health/diseases/24067-antigen>

24. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Immune response; [reviewed 2022, Jan 23; cited 2023, Nov 7]. <https://medlineplus.gov/ency/article/000821.htm>

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THE IMMUNE RESPONSE AND CANCER

There are three stages of the immune response to many malignancies²⁶ :

- **Elimination** (ĩ-lĩm-ĩ-nā-shŏn) occurs when the immune response first develops antibodies toward tumor-specific antigens and actively kills most cancer cells.
- **Equilibrium** (ē-kwĩ-lĩb-rē-ŭm) is the period that follows elimination when remaining cancer cells are held in check.
- **Escape** (ěs-kāp) from the immune response occurs because many cancers mutate and no longer express specific antigens for which the immune system responds.

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11.6 Diseases and Disorders of the Lymphatic and Immune System

Immune system disorders occur when the immune response is directed against normal body tissue or is excessive or deficient. For example, an **allergy** (AL-ĕr-jĕ) is an inflammatory response due to a hypersensitivity to a substance that most people's bodies perceive as harmless. Histamine released during the immune response is a primary cause of allergy and anaphylactic shock symptoms. **Autoimmune disease** (OT-ō-im-yŭn diz-ĒZ) is the inability of the body to distinguish its own cells from foreign invaders, producing antibodies that attack its own tissues. **Immunodeficiency** (ĭm-yŭ-nō-dĕ-FISH-ĕn-sĕ) results from a failure or absence of lymphocytes and phagocytes. Immunodeficiencies can be either primary or secondary.¹ These conditions are further discussed in the following subsections.

HYPERSENSITIVITY REACTIONS

The body's immune responses are essential defense mechanisms designed to protect us against threats, including infections and cancer. However, an individual's immune system can have an exaggerated immune response triggered by exposure to a specific antigen, referred to as a **hypersensitivity**

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(hī-pěr-sĕn-sĭ-TĭV-ĭ-tē) reaction. This kind of exaggerated reaction can damage normal tissues and cause a range of health issues.²

Allergic (AL-ĕr-jĭk) responses are specific types of hypersensitivity reactions that arise when the immune system reacts to allergens. **Allergens** (AL-ĕr-jĕnz) are substances that are generally harmless to most individuals. Common allergens include pollen, dust mites, pet dander, certain foods, and insect venom. When a person with allergies encounters these allergens, their immune system goes into overdrive, releasing histamines and other inflammatory molecules that trigger symptoms such as itching, sneezing, wheezing, hives, or anaphylaxis.

Anaphylaxis (ăn-ă-fĭ-LĂK-sĭs) is a severe, potentially life-threatening allergic reaction that can cause bronchoconstriction and swelling of the throat, leading to obstruction of the airway, as well as decreased cardiac output that can lead to shock. Recognition of early symptoms and signs of anaphylaxis and prompt intervention are crucial. Treatment typically involves the administration of epinephrine to counteract the systemic effects of anaphylaxis and stabilize the patient's condition.³

See Table 11.6 for a summary of hypersensitivity reactions, examples, and treatments.

Table 11.6. Hypersensitivity Reactions⁴

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Hypersensitivity Type	Description	Mechanism	Examples	Treatments
Type 1 Hypersensitivity (Immediate)	Rapid and excessive immune responses to harmless antigens (allergens) that lead to allergic reactions.	Upon initial exposure, sensitization occurs with production of IgE antibodies against the allergen. Upon subsequent exposure, the allergen binds to IgE antibodies, triggering the release of inflammatory mediators like histamine.	Inhaled allergens (pollens, animal dander), ingested allergens (foods, drugs), injected allergens (bee venom, drugs), contacted allergens (latex, environmental proteins); anaphylactic reactions can occur.	Antihistamines for allergic symptoms; corticosteroids for severe allergic reactions; epinephrine for anaphylactic reactions.
Type 2 Hypersensitivity (Cytotoxic)	Antibodies target antigens on cell surfaces, leading to the destruction or dysfunction of the affected cells.	Antibodies (IgG, IgM) bind to antigens on cell surfaces, triggering immune-mediated destruction through complement activation or antibody-dependent cell-mediated cytotoxicity.	Incompatible blood transfusion reactions and hemolytic disease of newborn (when Rh+ newborns are born to Rh- mothers who have existing antibodies to Rh+ blood).	Administer compatible blood product transfusions and plasmapheresis, as indicated.
Type 3 Hypersensitivity (Immune Complex)	Immune complexes formed between antibodies and antigens deposit in various tissues, leading to localized inflammation.	Immune complexes attract neutrophils, causing inflammation and tissue damage at the site of deposition.	Systemic lupus erythematosus and rheumatoid arthritis.	Anti-inflammatory medications.

Type 4 Hypersensitivity (Delayed)	Cell-mediated immune responses, mediated by T cells, cause inflammation and tissue damage.	Sensitized T cells recognize antigens and release cytokines that recruit inflammatory cells and induce tissue damage.	Contact dermatitis, tuberculin skin test reactions, and graft rejection.	Corticosteroids for severe reactions.
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Autoimmune Reactions

Autoimmune reactions (ǎ-tō-ĭ-mūn rē-ăk-shŏns) refer to actions within the body where one's own immune system initiates a response against the body's own healthy cells, tissues, or organs. When the body's immune system is functioning correctly, the body can recognize bacteria, viruses, or any abnormal invader. In autoimmune reactions, the body cannot always distinguish its own healthy cells and begins to target immune actions inappropriately against itself.⁵

Graft Reactions

The transplantation of tissues to replace diseased organs is an important medical therapy used for a variety of diseases and disorders. Adaptive immune responses are major barriers to successful transplantation. **Graft** (grăft) refers to transplanted donated tissue or organs.

Graft rejection (grăft rĭ-jĕk-shŏn) is caused by the patient's adaptive immune response to antigens on the donated graft that are interpreted as "foreign." To help prevent graft rejection, tissue typing (i.e., matching) of the organ donor and the person receiving the organ is performed. The more similar the antigens are between the donor and recipient, the less likely that the organ will be rejected. Recipients of donated grafts must typically take immunosuppressive medications for their lifetime to prevent their immune system from attacking the transplanted tissue.

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An opposite type of graft reaction can occur in donated bone marrow transplants called graft-versus-host disease (GVHD). Recall that “graft” refers to transplanted donated tissue or organs, and “host” refers to the tissues of the recipient. During GVHD, the transplanted bone marrow cells mount an immune response against the recipient’s tissues. GVHD occurs because the bone marrow cells being transplanted contain lymphocytes. Because the recipient’s bone marrow and adaptive immune response were destroyed with chemotherapy before receiving the bone marrow transplant, they cannot defend themselves against the attack. Patients undergoing bone marrow transplants receive preventative treatment with immunosuppressive medications for several months after the surgery to prevent GVHD. If GVHD does occur, the patient is treated with increased levels of immunosuppressive medications, as well as corticosteroids.

CANCER

Cancer (KĀN-sŏr) refers to abnormal cells that overgrow and have the ability to invade and harm tissues. **Malignant** (mă-lĭg-nănt) cells differ from benign cells in that malignant cells exhibit uncontrolled growth and rapidly divide, subsequently invading and causing damage to normal functioning cells. Some cancers also disrupt **apoptosis** (ap-ŏp-TŌ-sĭs), programmed cell death to regulate cell population. Malignant cells also have the potential to metastasize, or spread, to different parts of the body. **Benign** (bĭ-nĭn) cells grow and divide in a more controlled manner, remaining localized to a certain area.

Malignant cells are the most dangerous due to their ability to metastasize. When cells **metastasize** (mě-tăs-tă-sĭz), they spread through the blood or lymphatic system. The spread of cancer cells and their rapid replication and invasion in other areas of the body complicate medical treatment, making it

more difficult to rid the body of these abnormal invasive cells.⁶ See Figure 11.8⁷ for an illustration comparing benign and malignant tumors.

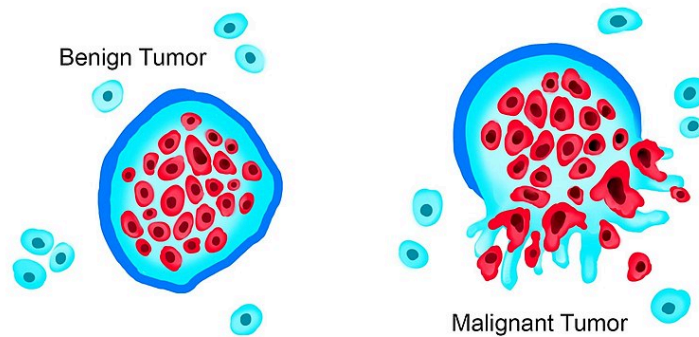


Figure 11.8 Benign and Malignant Tumors

The distinction between benign and malignant growths is also reflected in the associated medical interventions and prognosis. Benign growth is typically managed through close monitoring and/or minimal surgical interventions. For example, a benign tumor may be surgically removed with no further medical treatment required. However, malignant growths require prompt, targeted medical interventions to prevent progression and metastasis of cancer to other areas of the body.⁸

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7. [“Tumor_Types_MTK.jpg”](#) by WolfpackBME is licensed under [CC BY-SA 4.0](#)

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Metastasis

Metastasis of cancer cells can occur in different parts of the body. See Figure 11.9⁹ for an illustration of metastasis of a primary tumor.

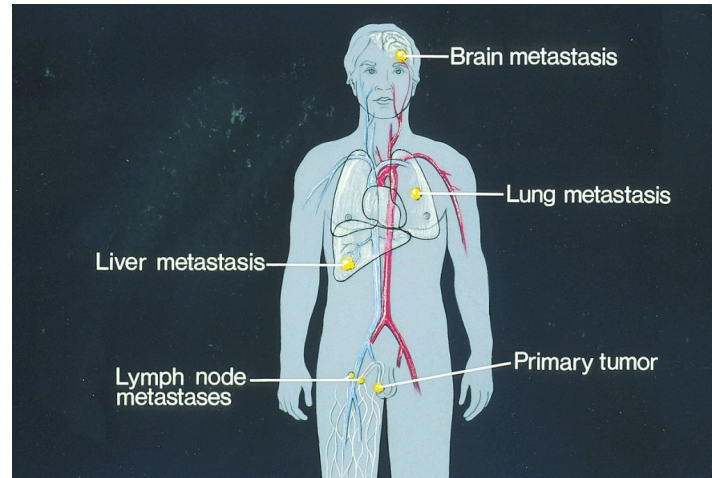


Figure 11.9 Metastasis

Common sites of metastasis include the following areas¹⁰:

- **Lungs** (lŭngz): The lungs are a frequent site of metastasis because they receive a large volume of blood from the body's circulation. Cancer cells circulating in the bloodstream can easily lodge in the small blood vessels of the lungs, leading to secondary tumor formation.
- **Liver** (lĭv-ĕr): The liver plays a significant role in blood filtration, making it another common site for metastasis.
- **Bones** (bŏnz): Many cancers, such as breast, lung, and prostate cancer,

9. "[Sites_of_potential_metastases_illustration.jpg](#)" by unknown author, via [National Cancer Institute](#) is licensed in the [Public Domain](#).

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have a tendency to metastasize to the bones.

- **Brain** (brān): Cancer cells can reach the brain through the bloodstream.
- **Lymph Nodes** (limf nōdz): Lymph nodes play a role in filtering lymph. Tumors located in close proximity to the lymph nodes, especially breast, gastrointestinal, urological, gynecological, and some skin cancers, are more likely to spread through the lymphatic system.
- **Small and Large Intestines** (smôl ănd lărj in-TĚS-tĭnz): The small and large intestines, including the colon and rectum, are susceptible to metastasis, particularly in colorectal cancer. Cancer cells from the colon can also spread to nearby lymph nodes and to the liver.
- **Adrenal Glands** (ă-DRĚ-năl glăndz): The adrenal glands that sit atop the kidneys can be affected by metastatic cancer. The adrenal glands have a rich blood supply, making them potential targets for cancer cells circulating in the bloodstream.
- **Skin** (skĭn): Melanoma, a type of skin cancer, has a propensity to spread to other parts of the body, including distant skin sites and internal organs.
- **Ovaries** (Ō-vă-rēz): In women, ovarian metastasis can occur from cancers that have spread through the bloodstream or lymphatic system. Breast, colorectal, and stomach cancers are examples of cancers that can metastasize to the ovaries.
- **Kidneys** (KĭD-nēz): Kidney metastasis can occur when cancer cells from other parts of the body reach the kidneys through the bloodstream. The kidneys filter the blood, making them a potential site for cancer cells to become trapped.

Cancer-Causing Viruses

Some cancers are caused by viruses, such as liver cancer caused by the hepatitis B virus and cervical cancer caused by the **human papilloma virus** (hū-măn pă-pĭ-LŌ-mă vī-rŭs) (**HPV**). Both of these viruses have vaccines available to prevent disease, so vaccination can also help prevent cancer by stimulating the immune response. **Kaposi's sarcoma** (kă-PO-sēz sār-KŌ-mă), caused by the herpes virus, is an example of cancer caused by a virus that is

almost never observed in individuals with strong immune systems. See Figure 11.10¹¹ for an image of Kaposi's sarcoma.



Figure 11.10 Kaposi's Sarcoma

IMMUNODEFICIENCIES

Immunodeficiency (im-yŭ-nō-dě-FISH-ĕn-sē) refers to inadequate immune response caused by immune system dysfunction. Someone who has an impaired or weakened immune system is referred to as **immunocompromised** (im-yū-nō-KŎM-prō-mīzd).

Inherited immunodeficiencies arise from genetic mutations that affect specific components of the immune response. Individuals can also acquire immunodeficiencies, such as acquired immunodeficiency syndrome (AIDS) caused by the human immunodeficiency virus (HIV).¹²

11. "[Kaposi's Sarcoma Lesions.jpg](#)" by OpenStax College is licensed under [CC BY-SA 3.0](#)

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Inherited Immunodeficiencies

While many inherited immunodeficiencies exist, the most serious is **severe combined immunodeficiency disease** (sē-vēr kōm-BĪND ĭm-yū-nō-dě-FISH-ĕn-sē dĩ-zēz) (**SCID**). This complex disease is caused by many different genetic defects that result in impaired B cell and T cell functioning of the adaptive immune response. Children with this disease usually die of opportunistic infections within their first year of life unless they receive a bone marrow transplant. **Opportunistic infection** (ōp-ōr-tū-NĪS-tĭk ĭn-FĚK-shōn) are infections that occur more often or are more severe in people with weakened immune systems than in people with healthy immune systems. An example of an opportunistic infection is pneumonia caused by *Candida*, a type of yeast.¹³

Acquired Immunodeficiency

The **human immunodeficiency virus** (hū-măn ĭm-yū-nō-dě-FISH-ĕn-sē vī-rŭs) (**HIV**) can completely wipe out the functioning of an individual's immune system if it progresses to **acquired immunodeficiency syndrome** (ādz āk-wīrd ĭm-yū-nō-dě-FISH-ĕn-sē sĭn-drōm) (**AIDS**). HIV is transmitted through semen, vaginal fluids, and blood. The presence of detectable anti-HIV antibodies in a person's blood indicates a positive HIV test, referred to as **seroconversion** (sē-rō-kōn-VĚR-zhōn).¹⁴

After seroconversion, the amount of HIV circulating in the blood drops and stays at a low level for several years. During this time, the levels of **CD4 T cells** (sē-dē fōr tē sĕlz), helper T cells, decline steadily, until at some point, the

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immune response is so weak that opportunistic diseases develop and eventually result in death. Treatment of HIV consists of drugs that target proteins necessary for viral replication but are absent from normal human cells. By targeting the virus itself and sparing the cells, this approach has been successful in significantly prolonging the lives of HIV-positive individuals.¹⁵

LYMPHOMA

Lymphoma (lĭm-FŌ-mă) is cancer that originates from the lymphatic system. There are two main types of lymphoma called Hodgkin lymphoma and non-Hodgkin lymphoma.

In **Hodgkin lymphoma** (HŎJ-kĭn lim-FŌ-mă), lymphocytes grow out of control, causing swollen lymph nodes and growths throughout the body. Treatments for Hodgkin lymphoma include chemotherapy, radiation therapy, targeted therapy (i.e., drugs or other substances that attack specific cancer cells with less harm to normal cells), and cancer immunotherapy. Hodgkin lymphoma can usually be cured if it is found and treated early.¹⁶

Non-Hodgkin lymphoma (nŏn-HŎJ-kĭn lim-FŌ-mă) (**NHL**) is a diverse group of blood cancers that includes all types of lymphoma except Hodgkin's lymphomas. NHL is much less predictable than Hodgkin lymphoma and is

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16. MedlinePlus [Internet]. Bethesda (MD): National Library of Medicine (US); [updated 2022, Apr. 4]. Hodgkin lymphoma; [cited 2023, Nov. 7]. <https://medlineplus.gov/hodgkinlymphoma.html>

more likely to metastasize. The prognosis depends on the type of white blood cell, the stage of the cancer, and the treatment options.¹⁷

17. National Cancer Institute. (2023, May 18). *Non-Hodgkin lymphoma treatment (PDQ) – Health professional version*. National Institutes of Health.
<https://www.cancer.gov/types/lymphoma/hp/adult-nhl-treatment-pdq>

11.7 Medical Specialists, Diagnostic Testing, and Procedures Related to the Lymphatic and Immune Systems

MEDICAL SPECIALISTS

Immunology (im-yŭ-NOL-ŏ-jē) is the study of disorders of the immune system. An **immunologist** (im-ŭ-NŎL-ŏ-jĭst) is a physician who specializes in the study and treatment of immune system disorders.

An **allergist** (AL-ěr-jĭst) is a physician who specializes in the study and treatment of allergies.

- ▶ Read more about careers in allergy and immunology on the [American Academy of Allergy Asthma and Immunology's Careers web page](#).

DIAGNOSTIC TESTING

Lymph Node Biopsy

During a lymph node biopsy, lymph node tissue is removed for examination under a microscope by a pathologist to diagnose medical conditions like infection or cancer. There are different types of lymph node biopsies, including the following¹:

- **Needle biopsy** (NĒ-dīl BĪ-öp-sē): After applying local anesthesia, a radiologist inserts a needle into a lymph node using ultrasound or CT scan to find the node.
- **Laparoscopic lymph node biopsy** (lăp-ăr-ö-SKÖ-pĭk limf nōd BĪ-öp-sē): After the patient is placed under general anesthesia, a small tube with a light and camera is inserted through a small incision. One or more other incisions will also be made for the insertion of tools to locate and remove the lymph node.
- **Open lymph node biopsy** (Ō-pĕn limf nōd BĪ-öp-sē): Surgery is performed to remove all or part of a lymph node, typically performed if the lymph node is large enough to be felt on physical exam.
- **Sentinel lymph node biopsy** (SĔN-tĭ-nĕl limf nōd BĪ-öp-sē): For some cancers, a sentinel lymph node biopsy is performed to find the best lymph nodes to biopsy. A tiny amount of a radioactive tracer or dye is injected in the area of the tumor. The tracer or dye flows into the nearest lymph nodes, the first lymph nodes to which a cancer may spread. These lymph nodes, called the sentinel nodes, are removed and analyzed.

Skin Testing for Allergies

Skin testing for allergies is performed by an immunologist or allergist to

1. Medline Plus. (2022). *Lymph node biopsy*. <https://medlineplus.gov/ency/article/003933.htm>

identify allergens in Type I hypersensitivity. In skin testing, allergen extracts are injected into the patient's epidermal layer of the skin. The development of a wheal at the site of injection indicates a positive result. Based on the test results, individuals should avoid allergens that trigger a Type I hypersensitivity reaction. See Figure 11.11² for an image of allergy testing with wheals indicating positive responses to an allergen.



Figure 11.11 Allergy Testing

Tissue Typing

Tissue typing (TĪSH-ū tī-pĭng) ensures that an organ from a donor will be compatible with its recipient. The process starts with identifying the unique **human leukocyte antigens** (hyū-măn lū-kō-sīt ĀN-tĭ-jĕnz) (**HLAs**) for the organ donor and recipient, either from blood or tissue. HLAs are an important part of the immune system's response to foreign substances and act as a barcode to distinguish “self” from “non-self” — the latter resulting in rejection of the transplanted organ.³

2. “[Another_allergy_skin_testing.jpg](#)” by [Ismael Olea](#) is licensed under [CC BY 4.0](#)

3. Brunk-Young, J. (2021, April 30). *What is tissue typing for transplant?* The Ohio

To date, more than 35,000 variations of the HLA protein have been identified. This makes it extremely difficult to find HLA-matched donors for transplant recipients. Half of a person's antigens are inherited from their mother and half from their father, so the more similar the antigen patterns are from two people, the more likely it is that those people are related. Identical twins have the same pattern, and brothers and sisters have a 1-in-4 chance of having an identical match.⁴

PROCEDURES RELATED TO THE LYMPHATIC AND IMMUNE SYSTEM

Splenectomy

Splenectomy (splĕ-NĔK-tŏ-mĕ) refers to surgical removal of a diseased or damaged spleen. Because of the important role the spleen plays in the immune system, individuals who have had a splenectomy are at increased risk of infection for the remainder of their lives.

Tonsillectomy

The tonsils help protect against infections. However, abnormally large tonsils may be removed if they contribute to recurrent cases of **tonsillitis** (tŏn-sĭl-Ī-tĭs) or breathing problems, especially at night. During a **tonsillectomy** (tŏn-sĭl-ĔK-tŏ-mĕ), the patient is placed under general anesthesia and the tonsils are

State University Wexner Medical Center. <https://wexnermedical.osu.edu/blog/tissue-typing>

4. Brunk-Young, J. (2021, April 30). *What is tissue typing for transplant?* The Ohio State University Wexner Medical Center. <https://wexnermedical.osu.edu/blog/tissue-typing>

removed by a surgeon. The adenoid, located behind the nasal cavity, may also be removed during this surgery and is referred to as an **adenoidectomy** (ăd-ě-noid-ĔK-tŏ-mē).⁵

5. Medline Plus. (2023). *Tonsillectomy*. <https://medlineplus.gov/ency/article/003013.htm>

11.8 Lymphatic and Immune System Learning Activities

Interactive Learning Activity: Practice labelling the parts of the lymphatic system using this drag and drop activity.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=4761#h5p-212>

Interactive Learning Activity: Study medical terms related to the lymphatic and immune system that are discussed in this chapter using these flashcards.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=4761#h5p-185>

Interactive Learning Activity: Test your knowledge on concepts related to the immune system.



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<https://wtcs.pressbooks.pub/medterm/?p=4761#h5p-19>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



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<https://wtcs.pressbooks.pub/medterm/?p=4761#h5p-16>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



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<https://wtcs.pressbooks.pub/medterm/?p=4761#h5p-17>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



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<https://wtcs.pressbooks.pub/medterm/?p=4761#h5p-18>



Interactive Learning Activity: Practice identifying and defining word parts for terms discussed in this chapter.



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<https://wtcs.pressbooks.pub/medterm/?p=4761#h5p-202>

- ▶ You can also print this as a [Chapter 11 Practice Worksheet](#) and check your answers with this [Answer Key PDF](#).

11.9 Glossary

Acquired immunodeficiency syndrome (ādz āk-wīrd ĩm-yū-nō-dě-FISH-ěň-sē sĭn-drōm) (AIDS): A disease caused by HIV leading to a significant weakening of the immune system. ([Chapter 11.6](#))

Adaptive immune response (ă-dăp-tĭv ĩ-mūn řĭ-spōns): It is activated when the innate immune response is insufficient to control an infection. It requires exposure to a pathogen to recognize it as a threat, leading to the development of memory cells for future defense. ([Chapter 11.5](#))

Adenoidectomy (ăd-ě-noid-ĚK-tō-mē): The surgical removal of the adenoid, which is located behind the nasal cavity, often performed along with a tonsillectomy. ([Chapter 11.7](#))

Allergens (AL-ěr-jěnz): Substances that are usually harmless but can cause allergic responses in some people. Common allergens include pollen, dust mites, pet dander, certain foods, and insect venom. ([Chapter 11.6](#))

Allergist (AL-ěr-jĭst): A physician specializing in the study and treatment of allergies. ([Chapter 11.7](#))

Allergy (AL-ěr-jē): An inflammatory response due to hypersensitivity to a substance that most people's bodies perceive as harmless, such as pollen or certain foods. Histamine release during the immune response is a primary cause of allergy symptoms. ([Chapter 11.6](#))

Anaphylaxis (ăn-ă-fĭ-LĂK-sĭs): A severe, potentially life-threatening allergic reaction. Treatment often involves epinephrine administration. ([Chapter 11.6](#))

Antibodies (ANT-i-bod-ēz): Proteins that are very specific to the antigens they recognize and destroy, fitting onto the antigen like a key to a lock. ([Chapter 11.5](#))

Antigens (ĂN-tĭ-jěnz): Markers that tell the immune system whether something in the body is harmful or not, found on viruses, bacteria, cancer cells, and even normal cells of the body. ([Chapter 11.5](#))

Apoptosis (ap-ōp-TŌ-sĭs): Programmed cell death that is disrupted in some cancers, allowing malignant cells to avoid natural cell death and continue uncontrolled growth. ([Chapter 11.6](#))

Autoimmune disease (OT-ō-im-yūn diz-ĒZ): The inability of the body to distinguish its own cells from foreign invaders, resulting in the production of antibodies that attack its own tissues. ([Chapter 11.6](#))

Autoimmune reactions (ō-tō-ī-mūn rē-āk-shōns): Responses within the body where the immune system mistakenly initiates a response against the body's own healthy cells, tissues, or organs, failing to distinguish them from harmful invaders. ([Chapter 11.6](#))

B cells (B sělz): A type of lymphocyte that plays a significant role in the humoral immune response. ([Chapter 11.4](#))

Benign (bī-nīn): Cells that overgrow and divide in a controlled manner, remaining localized to a certain area. They are less dangerous compared to malignant cells because they do not metastasize. ([Chapter 11.6](#))

Bone marrow (bōn MAR-ō): The primary lymphoid organ where B cells and T cells mature and are selected to attack pathogens. All blood cells, including lymphocytes, are formed in the red bone marrow. ([Chapter 11.5](#))

Cancer (KĀN-sōr): Abnormal cells that overgrow and have the ability to invade and harm tissues. Malignant cells differ from benign cells in that they exhibit uncontrolled growth and have the potential to metastasize. ([Chapter 11.6](#))

CD4 T cells (sē-dē fōr tē sělz): Helper T cells whose levels decline steadily in HIV-positive individuals, leading to weakened immune response. ([Chapter 11.6](#))

Cell-mediated response (Sěl-mēd-ē-āt-ed rī-spōns): An immune response that involves T cells destroying abnormal cells when nonspecific innate immunity and humoral immunity are not effective. ([Chapter 11.5](#))

Chyle (kīl): A milky bodily fluid consisting of lymph and emulsified fats, absorbed from the intestines during digestion. ([Chapter 11.4](#))

Cytokines (Sī-tō-kīnz): Proteins secreted by cells that act as chemical messengers in immune responses, directing immune cells to respond to and initiate inflammation. ([Chapter 11.5](#))

Equilibrium (ē-kwī-līb-rē-ŭm): In a medical context, it often refers to a state of balance or stability, particularly in physiological or biochemical processes. ([Chapter 11.5](#))

Fever (FĒ-vōr): A part of the inflammatory response that results in an overall

increase in body temperature, enhancing the innate immune response by stimulating white blood cells to kill pathogens. ([Chapter 11.5](#))

Graft (grăft): Transplanted tissue or organ. ([Chapter 11.6](#))

Graft rejection (grăft rǐ-jěk-shǒn): A complication after graft surgery caused by the recipient's immune response to antigens on the donated graft. ([Chapter 11.6](#))

Histamine (HIS-tǎ-mēn): A chemical released during the inflammatory response, causing increased permeability of blood vessels, redness, heat, and swelling. ([Chapter 11.5](#))

Hodgkin lymphoma (HÖJ-kǐn lim-FŌ-mǎ): Cancer originating from the lymphatic system, characterized by out-of-control growth of lymphocytes, causing swollen lymph nodes and growths throughout the body. ([Chapter 11.6](#))

Human immunodeficiency virus (hū-mǎn ĩm-yū-nō-dě-FISH-ě̃n-sē vī-rŭs) (HIV): A virus that can lead to acquired immunodeficiency syndrome (AIDS) and severely impair the immune system. ([Chapter 11.6](#))

Human leukocyte antigens (hyū-mǎn lū-kō-sīt ĀN-tǐ-jěnz) (HLAs): Proteins that are part of the immune system's response to foreign substances and help distinguish "self" from "non-self." ([Chapter 11.7](#))

Human papilloma virus (hū-mǎn pǎ-pǐ-LŌ-mǎ vī-rŭs) (HPV): A virus that can cause cervical cancer, with vaccines available for prevention. ([Chapter 11.6](#))

Humoral immunity (HYŌŌ-mǒr-ǎl ĩ-mū-nǐ-tē): Part of the immune response that refers to the function of B cells and their production of antibodies that target antigens. ([Chapter 11.5](#))

Hypersensitivity (hī-pěr-sě̃n-sǐ-TĪV-ĭ-tē): An exaggerated immune response triggered by exposure to a specific antigen, which can damage normal tissues and cause a range of health issues. ([Chapter 11.6](#))

Immune system (ĭ-MŪN SĪS-tēm): A complex collection of cells and organs that destroys or neutralizes pathogens, preventing infection, disease, or death. ([Chapter 11.4](#))

Immunization (ĭm-yū-nǐ-zā-shǒn): A method to trigger an individual's acquired immune response and prevent future disease, often through the administration of a vaccine. ([Chapter 11.5](#))

Immunocompromised (ĩm-yũ-nō-KŎM-prō-mĩzd): Someone with an impaired or weakened immune system. ([Chapter 11.6](#))

Immunodeficiency (ĩm-yũ-nō-dě-FISH-ě̃n-sē): Inadequate immune response due to immune system dysfunction. ([Chapter 11.6](#))

Immunological memory (ĩm-yũ-NOL-ŏ-jē- kǎl MEM-ŏ-rē): The adaptive immune response's ability to mount a stronger and faster response upon reexposure to a pathogen, with memory B and T cells providing long-term protection. ([Chapter 11.5](#))

Immunologist (ĩm-yũ-NŎL-ŏ-jĩst): A physician who specializes in the diagnosis and treatment of immune system disorders. ([Chapter 11.7](#))

Immunology (ĩm-yũ-NŎL-ŏ-jē): The study of disorders of the immune system. ([Chapter 11.7](#))

Inflammation (ĩn-flǎ-MĀ-shŏn): A localized physical condition in which part of the body becomes reddened, swollen, hot, and often painful, especially as a reaction to injury or infection. ([Chapter 11.5](#))

Inflammatory response (ĩn-FLĀM-ǎ-tŏr-ē ri-SPONS): A biological response to harmful stimuli, such as pathogens or damaged cells, characterized by redness, swelling, heat, and pain. ([Chapter 11.5](#))

Innate immune response (ĩn-NĀT i-MŪN ri-SPONS): A nonspecific defense mechanism that begins immediately or within hours of an antigen's appearance in the body. ([Chapter 11.5](#))

Interstitial space (ĩn-těr-STISH-ǎl spās): The space between individual cells in the tissues. ([Chapter 11.4](#))

Kaposi's sarcoma (kǎ-PO-sēz sār-KŎ-mǎ): A cancer caused by the herpes virus, typically observed in individuals with weakened immune systems. ([Chapter 11.6](#))

Laparoscopic lymph node biopsy (lǎp-ǎr-ŏ-SKŎ-pĩk limf nŏd Bĩ-ŏp-sē): A minimally invasive procedure performed under general anesthesia, where a small tube with a light and camera is used to remove lymph node tissue. ([Chapter 11.7](#))

Lymph (lĩmf): A clear-to-white fluid that transports immune system cells, dietary lipids, and fat-soluble vitamins absorbed in the small intestine. ([Chapter 11.4](#))

Lymphatic system (lĩmf-ǎ-TĩK sĩs-tũm): A network of organs, lymph nodes,

lymph ducts, and lymph vessels that produce and transport lymph from tissue spaces to the bloodstream and is a major part of the body's immune system. ([Chapter 11.4](#))

Lymphedema (limf-e-DĒ-ma): Inappropriate accumulation of fluid in interstitial spaces, often caused by damage to the lymphatic system. ([Chapter 11.4](#))

Lymph nodes (limf nōdz): Small bean-shaped organs located throughout the lymphatic system that store immune system cells and filter lymph fluid to remove foreign material. ([Chapter 11.4](#), [Chapter 11.6](#))

Lymphocyte (LIM-fō-sīt): A type of white blood cell in the vertebrate immune system. ([Chapter 11.4](#), [Chapter 11.5](#))

Lymphoma (līm-FŌ-mă): Cancer that originates from the lymphatic system. ([Chapter 11.6](#))

Malignant (mă-līg-nănt): Malignant cells exhibit uncontrolled growth and rapidly divide, subsequently invading and causing damage to normal functioning cells. ([Chapter 11.6](#))

Metastasize (mě-tăs-tă-sīz): The spread of malignant cells through the blood or lymphatic system and invasion in other areas of the body. ([Chapter 11.6](#))

Needle biopsy (NĒ-dīl BĪ-ōp-sē): A procedure where a needle is inserted into a lymph node, typically under local anesthesia and guided by ultrasound or CT scan, for tissue examination. ([Chapter 11.7](#))

Non-Hodgkin lymphoma (nōn-HŌJ-kīn lim-FŌ-mă) (NHL): A diverse group of blood cancers that includes all types of lymphoma except Hodgkin's lymphomas, less predictable than Hodgkin lymphoma, and more likely to metastasize. ([Chapter 11.6](#))

Open lymph node biopsy (Ō-pěn limf nōd BĪ-ōp-sē): A surgical procedure to remove all or part of a lymph node, usually performed if the lymph node is large enough to be felt on physical exam. ([Chapter 11.7](#))

Opportunistic infection (ōp-ōr-tū-NĪS-tīk īn-FĚK-shōn): Infections that occur more often or are more severe in people with weakened immune systems. ([Chapter 11.6](#))

Passive immunity (PĀS-iv im-Ū-nīt-ē): A type of immunity obtained by receiving antibodies produced by someone else, such as through the

placenta from the mother to the infant or via injection of antibodies. ([Chapter 11.5](#))

Pathogens (PĀTH-ō-jěnz): Bacteria, viruses, or other microorganisms that can cause infection and disease. ([Chapter 11.5](#))

Phagocytosis (făg-ō-sī-TŌ-sīs): The process by which a cell uses its plasma membrane to engulf a large particle, forming an internal compartment known as a phagosome. ([Chapter 11.5](#))

Sentinel lymph node biopsy (SĚN-tĩ-nělimf nōd BĪ-ōp-sē): A procedure used to find the best lymph nodes to biopsy, involving the injection of a radioactive tracer or dye near the tumor. ([Chapter 11.7](#))

Seroconversion (sē-rō-kōn-VĚR-zhōn): The presence of detectable anti-HIV antibodies in a person's blood, indicating a positive HIV test. ([Chapter 11.6](#))

Severe combined immunodeficiency disease (sē-vēr kōm-BĪND ĩm-yū-nō-dě-FISH-ěn-sē dĩ-zēz) (SCID): A serious disease caused by genetic defects leading to impaired B cell and T cell functioning. ([Chapter 11.6](#))

Spleen (splēn): An organ in the upper far left part of the abdomen, to the left of the stomach, which filters blood and is involved in immune response. ([Chapter 11.4](#))

Splenectomy (splě-NĚK-tō-mē): The surgical removal of a diseased or damaged spleen. Individuals who have had a splenectomy are at increased risk of infection for the remainder of their lives due to the spleen's role in the immune system. ([Chapter 11.7](#))

T cells (T sěls): A type of lymphocyte involved in cell-mediated immunity. ([Chapter 11.4](#))

Thymus gland (THĪ-mūs gland): A specialized primary lymphoid organ of the immune system where T cells mature. ([Chapter 11.4](#))

Tissue typing (TĪSH-ū tī-pǐng): A process to ensure organ compatibility between a donor and recipient, involving the identification of unique human leukocyte antigens (HLAs). ([Chapter 11.7](#))

Tonsillectomy (tōn-sīl-ĚK-tō-mē): The surgical removal of the tonsils, often performed to address recurrent cases of tonsillitis or breathing issues. ([Chapter 11.7](#))

Tonsillitis (tōn-sīl-Ī-tīs): Inflammation of the tonsils, often due to infection. ([Chapter 11.7](#))

Tonsils (TŎN-sĭls): A pair of soft tissue masses located at the rear of the throat, part of the immune system. ([Chapter 11.4](#))

PART XII

CHAPTER 12 DIGESTIVE SYSTEM TERMINOLOGY

12.1 Digestive System Introduction

Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the digestive system
- Identify meanings of key word components of the digestive system
- Categorize diagnostic, therapeutic, procedural, or anatomic terms related to the digestive system
- Use terms related to the digestive system
- Use terms related to the diseases and disorders of the digestive system

Introduction to the Digestive System

The function of the digestive system is to break down the foods you eat, release their nutrients, and absorb those nutrients into the body. The digestive system is continually at work, yet people seldom appreciate the complex tasks it performs until something malfunctions. Consider what happens when you eat an apple. You enjoy the apple's taste as you chew it, but in the hours that follow, unless something goes amiss and you get a stomachache, you don't notice your digestive system is working. You may be working, studying, or sleeping, having forgotten all about the apple, but your

stomach and intestines are busy digesting it. By the time any waste material is excreted, the body has absorbed all the nutrients it can use from the apple. In short, whether you pay attention or not, the organs of the digestive system perform their specific functions, allowing you to use the food you eat to provide energy for your daily activities.¹

This chapter will review common word components related to the digestive system to assist learners in analyzing, building, and defining medical terms. Other terms, whose definitions cannot be easily built from word components, will be described in context based on the anatomy and physiology of the digestive system and common diseases and disorders. Medical specialists, diagnostic tests, and procedures related to the digestive system will also be discussed.

View a supplementary YouTube video² overview of the
 digestive system from TED-Ed: [How your digestive system works – Emma Bryce](https://youtu.be/Og5xAdC8EUI)

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2. TED-Ed. (2017, December 14). *How your digestive system works – Emma Bryce* [Video]. YouTube. All rights reserved. <https://youtu.be/Og5xAdC8EUI?si=883ROcHlXHlj9NE3>

12.2 Word Components Related to the Digestive System

This section will describe common word components related to the digestive system. These word components help build definitions for many medical terms. Other common prefixes are described in [Chapter 1.3](#), and common suffixes are described in [Chapter 1.5](#).

COMMON PREFIXES RELATED TO THE DIGESTIVE SYSTEM

- **dys-**: Painful, abnormal, difficult, labored
- **endo-**: Within, in
- **hemi-**: Half
- **sub-**: Under, below

COMMON WORD ROOTS WITH A COMBINING VOWEL RELATED TO THE DIGESTIVE SYSTEM

- **abdomin/o**: Abdomen, abdominal

- **an/o**: Anus
- **antr/o**: Antrum
- **append/o**: Appendix
- **appendic/o**: Appendix
- **cec/o**: Cecum
- **celi/o**: Abdomen, abdominal cavity
- **cheil/o**: Lip
- **chol/e**: Gall, bile
- **cholangi/o**: Bile duct
- **choledoch/o**: Common bile duct
- **col/o**: Colon
- **colon/o**: Colon
- **diverticul/o**: Diverticulum
- **duoden/o**: Duodenum
- **enter/o**: Intestine
- **esophag/o**: Esophagus
- **gastr/o**: Stomach
- **gingiv/o**: Gum
- **gloss/o**: Tongue
- **hepat/o**: Liver
- **herni/o**: Hernia, protrusion of an organ through a membrane or cavity wall
- **ile/o**: Ileum
- **jejun/o**: Jejunum
- **lapar/o**: Abdomen, abdominal cavity
- **lingu/o**: Tongue
- **or/o**: Mouth
- **palat/o**: Palate
- **pancreat/o**: Pancreas
- **peritone/o**: Peritoneum
- **polyp/o**: Polyp, small growth
- **proct/o**: Rectum
- **pylor/o**: Pylorus, pyloric sphincter
- **rect/o**: Rectum
- **sial/o**: Saliva, salivary gland

- **sigmoid/o**: Sigmoid colon
- **steat/o**: Fat
- **stomat/o**: Mouth
- **uvul/o**: Uvula
- **xer/o**: Dryness

COMMON SUFFIXES RELATED TO THE DIGESTIVE SYSTEM

- **-ac**: Pertaining to
- **-al**: Pertaining to
- **-cele**: Hernia, protrusion
- **-centesis**: Surgical puncture to aspirate fluid
- **-eal**: Pertaining to
- **-ectomy**: Excision
- **-gram**: The record, radiographic image
- **-graph**: Instrument used to record
- **-graphy**: Process of recording
- **-ia**: Condition of, diseased state, abnormal state
- **-iasis**: Condition
- **-ic**: Pertaining to
- **-itis**: Inflammation
- **-lith**: Stone
- **-logist**: Specialist who studies and treats
- **-logy**: Study of
- **-malacia**: Softening
- **-megaly**: Enlargement
- **-oma**: Tumor
- **-osis**: Abnormal condition
- **-pathy**: Disease
- **-pepsia**: Digestion

- **-phagia:** Eating or swallowing
- **-plasty:** Surgical repair
- **-ptosis:** Prolapse, drooping
- **-rrhaphy:** Suturing, repairing
- **-rrhea:** Flow, discharge
- **-scope:** Instrument used for visualization
- **-scopy:** Process of viewing, visualization
- **-stomy:** Creation of an artificial opening
- **-tomy:** Incision, cut into

12.3 Examples of Digestive Terms Easily Defined By Their Word Components

Here are examples of common medical terms related to the digestive system that can be easily defined by breaking the terms into their word components.

Dysphagia

1. Break down the medical term into word components:
Dys/phagia
2. Label the word components: **Dys** = P; **phagia** = S
3. Define the word components: **Dys** = difficult, abnormal, or painful; **phagia** = swallowing or eating
4. Create a final definition of the medical term: **Difficulty swallowing**

Gastritis

1. Break down the medical term into word components:
Gastr/itis
2. Label the word components: **Gastr** = WR; **itis** = S
3. Define the word components: **Gastr** = stomach; **itis** = inflammation

4. Create a final definition of the medical term:
Inflammation of the stomach

Hepatomegaly

1. Break down the medical term into word components:
Hepat/o/megaly
2. Label the word components: **Hepat** = WR; **o** = CV; **megaly** = S
3. Define the word components: **Hepat** = liver; **megaly** = enlarged
4. Create a final definition of the medical term: **Enlarged liver**



Interactive Learning Activity: Practice defining and pronouncing digestive system medical terms by breaking them down into word parts.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=4319#h5p-108>

- ▶ You can also print these flashcard activities as a [Chapter 12 Student Companion Worksheet](#) and check your answers with this [Answer Key](#).

12.4 Anatomy of the Digestive System

Digestion (dī-JĔS-tĭon) is the process by which food is broken down into absorbable units. This section will provide an overview of the anatomy of the digestive system, including the mouth, tongue, salivary glands, pharynx, esophagus, stomach, small intestine, and large intestine, as well as the accessory organs of the liver, pancreas, and gallbladder. See Figure 12.1¹ for an illustration of digestive system organs.

1. "abe85277d60c52f85be133e1b5ddc40aea009e1c.jpg" by J. Gordon Betts, et al. is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology-2e/pages/23-1-overview-of-the-digestive-system>

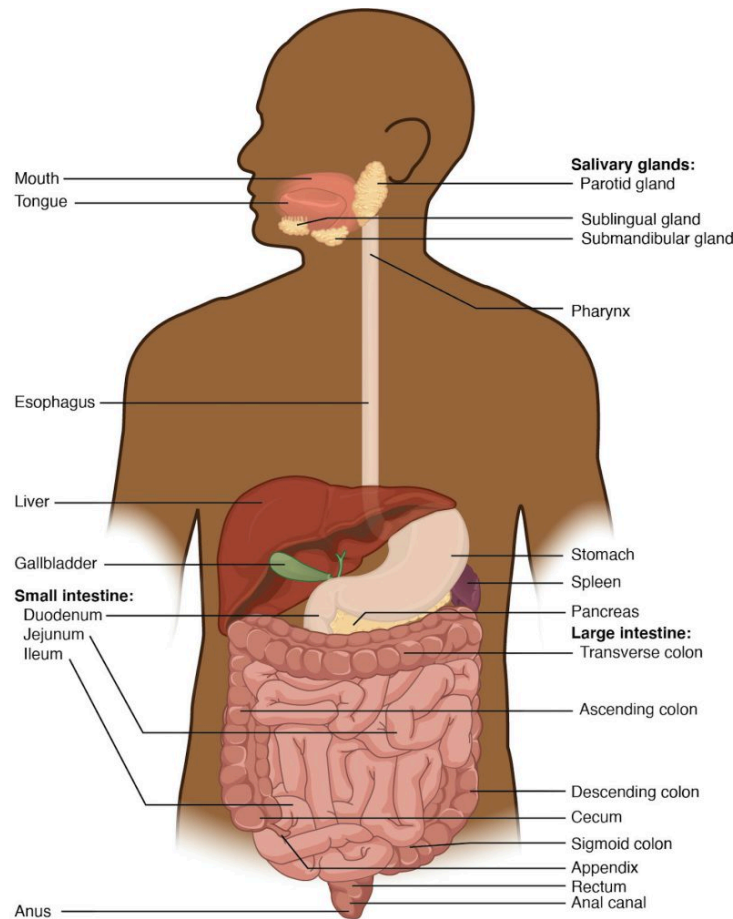


Figure 12.1 Digestive System

The **peritoneum** (pĕr-ĭ-tō-NĒ-ŭm) is the serous membrane lining the cavity of the abdomen and covering the abdominal organs. **Peritonitis** (per-ĭt-ŏ-NĪT-ĭs) refers to inflammation of the peritoneum. Read more about peritonitis in the [“Diseases and Disorders of the Digestive System”](#) section.

MOUTH

The mouth, cheeks, tongue, and palate form the **oral cavity** (ŌR-ăl KAV-ĭ-tē).

See Figure 12.2² for an illustration of the oral cavity. If you run your tongue along the roof of your mouth, you'll notice the roof of the mouth has an arch called a **hard palate** (HARD PAL-āt). The anterior region of the palate serves as a septum (i.e., wall) between the oral and nasal cavities, as well as a rigid shelf against which the tongue can push food when swallowing. The hard palate ends in the posterior oral cavity where the tissue becomes fleshier. This part of the palate, known as the **soft palate** (SOFT PAL-āt), is composed mainly of skeletal muscle that can be manipulated for actions like swallowing or singing.³

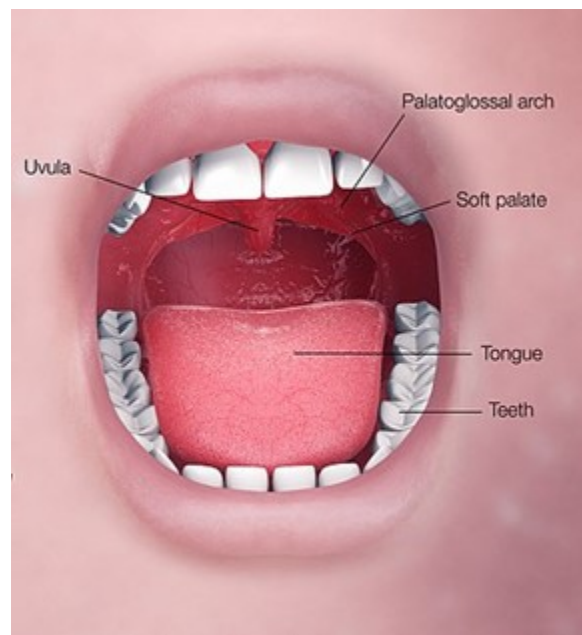


Figure 12.2 Oral Cavity

A fleshy extension of tissue called the **uvula** (YŪ-vyū-lă) drops down from the

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center of the soft palate. When swallowing, the soft palate and uvula move upward, helping to keep foods and liquid from entering the nasal cavity and respiratory tract.⁴

Two muscular folds extend downward from the soft palate on either side of the uvula. Between these two folds are the palatine tonsils, clusters of lymphoid tissue involved in the immune system. The lingual tonsils are located at the base of the tongue.⁵

Stomatitis (stō-mă-TĪT-īs) refers to inflammation of the mouth. **Xerostomia** (zēr-ō-STŌ-mē-ă) refers to the condition of a dry mouth. **Uvulitis** (ū-vyŭ-LĪT-īs) refers to inflammation of the uvula. **Gingivitis** (jin-jĭ-VĪT-īs) refers to inflammation of the gums.

TONGUE

The **tongue** (TUNG) facilitates ingestion, digestion, sensation (of taste, texture, and temperature of food), swallowing, and vocalization. It has a mucous membrane covering and is composed of skeletal muscles that facilitate eating, swallowing, and speaking. The top and sides of the tongue are studded with papillae and taste buds to facilitate sensation. Lingual glands secrete mucus and a watery fluid that contains the enzyme lipase, which

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becomes active in the acidic environment of the stomach.⁶ See Figure 12.3⁷ for an illustration of the tongue and its papillae.

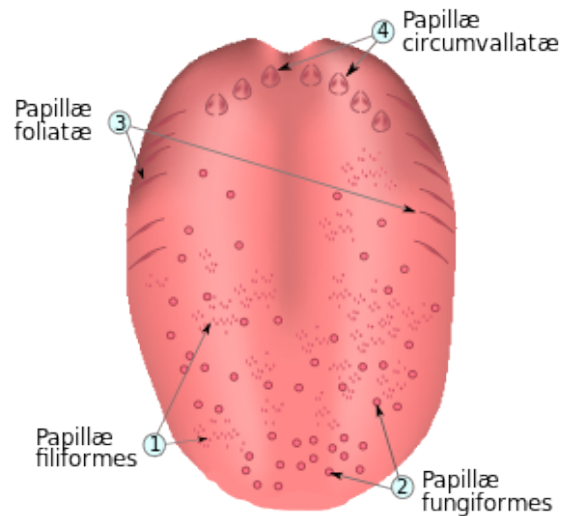


Figure 12.3 Tongue

Glossitis (glo-SĪT-ĭs) refers to inflammation of the tongue. **Sublingual** (sŭb-LING-gwăĭl) means “pertaining to under the tongue” and is also a route of medication administration.

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7. “Papillae on tongue.svg” is a derivative work by Kjell ANDRÉ licensed under CC BY-SA 3.0

SALIVARY GLANDS

Salivary (SĂL-ĭ-văr-ē) glands are housed within the mucous membranes of the mouth and are constantly secreting saliva into the oral cavity to keep the mouth moist. Saliva secretion increases when eating or even thinking about eating food. Saliva contains an enzyme called salivary amylase, which starts the breakdown of carbohydrates in the mouth. There are six salivary glands that secrete into the oral cavity – two parotid glands located in the cheeks anterior to the ears, two sublingual salivary glands located beneath the tongue, and two submandibular salivary glands located just beneath the mandible.⁸ See Figure 12.4⁹ for an illustration of the salivary glands.

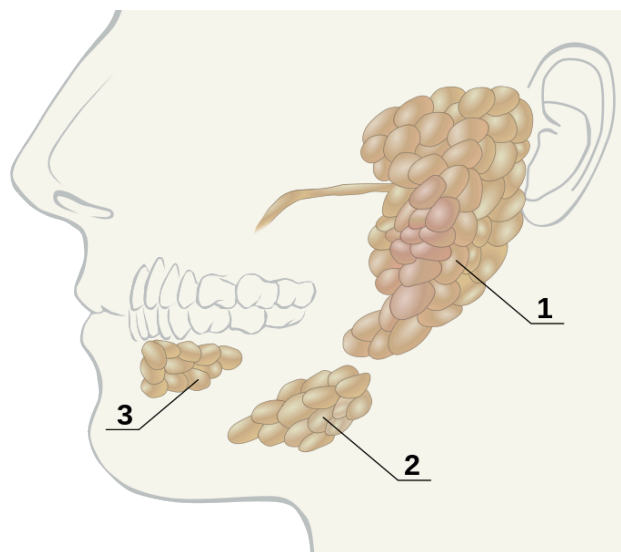


Figure 12.4 Salivary Glands 1) Parotid gland, 2) Submandibular gland, 3) Sublingual gland

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PHARYNX

The **pharynx** (FAR-inks), commonly called the throat, is a muscular tube lined with a mucous membrane that runs from the posterior oral and nasal cavities to the esophagus and the larynx.¹⁰ See Figure 12.5¹¹ for an illustration of the pharynx.

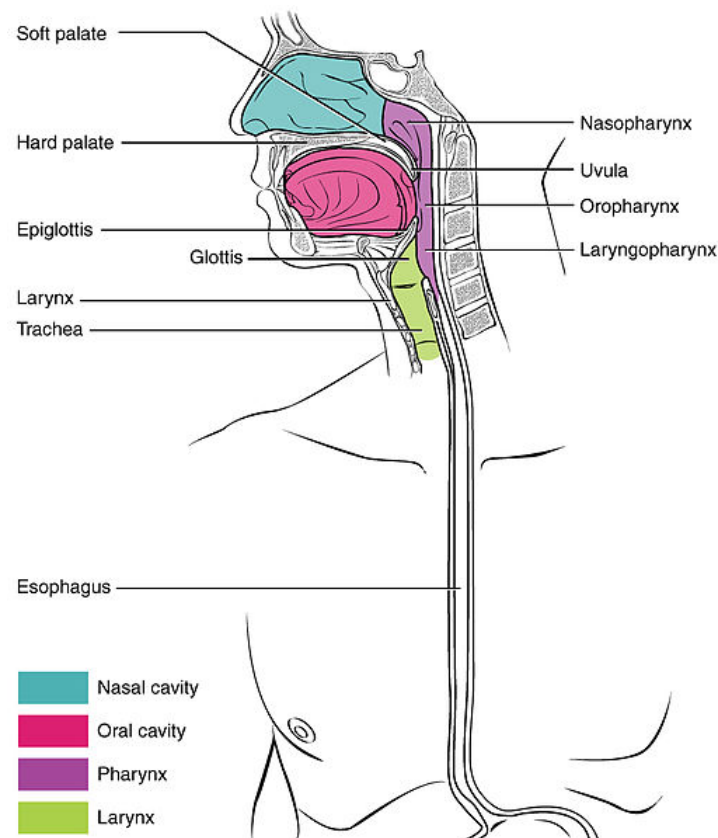


Figure 12.5 Pharynx

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The pharynx has three subdivisions. The superior section, the nasopharynx, is involved only in breathing and speech. The other two subdivisions, the oropharynx and the laryngopharynx, are used for both functions of breathing and digestion. The oropharynx begins inferior to the nasopharynx and continues to the laryngopharynx. In the laryngopharynx, the inferior border of the laryngopharynx connects to the esophagus, whereas the anterior portion connects to the larynx.¹²

The pharynx is involved in both digestion and breathing. It receives air from the mouth and nasal cavities and food from the mouth. When food enters the pharynx, involuntary muscle contractions close a flap of tissue called the **epiglottis** (ěp-ĭ-GLŎT-ĭs) to prevent food from entering the trachea and to ensure it enters the esophagus. **Dysphagia** (dis-FĀj-ē-ă), also called aspiration, refers to difficulty swallowing that can result in food entering the respiratory tract.

ESOPHAGUS

The **esophagus** (ĭ-SOF-ă-gŭs) is a muscular tube that connects the laryngopharynx to the stomach. It is located posteriorly to the trachea and is approximately ten inches long. See Figure 12.6¹³ for an illustration of the esophagus. The upper esophageal sphincter is a muscular ring that controls the movement of food from the pharynx to the esophagus.¹⁴

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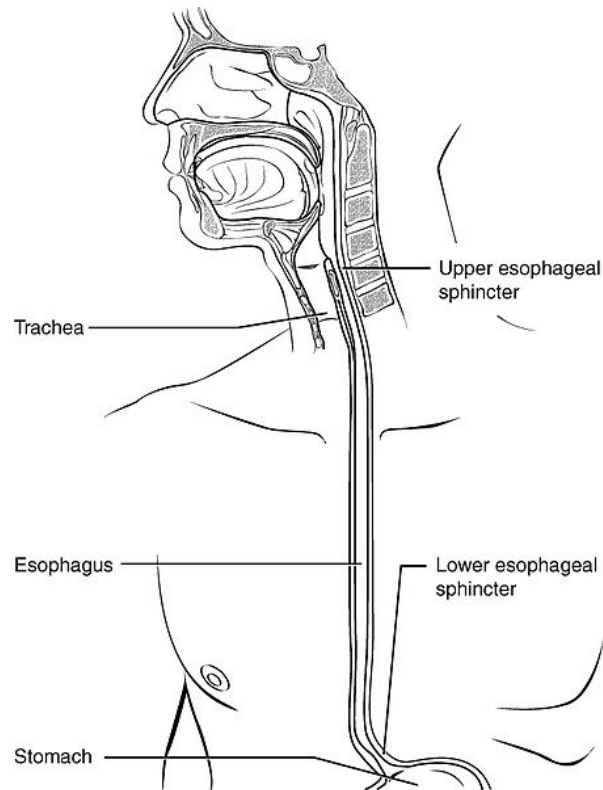


Figure 12.6 Esophagus

A series of wave-like muscle contractions called **peristalsis** (per-ĭ-STAL-sĭs) push food through the esophagus and into the stomach. Just before the opening to the stomach is another ring-shaped muscle called the **lower esophageal sphincter** (LOH-ĕr ĭ-SOF-ă-gĕ-al SFINGK-tĕr), also known as the cardiac sphincter. Recall that sphincters are muscles that surround tubes and serve as valves, closing the tube when the sphincters contract and opening it when they relax. This sphincter opens to let food pass into the stomach and closes to keep it from backing up into the esophagus.¹⁵

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Esophageal varices (ě-sŏf-ă-JĚ-ăl VĀR-ĭ-sēz) refers to an abnormal condition of swollen veins in the lower part of the esophagus.

STOMACH

The **stomach** (STUM-ăk) is a sac-like organ where food is mixed with gastric juice. There are four main regions in the stomach: the cardia, fundus, body, and pylorus. The funnel-shaped pylorus connects the stomach to the duodenum, the first part of the small intestine. The **pyloric sphincter** (pĭ-LOR-ĭk SFINGK-těr) is located at this latter point of connection and controls stomach emptying into the small intestine.¹⁶ See Figure 12.7¹⁷ for an illustration of the stomach.

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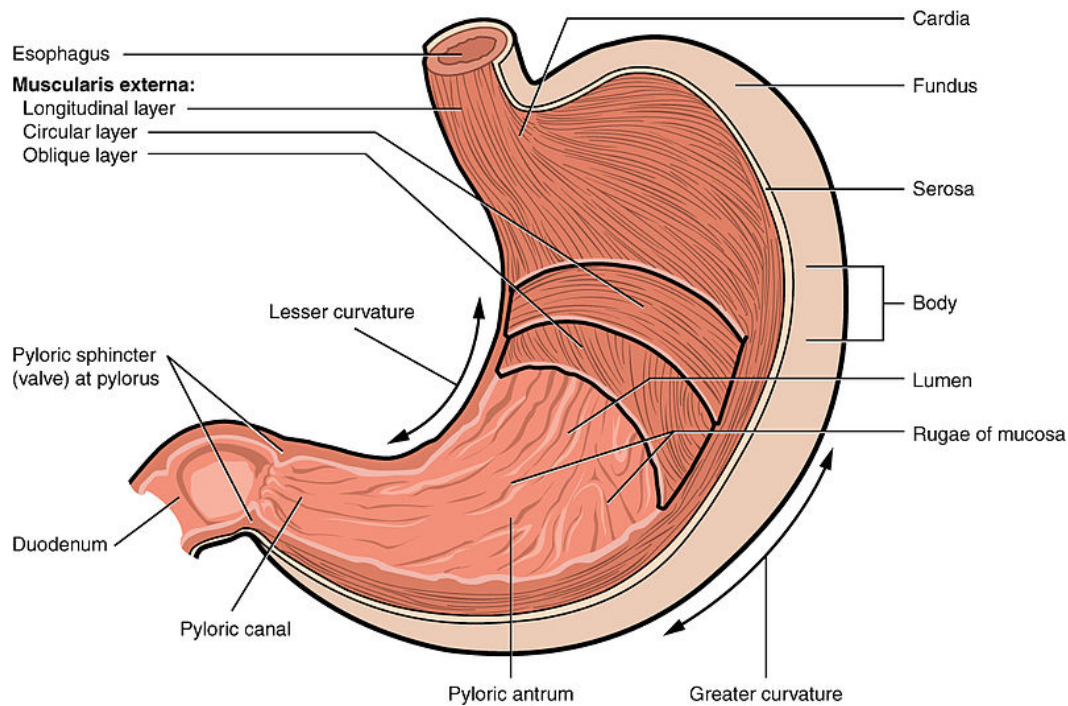


Figure 12.7 Stomach

The inner lining of the stomach is covered by a mucous membrane that secretes a protective coat of alkaline mucus. The mucous protects the stomach from corrosive stomach acid. Gastric glands lie under the surface of this lining and secrete a complex digestive fluid referred to as **gastric juice** (GAS-trīk JOOS).¹⁸

Cells in the stomach lining secrete digestive hormones, such as gastrin and pepsin, as well as **hydrochloric acid** (HĪ-drō-klōr-ĪK AS-id). The acidity stimulates digestive hormones and also kills most of the bacteria ingested with food. A common digestive disorder called **gastroesophageal reflux disease** (GAS-trō-ě-sōf-ă-JĒ-ăl REE-flŭks dĭ-ZĒZ) (**GERD**) is caused by

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excessive hydrochloric acid that backs up into the lower esophagus.¹⁹ Read more information about this condition in the “[Diseases and Disorders of the Digestive System](#)” section.

The muscular walls of the stomach move food through the stomach and vigorously churn it, mechanically breaking it down into smaller particles.

SMALL INTESTINE

Partially digested food, called **chyme** (KĪM) is released from the stomach via the pyloric sphincter and enters the **small intestine** (SMOL IN-těs-tĭn), the part of the digestive tract where most of the digestion and absorption into the blood occurs. Approximately 90 percent of nutrients from food are absorbed through **villi** (VIL-ĭ), small fingerlike extensions on the inner surface of the small intestine. The small intestine is about ten feet long. Its name derives from its small diameter of about one inch, compared to the large intestine's diameter of about three inches.²⁰

The coiled tube of the small intestine is subdivided into three regions called the **duodenum** (dū-ō-DĒ-nŭm), **jejunum** (jĭ-JŪ-num), and **ileum** (ĭL-ē-ŭm). The ileum joins the cecum of the large intestine at the ileocecal valve. The **ileocecal valve** (ĭL-ē-ō-SĒ-kă VALV) controls the flow of chyme from the small

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intestine to the large intestine.²¹ See Figure 12.8²² for an illustration of these regions.

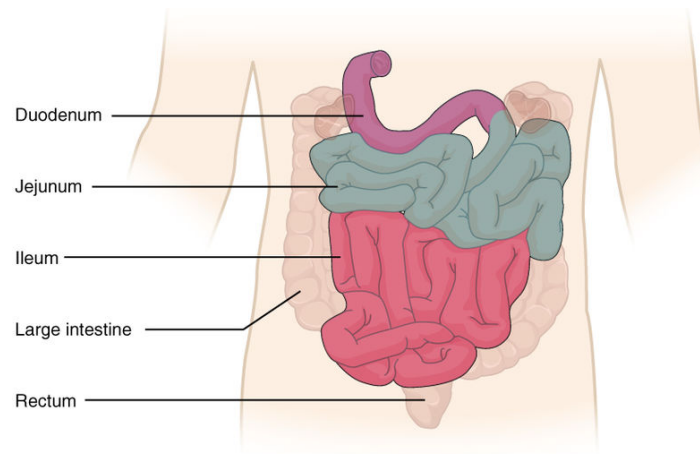


Figure 12.8 Small Intestine

LARGE INTESTINE

The **large intestine** (LARJ IN-tēs-tĭn) runs from the cecum to the anus. The primary functions of the large intestine are to finish absorption of nutrients and water, synthesize certain vitamins, and form and eliminate **feces** (FĒ-sēz), also called stool. The large intestine is about one half the length of the small intestine but is called large because its diameter is three inches, about twice the diameter of the small intestine. The large intestine is subdivided into four

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main regions: cecum, colon, rectum, and anal canal.²³ See Figure 12.9²⁴ for an illustration of the large intestine.

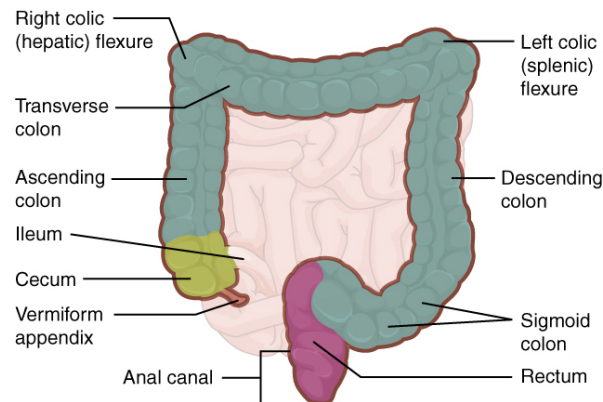


Figure 12.9 Large Intestine

Cecum

The **cecum** (SĒ-kŭm) is the initial part of the large intestine. It receives the contents of the small intestine and continues absorbing water and salts. The **appendix** (ă-PEN-diks) is a small pouch attached to the end of the cecum. Its twisted anatomy provides a haven for the accumulation and multiplication of intestinal bacteria that can lead to **appendicitis** (ă-pen-dĭ-SĪT-ĭs). An **appendectomy** (ap-ĕn-DEK-tŏ-mĕ) is the surgical removal of the appendix.²⁵

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Colon

Food residue entering the colon travels up the **ascending colon** (ă-SEN-ding KŌ-lŏn) on the right side of a person's abdomen. At the inferior surface of the liver, the colon bends to become the **transverse colon** (trans-VURS KŌ-lŏn), where it travels across to the left side of their abdomen. From there, chyme passes through another bend inferior to the spleen and down the **descending colon** (dě-SEN-ding KŌ-lŏn), which runs down the left side of the posterior abdominal wall and becomes the S-shaped **sigmoid colon** (SIG-moyd KŌ-lŏn).²⁶

Rectum

The **rectum** (REK-tŭm) is the final eight inches of the large intestine. It has three folds called rectal valves that help separate **feces** (FĒ-sēz) from **flatus** (FLĀ-tŭs), commonly referred to as gas.²⁷

A **proctoscope** (PRŎK-tă-skōp) is an instrument used by a health care provider to view the rectum.

Anal Canal

The **anal** (ĀN-ăl) canal is about three inches long and opens to the exterior of the body at the **anus** (Ā-nŭs), the end of the digestive tract. The anal canal includes two sphincters. The internal anal sphincter is made of smooth

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muscle, and its contractions are involuntary. The external anal sphincter is made of skeletal muscle, which is under voluntary control. Except when defecating, both sphincters usually remain closed.²⁸

A **hemorrhoid** (HEM-ō-royd) is a common but abnormal condition of a distended and swollen vein in the anus or rectum.

ACCESSORY ORGANS OF DIGESTION

Chemical digestion in the small intestine relies on the activities of three accessory digestive organs: the liver, pancreas, and gallbladder. See Figure 12.10²⁹ for an illustration of these digestive accessory organs. The digestive role of the liver is to produce bile and export it to the duodenum. The gallbladder stores, concentrates, and releases bile. The pancreas produces pancreatic juice, which contains digestive enzymes and bicarbonate ions, and delivers it to the duodenum.³⁰

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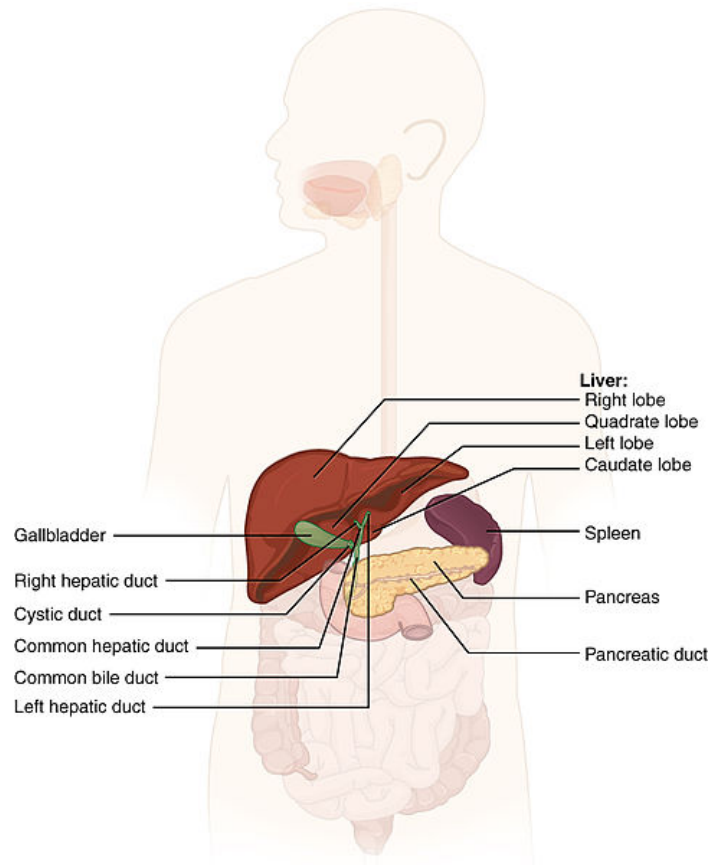


Figure 12.10 Accessory Organs of the Digestive System

Liver

The **liver** (LIV-ĕr) plays many roles in digestion, metabolism, and hemostasis. The liver lies inferior to the diaphragm in the right upper quadrant of the abdominal cavity. It is protected by the surrounding ribs. The liver is divided into two primary lobes, a large right lobe and a much smaller left lobe.

Hepatomegaly (hep-ăt-ō-MEG-ă-lĕ)³¹ refers to an enlarged liver.

The portal vein delivers nutrient-rich blood from the small intestine to the liver. The liver absorbs and/or metabolizes nutrients, toxins, and medications.

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After the liver has broken down harmful substances, the by-products are excreted into the bile or blood. **Bile** (BĪL) is a digestive fluid produced and secreted by the liver. Bile enters the intestine and leaves the body in the form of feces. After the liver processes these substances in the blood, it releases the filtered blood through the hepatic vein that flows into the inferior vena cava. See Figure 12.11³² for an illustration of these structures related to the liver.³³

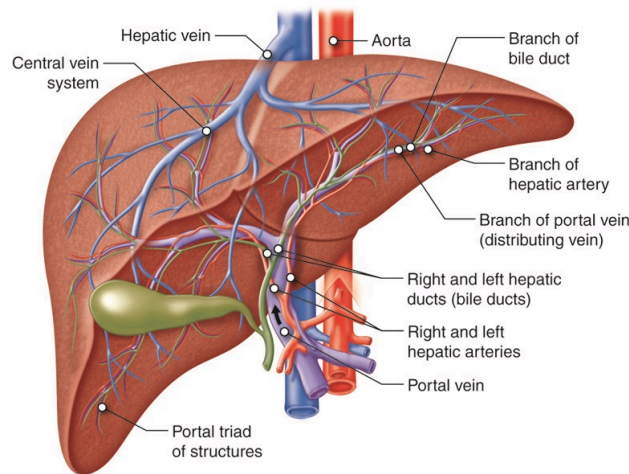


Figure 12.11 Structures Related to the Liver

Bilirubin (bil-ĭ-ROO-bin) is a yellowish pigment produced by the breakdown of red blood cells that is filtered out of the blood by the liver. If a person's liver

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is not functioning properly, it cannot adequately filter out the bilirubin, causing yellowing of the skin and eyes referred to as **jaundice** (JAWN-dīs).³⁴

In some digestive diseases, bile does not enter the intestine, resulting in white stool with a high fat content because virtually no fats are broken down by the bile. **Steatorrhea** (stē-ăt-ō-RĒ-ă) refers to excessive fat excreted in the stool.³⁵

Pancreas

The soft, oblong, glandular **pancreas** (PAN-krē-ăs) lies transversely behind the stomach. Refer back to Figure 12.10 for an illustration of the location of the pancreas. The pancreas has two functions referred to as **exocrine** (ĖK-sŏ-krĭn), meaning secreting digestive enzymes, and **endocrine** (EN-dŏ-krĭn), meaning releasing hormones into the blood.³⁶

The exocrine portion of the pancreas produces many protein-digesting enzymes, pancreatic **amylase** (ĀM-ĭ-lās) that digests carbohydrates, and pancreatic **lipase** (Lĭ-pās) that digests fat. The pancreas delivers these enzymes to the duodenum through the pancreatic duct and into the common bile duct (carrying bile from both the liver and gallbladder). The endocrine function of the pancreas secretes the hormones insulin and

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glucagon to regulate blood glucose levels.³⁷ See Figure 12.15³⁸ for an illustration of the pancreas.

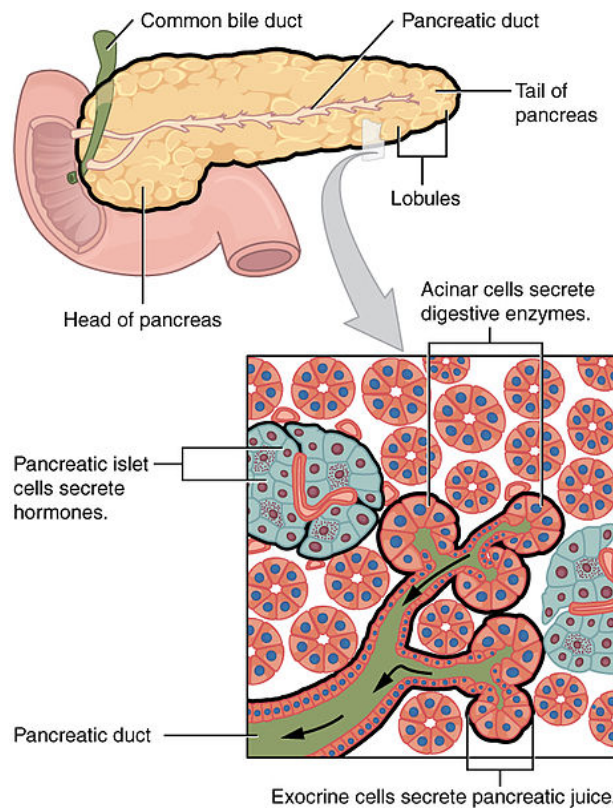


Figure 12.12 Pancreas

Gallbladder

The **gallbladder** (GAWL-blăd-ěr) is about 3-4 inches long and is nested in a shallow area underneath the right lobe of the liver. This muscular sac stores,

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38. “2424_Exocrine_and_Endocrine_Pancreas.jpg” by OpenStax College is licensed under CC BY 3.0

concentrates, and releases bile into the duodenum via the common bile duct. Refer back to Figure 12.10 for an illustration of the location of the gallbladder.³⁹

Gallstones can form in the gallbladder, a condition called **cholelithiasis** (kō-li-lith-ī-ă-sīs). Inflammation of the gallbladder is referred to as **cholecystitis** (kōl-ě-sīs-Tī-tīs). Read more information about these conditions in the “[Diseases and Disorders of the Digestive System](#)” section.

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12.5 Physiology of the Digestive System

FUNCTIONS OF THE DIGESTIVE SYSTEM

The main functions of the digestive system are ingesting food, digesting food, absorbing nutrients, and eliminating waste products. See Table 12.5 for an overview of the functions of the organs of the digestive tract.

Table 12.5. Functions of the Digestive Organs¹

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Organ	Major Functions	Other Functions
Mouth	• Ingests food • Chews and mixes food • Begins chemical breakdown of carbohydrates • Moves food into the pharynx • Begins breakdown of lipids via lingual lipase	• Moistens and dissolves food, allowing for taste • Cleans and lubricates the teeth and oral cavity • Promotes some antimicrobial activity
Pharynx	• Propels food from the oral cavity to the esophagus	• Lubricates food and passageways
Esophagus	• Propels food to the stomach	• Lubricates food and passageways
Stomach	• Mixes and churns food with gastric juices to form chyme • Begins chemical breakdown of proteins • Releases food into the duodenum as chyme • Absorbs some fat-soluble substances • Possesses antimicrobial functions	• Stimulates protein-digesting enzymes • Secretes intrinsic factor required for vitamin B12 absorption in small intestine

Small Intestine	• Mixes chyme with digestive juices • Propels food at a rate slow enough for digestion and absorption • Absorbs breakdown products of carbohydrates, proteins, lipids, and nucleic acids, along with vitamins, minerals, and water • Performs physical digestion via segmentation	• Provides optimal medium for enzymatic activity
Large Intestine	• Further breaks down food residues • Absorbs most residual water, electrolytes, and vitamins produced by enteric bacteria • Propels feces toward rectum • Eliminates feces	• Temporarily stores concentrated food residue prior to defecation • Eases passage of feces through colon from mucus

Accessory Organs	• Liver: produces bile salts, which emulsify lipids, aiding their digestion and absorption • Gallbladder: stores, concentrates, and releases bile • Pancreas: produces digestive enzymes and bicarbonate	• Help neutralize acidic chyme and provide optimal environment for enzymatic activity
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DIGESTIVE PROCESSES

Digestive processes involve the interaction of several organs and occur gradually as food moves through the gastrointestinal tract. The processes of digestion include six activities: ingestion, propulsion, mechanical digestion, chemical digestion, absorption, and defecation.² See Figure 12.13³ for an illustration of digestive processes.

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3. “[2405_Digestive_Process.jpg](#)” by OpenStax College is licensed under [CC BY 3.0](#)

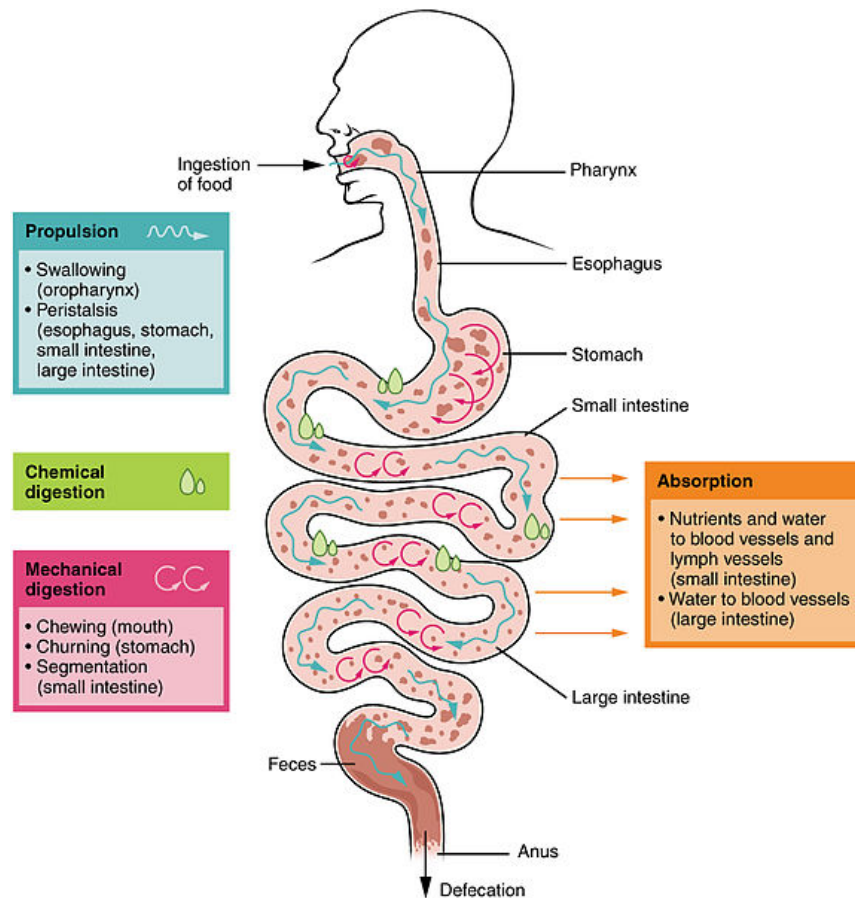


Figure 12.13 Digestive Processes

Ingestion

Ingestion refers to the intake of food through the mouth where it is chewed and mixed with saliva. Saliva contains enzymes that begin breaking down the carbohydrates and fats in the food. Chewing produces a soft mass of food called a **bolus** (BŌL-ŭs) that is an appropriate size for swallowing.⁴

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Propulsion

Food leaves the mouth when the tongue and pharyngeal muscles propel it into the esophagus. This act of swallowing is an example of propulsion, which refers to the movement of food through the digestive tract. It includes both the voluntary process of swallowing and the involuntary process of **peristalsis** (per-ĭ-STAL-sĭs). Peristalsis consists of sequential, alternating waves of contraction and relaxation of smooth muscles, which act to propel food through the digestive tract. See Figure 12.14⁵ for an illustration of peristalsis. Peristaltic waves also play a role in mixing food with digestive juices. Peristalsis is so powerful that swallowed foods and liquids enter the stomach even if you are standing on your head.⁶

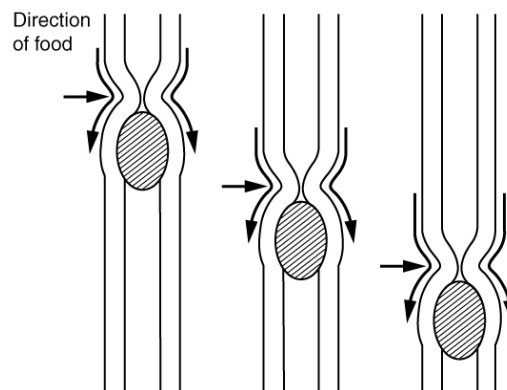


Figure 12.14 Peristalsis

Mechanical Digestion

Mechanical digestion is a physical process that does not change the chemical nature of the food but makes it smaller to increase its surface area and

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mobility. Mechanical digestion starts with chewing and then progresses to mechanical churning of food in the stomach. In the stomach, the bolus of food further breaks apart with more surface area that is exposed to digestive juices of chemical digestion.⁷

Chemical Digestion

Chemical digestion begins in the mouth and is completed in the small intestine. Digestive secretions contain water, **enzymes** (EN-zīmz), acids, and salts that create an acidic “soup” that breaks down food molecules into their chemical building blocks. For example, proteins are broken down into **amino acids** (Ā-mē-nō AS-idz).⁸

Absorption

Nutrients (NŪ-trē-ěntz) are substances that provide nourishment to cells. After food molecules have been broken down during chemical digestion, nutrients enter the bloodstream through the process of **absorption** (ab-SORP-shŏn). Absorption takes place primarily in the small intestine.

Defecation

During **defecation** (děf-ě-KĀ-shŏn), the final step in digestion, undigested materials are expelled from the body as feces.⁹

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ADDITIONAL TERMS RELATED TO THE DIGESTIVE SYSTEM

Additional common medical terms related to the digestive system include the following:

- **Adhesion** (ad-HĒ-zhŏn): Scar tissue from disease or previous surgery that binds anatomic surfaces to each other.
- **Ascites** (ă-SĪ-tēz): Abnormal fluid buildup in the abdominal cavity.
- **Dysentery** (DIS-ĕn-ter-ē): Inflammation of the intestine presenting with abdominal pain and bloody diarrhea.
- **Dyspepsia** (dĭs-PEP-sē-ă): Indigestion.
- **Emesis** (ĔM-ĕ-sĭs): Vomiting
- **Flatus** (FLĀ-tŭs): Gas in the GI tract.
- **Gastroenteritis** (GAS-trō-ĕn-tĕr-Ī-tĭs): Inflammation of the stomach and intestines.
- **Hernia** (HUR-nē-ă): Protrusion of an organ through a muscular wall.
- **Melena** (mě-LĒ-nă): Black, tarry feces that contains blood from the digestive tract.
- **Nausea** (NAW-zē-ă): The feeling of an urge to vomit.
- **NPO** (en-pee-ō): A commonly used medical abbreviation standing for “nothing by mouth,” meaning not to ingest food, fluids, or medications orally.
- **Obesity** (ō-BĒ-sĭ-tē): Increased proportion of fat cells, resulting in excessive body weight in proportion to height.
- **Palpate** (PAL-pāt): A physical examination technique where the examiner feels for texture, size, consistency, and location of organs with their hands.
- **Percutaneous endoscopic gastrostomy** (pŭr-kŭ-TĀ-nē-ŭs ĕn-DŎS-kŏ-pĭk

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gās-TRŌS-tŏ-mē) (**PEG**): A surgical procedure that places a feeding tube into the stomach through the abdominal wall to administer nutrition when swallowing is impaired.

- **Probiotics** (prō-bī-OT-ĭks): Normally occurring bacteria that are beneficial for digestion.
- **Reflux** (RĒ-flŭks): Abnormal backward flow.
- **Visceral** (VĪS-ĕr-ăl): Relating to the organs.
- **Vomiting** (VOM-ĭ-ting): Forceful ejection of stomach contents.

12.6 Diseases and Disorders of the Digestive System

Common diseases and disorders of the digestive system are discussed in this section.

CELIAC DISEASE

Celiac disease (SĒ-lē-ăk dĩ-ZĒZ) is a chronic digestive and autoimmune disease that damages the small intestine. It is triggered by eating foods containing gluten. Gluten is a protein found in foods containing wheat, barley, or rye. When a person with celiac disease eats gluten, an immune response is triggered to the gluten protein in the small intestine. Celiac disease can cause long-lasting digestive problems and prevent absorptions of nutrients. It is diagnosed with blood tests and biopsy taken during an upper GI endoscopy. Individuals with celiac disease must avoid gluten in their diets and often take dietary supplements.¹ Read more about upper GI endoscopy in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Digestive System](#)” section.

1. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Celiac disease*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/digestive-diseases/celiac-disease>

CHOLECYSTITIS AND GALLSTONES

Cholecystitis (kō-lě-sis-TĪT-īs) is inflammation of the gallbladder. The gallbladder stores and distributes bile through the bile ducts. A **gallstone** (GAWL-stōn) is a piece of hardened bile residue that can form for a variety of reasons, including elevated cholesterol levels. When a gallstone gets stuck in a bile duct, it can cause bile to back up into the gallbladder, causing severe upper right abdominal pain and swelling, chest pain, back pain, nausea, vomiting, and fever. The condition of having gallstones is **cholelithiasis** (kō-li-lith-Ī-ă-sīs). See Figure 12.15² for an image of a gallstone in the gallbladder on an ultrasound. An inflamed gallbladder can be an urgent problem requiring immediate surgery or a slow response to long-term inflammation.³

2. “[Gallstone_in_neck_of_Gallbladder_on_CT.jpg](#)” by James Heilman, MD is licensed under [CC BY-SA 4.0](#)

3. Cleveland Clinic. (2023, September 21). *Cholecystitis*. <https://my.clevelandclinic.org/health/diseases/15265-gallbladder-swelling-inflammation-cholecystitis>



Figure 12.15 Gallstone in the Gallbladder on an Ultrasound

Cholecystitis is diagnosed with blood tests and an abdominal ultrasound. To remove gallstones, a procedure called an **endoscopic retrograde cholangiopancreatography** (en-dŏ-SKOP-ik rě-trŏ-grād kŏ-LAN-jě-ŏ-pan-krě-ă-TŏG-ră-fě) (**ERCP**) may be performed that combines an upper endoscopy with X-ray technology. The doctor visualizes the biliary system and then removes gallstones during an endoscopy to relieve immediate symptoms. **Cholecystectomy** (kŏ-lě-sis-TEK-tŏ-mě) refers to surgery to remove the gallbladder to prevent repeat episodes of gallbladder inflammation, typically performed with a **laparoscope** (LAP-ă-rŏ-skŏp), an instrument used to view the abdominal cavity.⁴

4. Cleveland Clinic. (2023, September 21). *Cholecystitis*.
<https://my.clevelandclinic.org/health/diseases/15265-gallbladder-swelling-inflammation-cholecystitis>

CIRRHOSIS

Cirrhosis (sĭr-RŌ-sĭs) is a serious, life-threatening condition where the liver becomes scarred and permanently damaged. The most common causes of cirrhosis are alcoholism and liver disease like hepatitis B or hepatitis C. Symptoms of cirrhosis may not appear until the liver is badly damaged and may include the following⁵:

- Fatigue and weakness
- Pruritis (itching of the skin)
- Poor appetite and weight loss without trying
- Nausea and vomiting
- Pain in the upper right side of the abdomen
- Easy bleeding and bruising
- **Ascites** (ă-SĪ-tēz), abdominal swelling due to fluid retention (See Figure 12.16⁶ for an image of ascites.)
- **Jaundice** (JAWN-dĭs), yellowed discoloration of the skin and eyes.

5. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Cirrhosis*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/liver-disease/cirrhosis>

6. “16650267836_edald47696_k.jpg” by John Campbell is licensed in the [Public Domain](#).



Figure 12.16 Ascites

Diagnostic testing for cirrhosis includes blood tests that evaluate liver function, liver ultrasound, CT scan, and liver biopsy. Treatment includes treating the cause of the cirrhosis, including treating infections and abstaining from alcohol.⁷

COLON CANCER

Colon cancer (KŌ-lŏn KAN-sĕr) is the third most common cancer diagnosed in people in the United States. It develops from polyps in the lining of the colon and typically affects people aged 50 years and older. Individuals can greatly reduce their risk for colon cancer by having regular screenings for

7. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Cirrhosis*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/liver-disease/cirrhosis>

polyps, including stool-based testing or a colonoscopy.⁸ Read more about these tests in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Digestive System](#)” section.

Risk factors for colon cancer include a personal or family history of colon polyps or colon cancer and inflammatory bowel disease like Crohn’s disease and ulcerative colitis. Early symptoms of colon cancer include blood in the stool and persistent bowel changes like diarrhea and constipation. Colon cancer is diagnosed with biopsies taken during a colonoscopy.⁹

Depending on the severity of colon cancer, there are many types of surgeries that may be performed¹⁰:

- **Polypectomy** (pöl-ĭ-PĚK-tō-mē): Removal of polyps.
- **Partial colectomy** (pah-rshul kō-LEK-tō-mē), also called **colon resection surgery** (KŌ-lŏn rĭ-SĚK-shŭn SUR-jĕr-ē): The section of the colon containing the tumor is removed, and healthy colon sections are reattached in a procedure called **anastomosis** (ăn-ăs-tō-MŌ-sĭs).
- **Colon resection with colostomy** (KŌ-lŏn rĭ-SĚK-shŭn with kŏl-ŌS-tō-mē): The section of the colon that contains the tumor is removed, but healthy colon sections cannot be reattached, so a colostomy is performed. In a **colostomy** (kŏ-LOS-tō-mē), the colon is attached to an opening in the abdominal wall called a stoma. Instead of eliminating feces through the anus, it is collected in an external bag.
- **Radiofrequency ablation** (RĀ-dē-ō-FRĒ-kwĕn-sē ă-blā-shŭn): Heat is used during a procedure to destroy cancer cells.

8. Cleveland Clinic. (2022, November 14). *Colorectal (colon) cancer*.
<https://my.clevelandclinic.org/health/diseases/14501-colorectal-colon-cancer>

9. Cleveland Clinic. (2022, November 14). *Colorectal (colon) cancer*.
<https://my.clevelandclinic.org/health/diseases/14501-colorectal-colon-cancer>

10. Cleveland Clinic. (2022, November 14). *Colorectal (colon) cancer*.
<https://my.clevelandclinic.org/health/diseases/14501-colorectal-colon-cancer>

In addition to surgery, additional medical treatment may be required, such as chemotherapy or targeted therapy (treatment that targets the genes, proteins, and tissues that help colon cancer cells grow and multiply).¹¹

COLON POLYPS

Colon polyps (KŌ-lŏn PŎL-ĭps) are growths on the inner lining of the colon and rectum. See Figure 12.17¹² for an image of a colon polyp seen on colonoscopy. Most polyps are not cancerous, but some may develop into colon cancer over time. Anyone can develop colon polyps. Risk factors for developing colon polyps are age of 50 years or older, personal or family history of colon polyps or colon cancer, obesity, and smoking. People can greatly reduce their risk for colon cancer if polyps are removed in a procedure called a **polypectomy** (pŏl-ĭ-PĚK-tō-mē). Read more about these tests in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Digestive System](#)” section.

11. Cleveland Clinic. (2022, November 14). *Colorectal (colon) cancer*.
<https://my.clevelandclinic.org/health/diseases/14501-colorectal-colon-cancer>

12. “600H0019.jpg” by [Vivat.iden](#) is licensed under [CC BY-SA 4.0](#)

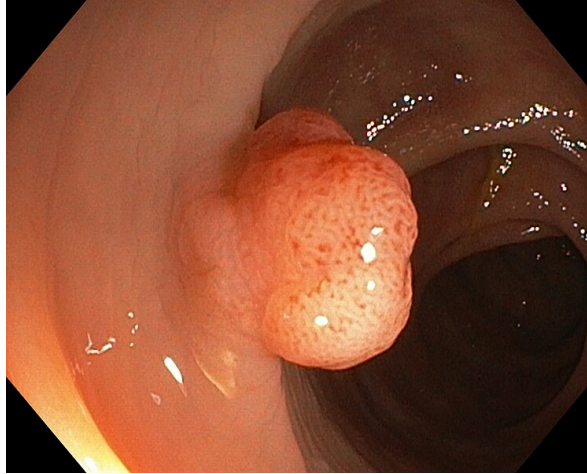


Figure 12.17 Colon Polyp

CROHN'S DISEASE AND ULCERATIVE COLITIS

Crohn's disease (krōnz diz-ĒZ) and **ulcerative colitis** (UL-sĕr-ă-tiv kō-LĪ-tĭs) are chronic inflammatory bowel diseases (IBD) that cause inflammation and ulcers in the digestive tract. See Figure 12.18¹³ for an image of ulcerative colitis on a colonoscopy, illustrating how the internal surface of the colon is blotchy and broken in places. Symptoms include abdominal pain, diarrhea, weight loss, and fatigue. These diseases are typically diagnosed with procedures like upper GI endoscopy, colonoscopy, and upper GI series.¹⁴ Read more about these procedures in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Digestive System](#)” section.

13. “[UC_granularity.png](#)” by unknown author is licensed under [CC BY-SA 3.0](#)

14. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Crohn's disease*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/digestive-diseases/crohns-disease>

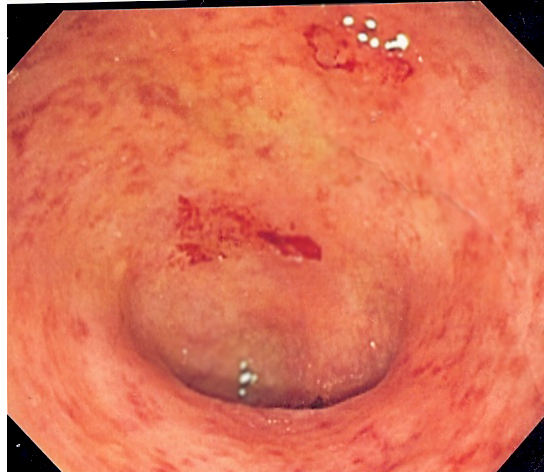


Figure 12.18 Ulcerative Colitis

Crohn's disease and ulcerative colitis are treated with medications, bowel rest, and surgery. No single treatment works for everyone with Crohn's disease. The goals of treatment are to decrease the inflammation in the intestines and prevent flare-ups of symptoms. Surgery may include **small bowel resection** (SMOL BOW-əl rī-SĚK-shŭn) or **large bowel resection** (LARJ BOW-əl rī-SĚK-shŭn), where part of the bowel is removed. In severe cases, **proctocolectomy** (prŏk-tō-kō-LEK-tŏ-mē) is performed where the entire colon and rectum are removed. An **ileostomy** (IL-ē-OS-tŏ-mē) is created, where part of the ileum is brought through an artificial opening in the abdomen called a **stoma** (STŌ-mă). A removable external collection pouch, called an **ostomy appliance** (ŎS-tŏ-mē ä-PLĪ-ăns), connects to the stoma and collects stool instead of it passing through the anus.¹⁵ See Figure 12.19¹⁶ for an illustration of an ileostomy and a stoma.

15. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Crohn's disease*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/digestive-diseases/crohns-disease>

16. "Ileostomy.png" by [BruceBlaus](#) is licensed under [CC BY-SA 4.0](#)

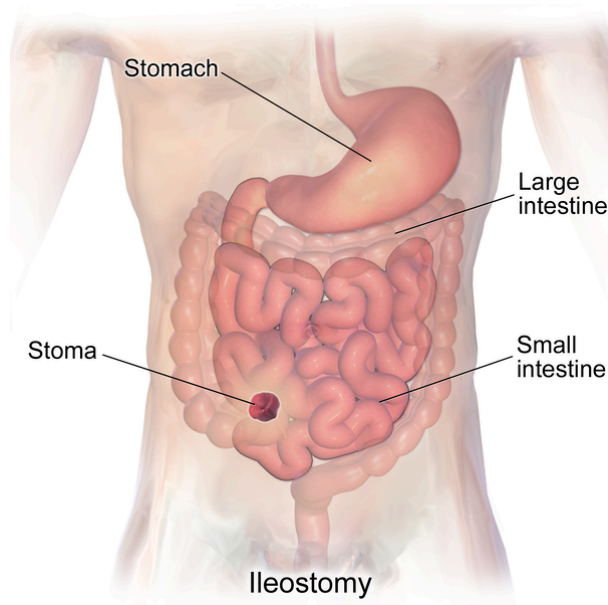


Figure 12.19 Ileostomy and Stoma

DIVERTICULOSIS AND DIVERTICULITIS

Diverticula (dī-věr-TIK-yū-lă) are small, bulging pouches that form in the lower part of the large intestine (colon). Diverticula are common, especially after age 40, and seldom cause problems. The presence of diverticula is known as **diverticulosis** (dī-věr-tik-yŭ-LŌ-sīs). See Figure 12.20¹⁷ for an illustration of diverticulosis. If one or more of the pouches become inflamed or infected, this condition is called **diverticulitis** (dī-věr-tik-yŭ-LĪT-īs). Diverticulitis can cause severe abdominal pain, fever, nausea, and a change in bowel habits. Diverticulitis is diagnosed with a CT scan, which can identify inflamed or infected pouches. Mild diverticulitis can be treated with rest, diet

¹⁷. “Sigmoid_diverticulum_(diagram).jpg” by Anpol42 is licensed under [CC BY-SA 4.0](#)

changes, and antibiotics. Severe or recurring diverticulitis may require bowel resection surgery.¹⁸

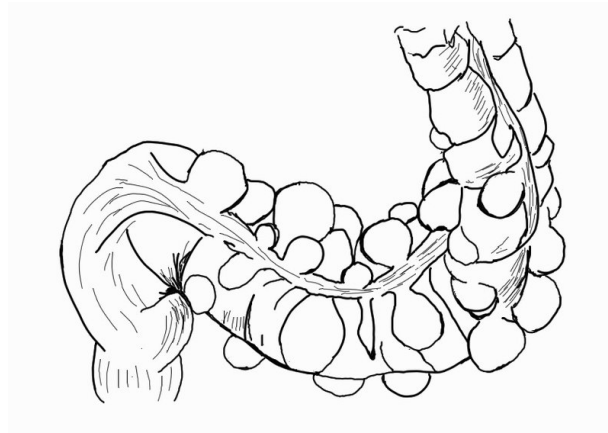


Figure 12.20 Diverticulosis

ESOPHAGEAL CANCER

Esophageal cancer (ĩ-sŏf-ă-JĔ-ăl KAN-sĕr) starts in the tissues of the esophagus. Tumors caused by esophageal cancer may not cause noticeable symptoms until the cancer has spread. As the tumor grows, it starts to block the esophagus, and the person may have trouble swallowing or notice that it hurts to swallow. Esophageal cancer typically affects men who are age 60 or older and grows and spreads rapidly. Risk factors include tobacco use, alcohol use, obesity, chronic gastroesophageal reflux disease, and *Human papillomavirus (HPV)*. Diagnostic tests include an upper GI series or upper GI endoscopy with biopsy. An **esophagectomy** (ĕ-sŏf-ă-JĔK-tŏ-mĕ) is the most common treatment for early-stage esophageal cancer. It involves removing some or most of the esophagus and creating a new esophagus by pulling up

18. Mayo Clinic. (2022, April 19). *Diverticulitis*. <https://www.mayoclinic.org/diseases-conditions/diverticulitis/symptoms-causes/syc-20371758>

part of the stomach into the chest and neck. Chemotherapy, radiation, targeted therapy, and immunotherapy are also commonly prescribed treatments.¹⁹

GASTROESOPHAGEAL REFLUX DISEASE (GERD)

Gastroesophageal reflux disease (GAS-trō-ě-sōf-ă-JĒ-ăl REE-flŭks dĭ-ZĒZ) (**GERD**) occurs when stomach acid repeatedly flows back into the esophagus from the stomach. The acid irritates the lining of the esophagus and causes an ulcer. See Figure 12.21²⁰ for an illustration of GERD and backup of acid into the esophagus. GERD is typically diagnosed with a procedure called an upper GI endoscopy. Most people are able to manage the discomfort of GERD with lifestyle changes and medications.²¹ Read more about upper GI endoscopy in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Digestive System](#)” section.

19. Cleveland Clinic. (2022, September 6). *Esophageal cancer*.
<https://my.clevelandclinic.org/health/diseases/6137-esophageal-cancer>
20. “[GastroEsophageal Reflux Disease \(GERD\).jpg](#)” by BruceBlaus is licensed under [CC BY-SA 4.0](#)
21. National Institute of Diabetes and Digestive and Kidney Diseases. (2020, July). *Diagnosis of GER & GERD*. National Institutes of Health.
<https://www.niddk.nih.gov/health-information/digestive-diseases/acid-reflux-ger-gerd-adults/diagnosis>

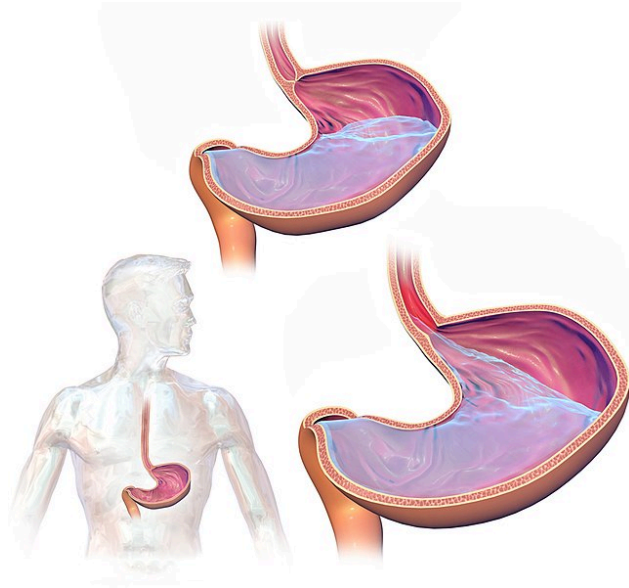


Figure 12.21 GERD

HEPATITIS

Hepatitis (hep-ă-TĪT-ĭs) is a general term used to describe inflammation of the liver. Liver inflammation can be caused by several viruses (such as hepatitis B and hepatitis C), drugs, excessive alcohol intake, genetic disorders, or by an overactive immune system that mistakenly attacks the liver, called autoimmune hepatitis. Symptoms include right upper quadrant abdominal pain, jaundice, light-colored stools, dark colored urine, fatigue, nausea, vomiting, and ascites (abdominal swelling due to fluid retention). See Figure 12.22²² for an image of jaundice. Hepatitis is diagnosed with blood tests, ultrasound of the liver, and liver biopsy. Treatment focuses on preventing further damage to the liver and cirrhosis.²³

22. “[Scleral_Icterus.jpg](#)” by [Sheila J. Toro](#) is licensed under [CC BY 4.0](#)

23. Johns Hopkins Medicine. (n.d.). *Hepatitis*. <https://www.hopkinsmedicine.org/health/conditions-and-diseases/hepatitis>



Figure 12.22 Jaundice

HERNIA

A hernia occurs when an organ or fatty tissue squeezes through a weak spot in a surrounding muscle or connective tissue. A **hiatal hernia** (hī-Ā-tāl HĔR-nē-ă) is a condition in which the upper part of the stomach bulges through an opening in the diaphragm. A large hiatal hernia can cause acid to back up into the esophagus, causing gastroesophageal reflux disorder (GERD). Medications usually resolve the GERD symptoms, but very large hiatal hernias may require surgery.²⁴

IRRITABLE BOWEL SYNDROME (IBS)

Irritable bowel syndrome (ĪR-ĭ-tă-bl BOWL SĪN-drōm) (**IBS**) is a group of

24. Mayo Clinic. (2021, February 23). *Hiatal hernia*. <https://www.mayoclinic.org/diseases-conditions/hiatal-hernia/symptoms-causes/syc-20373379>

symptoms that occur together, including repeated pain in the abdomen and changes in bowel movements, which may be diarrhea, constipation, or both. Individuals with IBS have these symptoms without any visible signs of damage or disease in the digestive tract. Health care providers diagnose IBS based on a medical history and physical exam. Diagnostic testing, like upper GI endoscopy and colonoscopy, may be performed to rule out other conditions. IBS is treated with diet changes.²⁵

PANCREATITIS

Pancreatitis (pan-krē-a-TĪT-ĭs) is inflammation of the pancreas. Pancreatitis can be an acute or chronic condition. Acute pancreatitis appears suddenly and lasts a short time. Chronic pancreatitis is a long-term condition, and the damage to the pancreas can get worse over time. Pancreatitis can be caused by blockage in the bile duct caused by gallstones, heavy alcohol use, diabetes, and pancreatic cancer. However, sometimes a cause is never found. Severe pancreatitis requires treatment in a hospital and can cause life-threatening complications.²⁶

25. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Irritable bowel syndrome*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/digestive-diseases/irritable-bowel-syndrome>

26. Mayo Clinic. (2023, September 23). *Pancreatitis*. <https://www.mayoclinic.org/diseases-conditions/pancreatitis/symptoms-causes/syc-20360227>

PEPTIC ULCER DISEASE

Peptic ulcer disease (PĚP-tĭk UL-sĕr dĭ-ZĚZ) (**PUD**) refers to ulcers in the stomach lining (gastric ulcers) or the duodenum (duodenal ulcers). See Figure 12.23²⁷ for an image of an ulcer on an upper endoscopy. PUD can cause complications such as bleeding, perforation, or blockage in the stomach or duodenum. A common symptom of PUD is pain in the upper part of the abdomen. Common causes of PUD are *Helicobacter pylori* (*H. pylori*) infection and use of nonsteroidal anti-inflammatory drugs (NSAIDs) like aspirin, ibuprofen, and naproxen.²⁸

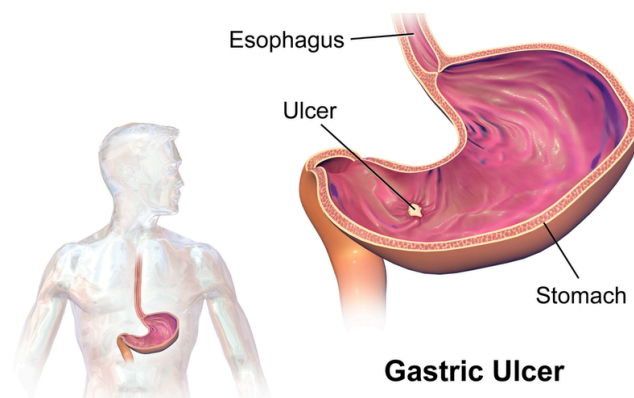


Figure 12.23 Gastric Ulcer

Common diagnostic tests for PUD include blood tests for *H. pylori*, a urea breath test, an upper GI endoscopy, or an upper GI series. In a **urea breath**

27. “Gastric_Ulcer.png” by BruceBlaus is licensed under CC BY-SA 4.0

28. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Peptic ulcers (stomach and duodenal ulcers)*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/digestive-diseases/peptic-ulcers-stomach-ulcers>

test (yöö-RĒ-ă brĕth tĕst), the patient swallows a capsule, liquid, or pudding that contains urea that is “labeled” with a special carbon atom. If *H. pylori* is present, the bacteria convert the urea into carbon dioxide. After a few minutes, the patient breathes into a container, exhaling carbon dioxide. The exhaled breath is evaluated by a medical lab technician. If the test detects the labeled carbon atoms, an *H. pylori* infection is confirmed.²⁹ Read more about upper GI endoscopy and upper GI series in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Digestive System](#)” section.

PERITONITIS

Peritonitis (per-īt-ŏ-NĪT-īs) refers to inflammation of the peritoneum, the tissue that lines the inside of the abdominal cavity. It is typically caused by an infection or by leakage of body fluids from one of the abdominal organs (such as an inflamed appendix, intestine, pancreas, or gallbladder). Infection of the peritoneum is especially dangerous because it can impact the functioning of the abdominal organs and also transfer bacteria to the bloodstream where it can cause a life-threatening infection called sepsis. Health care providers treat peritonitis as an emergency because it can become severe very quickly. It is treated with intravenous antibiotics. Common symptoms of peritonitis are as follows³⁰:

- Mild to severe abdominal pain with sensitivity to touch

29. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Peptic ulcers (stomach and duodenal ulcers)*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/digestive-diseases/peptic-ulcers-stomach-ulcers>

30. Cleveland Clinic. (2022, November 2). *Peritonitis*. <https://my.clevelandclinic.org/health/diseases/17831-peritonitis>

- Swollen, distended abdomen
- **Paralytic ileus** (pă-r-ă-LĭT-ĭk Ī-lē-ŭs), which is when the bowels become temporarily paralyzed

12.7 Medical Specialists, Diagnostic Testing, and Procedures Related to the Digestive System

MEDICAL SPECIALISTS

Gastroenterology

Gastroenterology (găs-trō-ěn-těr-ŎL-ă-jē) is the study of the normal function and diseases of the esophagus, stomach, small intestine, colon and rectum, pancreas, gallbladder, bile ducts, and liver. A physician who specializes in the diagnosis and treatment of gastrointestinal disorders is known as a **gastroenterologist** (găs-trō-ěn-těr-ŎL-ŏ-jĭst).

A **colorectal surgeon** (kō-lō-REK-tăl SUR-jĕn) is a surgeon who specializes in conditions affecting the large intestine (i.e., colon, rectum, and anus.) A **proctologist** (prok-TOL-ŏ-jĭst) is a physician who specializes in the diagnosis and treatment of diseases of the rectum.

▶ To learn more about gastroenterology, visit the [American College of Gastroenterology web page](#).

DIAGNOSTIC TESTS

Barium Enema

A **barium enema** (BĀR-ē-ŭm EN-ĕ-mă) is a diagnostic procedure involving the use of a contrast material known as barium. Barium is a chalky material that appears white on X-ray and coats the inner wall of the large intestine for visualization. During the procedure, barium is administered into the rectum, along with air (that appears black on X-ray). Fluoroscopy is often used during a barium enema. During fluoroscopy, a continuous X-ray is passed through the large intestine and is transmitted to a monitor so the movement of the barium through the large intestine can be visualized as it is instilled through the rectum. After the procedure, if the barium isn't completely eliminated from the body, constipation or fecal impaction may occur.¹ See Figure 12.24² for an image of a barium enema showing herniation of the colon. The barium causes the colon to appear white on the left side of the image, and air in the colon causes it to appear black on the right side of the image.

1. Johns Hopkins Medicine. (n.d.). *Barium enema*.

<https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/barium-enema>

2. “[Colonic Herniation_08787.jpg](#)” by [Nevit Dilmen](#) (talk) is licensed under [CC BY-SA 3.0](#)

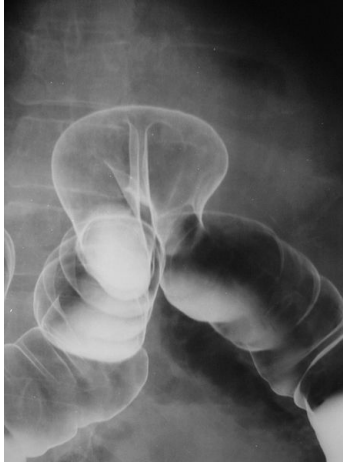


Figure 12.24 Barium Enema Showing Colon Herniation

Colonoscopy

A **colonoscopy** (köl-ŏn-OS-kŏ-pē) is a procedure that examines the inside of the large intestine, including the colon, rectum, and anus. A **sigmoidoscopy** (sig-moy-DOS-kŏ-pē) is a similar procedure but only examines the sigmoid colon. During both procedures, the physician uses an **endoscope** (EN-dŏ-skŏp), a flexible tube with a lighted camera on the end that is inserted into the anus and colon. Along the way, it sends pictures of the inside of the large intestine to a screen. The physician can take biopsies during these procedures and also remove polyps.³ See Figure 12.25⁴ for an illustration of a colonoscopy.

3. Cleveland Clinic. (2022, November 30). *Colonoscopy*.
<https://my.clevelandclinic.org/health/diagnostics/4949-colonoscopy>
4. “[Diagram showing a colonoscopy CRUK_060.svg](#)” by [Cancer Research UK](#). Wikimedia Commons is licensed under [CC BY-SA 4.0](#)

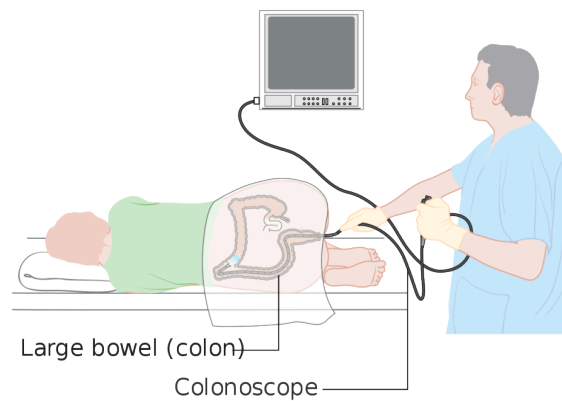


Figure 12.25 Colonoscopy

The American Cancer Society recommends routine colonoscopy screening for colon cancer for individuals of average risk starting at age 45.⁵ Colonoscopies are also used to diagnose medical conditions like inflammatory bowel disease or colon cancer.

Colonoscopy prep is very important to the success of the procedure. The health care provider provides detailed instructions to the patient to follow in the days leading up to the procedure. The purpose of these preparations is to make sure the large intestine is as clear as possible for visualization of the tissue. Typically, a low-fiber diet is followed for two or three days, followed by a clear liquid diet on the day before the procedure. The afternoon before the colonoscopy, a strong laxative is taken to purge the bowels.⁶

5. American Cancer Society. (2020, November 17). *American Cancer Society guideline for colorectal cancer screening*. <https://www.cancer.org/cancer/types/colon-rectal-cancer/detection-diagnosis-staging/acs-recommendations.html>

6. Cleveland Clinic. (2022, November 30). *Colonoscopy*. <https://my.clevelandclinic.org/health/diagnostics/4949-colonoscopy>

Upper GI Endoscopy

During an **upper GI endoscopy** (ŮP-ěr Jī ěn-DŎS-kŏ-pē en-DOS-kŏ-pē), also called an **esophagogastroduodenoscopy** (ē-sof-ă-gŏ-gas-trō-doo-ŏ-dē-NOS-kŏ-pē) (**EGD**), a doctor uses a flexible tube with a camera to see the lining of the upper gastrointestinal tract, including the esophagus, stomach, and duodenum. During upper GI endoscopy, biopsies may be taken by passing an instrument through the endoscope to take small pieces of tissue from the lining of the esophagus. A pathologist examines the tissue under a microscope.⁷ See Figure 12.26⁸ for an image of an upper GI endoscopy.



Figure 12.26 Upper GI Endoscopy

7. National Institute of Diabetes and Digestive and Kidney Diseases. (2020, July). *Diagnosis of GER & GERD*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/digestive-diseases/acid-reflux-ger-gerd-adults/diagnosis>

8. “180619235_391dec588d_b.jpg” by Yuya Tamai is licensed under [CC BY 2.0](https://creativecommons.org/licenses/by/2.0/)

Upper GI Series

An **upper gastrointestinal series** (ŮP-ěr GAS-trō-in-TĚS-tĩ-năl SĪR-ēz) is an X-ray examination of the upper gastrointestinal (GI) tract. The esophagus, stomach, and duodenum are made visible on X-ray film by a liquid suspension that may be barium or a water-soluble contrast. If only the pharynx and esophagus are examined with barium, the procedure is called a **barium swallow** (BĀR-ē-ŭm SWŎL-ō). Fluoroscopy is often used during an upper GI series to allow the radiologist to visualize the movement of the barium through the esophagus, stomach, and duodenum as a person drinks. After the procedure, if barium is not completely eliminated from the body, constipation and fecal impaction can occur.⁹ See Figure 12.27¹⁰ for an image of an upper GI series that shows a hernia and an obstruction. The barium causes the stomach and esophagus to appear white.

9. Johns Hopkins Medicine. (n.d.). *Upper gastrointestinal series*.

<https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/upper-gastrointestinal-series>

10. “Radiology_0014_Nevit.jpg” by [Nevit Dilmen](#) (talk) is licensed under [CC BY-SA 3.0](#)

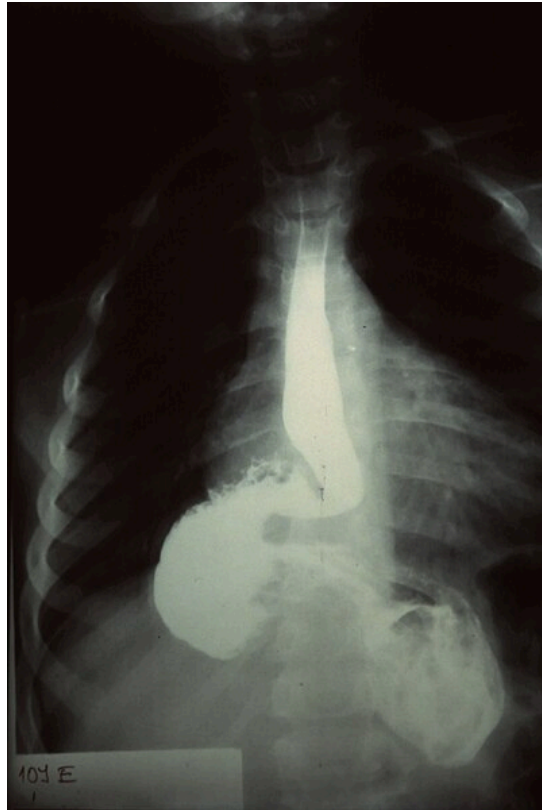


Figure 12.27 Upper GI Series Showing a Hernia and Obstruction

Stool-Based Tests

The U.S. Preventive Services Task Force recommends that adults aged 45 to 75 be screened for colorectal cancer. Several stool-based tests can be used to screen for polyps or colorectal cancer¹¹:

- **Fecal occult blood test** (FĒ-kāl ō-KULT blūd tĕst) (**FOBT**) or (**gFOBT**): Uses a chemical called guaiac to detect blood in the stool. For this test, the patient receives a test kit from their health care provider. At home, they

11. Centers for Disease Control and Prevention. (2023, February 23). *Colorectal cancer screening tests*. U.S. Department of Health & Human Services. https://www.cdc.gov/cancer/colorectal/basic_info/screening/tests.htm

use a small stick or brush to obtain a small amount of stool and place it on a card. The test kit is returned to a lab, where the stool sample is checked for the presence of blood.

- **Fecal immunochemical test** (FĒ-kāl im-yŭn-Ō-kēm-ĭ-kāl tĕst): Uses antibodies to detect blood in the stool.
- **Stool DNA test** (stōōl dē-ĕn-ā tĕst): Combines the fecal immunochemical test with a test that detects altered DNA in the stool. For this test, an entire bowel movement is collected and sent to a lab, where it is checked for altered DNA and the presence of blood.

If a stool test is positive, then a colonoscopy is scheduled for follow-up testing. See Figure 12.28¹² for an image of a stool specimen container.



Figure 12.28 Stool Specimen Container

12. “[Stool_specimen_container.jpg](#)” by [Whispyhistory](#) is licensed under [CC BY-SA 4.0](#)

Stool Culture

A **stool culture** (stōōl KUL-chŭr) is a test that detects and identifies bacteria that cause infections of the lower digestive tract. The test distinguishes between the types of bacteria that cause disease (pathogenic) and the types that are normally found in the digestive tract (normal flora). The test helps to determine if pathogenic bacteria are the cause of a person's gastrointestinal symptoms.¹³

13. Testing.com. (2021, November 9). *Stool culture*. <https://www.testing.com/tests/stool-culture>

12.8 Digestive System Learning Activities

Interactive Learning Activity: Label the parts of the digestive system.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=518#h5p-110>

Interactive Learning Activity: Study digestive system medical terms discussed in this chapter using these flashcards.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=518#h5p-186>

Interactive Learning Activity: Test yourself on these digestive related terms.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=518#h5p-115>

Interactive Learning Activity: Test yourself on digestive system terms.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=518#h5p-109>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=518#h5p-113>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=518#h5p-114>



Interactive Learning Activity: Practice identifying and defining word parts for terms discussed in this chapter.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=518#h5p-203>

- ▶ You can also print this as a [Chapter 12 Practice Worksheet](#) and check your answers with this [Answer Key PDF](#).

12.9 Glossary

Absorption (ab-SORP-shŏn): The process in which nutrients enter the bloodstream after food molecules have been broken down during chemical digestion. ([Chapter 12.5](#))

Adhesion (ad-HĒ-zhŏn): Scar tissue from disease or previous surgery that binds anatomical surfaces to each other. ([Chapter 12.5](#))

Amino acids (Ā-mē-nō AS-idz): Molecules that combine to form proteins. ([Chapter 12.5](#))

Amylase (ĀM-ĭ-lās): An enzyme, produced chiefly in the pancreas and salivary glands, that converts starch and glycogen into simple sugars. ([Chapter 12.4](#))

Anal (ĀN-ăl): Pertaining to the anus, the opening at the end of the digestive tract from which feces exit the body. ([Chapter 12.4](#))

Anastomosis (ăn-ăs-tō-MŌ-sĭs): A surgical connection between two tubes, vessels, or ducts. ([Chapter 12.6](#))

Anus (Ā-nŭs): The opening at the end of the digestive tract where feces leave the body. ([Chapter 12.4](#))

Appendectomy (ap-ĕn-DEK-tŏ-mē): Surgical removal of the appendix. ([Chapter 12.4](#))

Appendicitis (ă-pen-dĭ-SĪT-ĭs): Inflammation of the appendix. ([Chapter 12.4](#))

Appendix (ă-PEN-dĭks): A tube-shaped sac attached to and opening into the lower end of the large intestine. ([Chapter 12.4](#))

Ascending colon (ă-SEN-dĭng KŌ-lŏn): The first part of the colon which travels upward on the right side of the abdomen. ([Chapter 12.4](#))

Ascites (ă-SĪ-tēz): Abnormal fluid buildup in the abdominal cavity, causing abdominal swelling, often due to liver disease or cancer. ([Chapter 12.5](#), [Chapter 12.6](#))

Barium enema (BĀR-ē-ŭm EN-ĕ-mă): An X-ray exam that can detect changes or abnormalities in the large intestine (colon). ([Chapter 12.7](#))

Barium swallow (BĀR-ē-ŭm SWŌL-ŏ): A test that checks for problems in the throat, esophagus, stomach, and small intestine. ([Chapter 12.7](#))

Bile (BĪL): A bitter, greenish-brown alkaline fluid that aids digestion, secreted by the liver and stored in the gallbladder. ([Chapter 12.4](#))

Bilirubin (bil-ĭ-ROO-bin): A yellowish pigment formed in the liver by the breakdown of red blood cells. ([Chapter 12.4](#))

Bolus (BŌL-ŭs): A soft mass of food that is an appropriate size for swallowing. ([Chapter 12.5](#))

Cecum (SĒ-kŭm): The first section of the large intestine, into which the ileum opens. ([Chapter 12.4](#))

Celiac disease (SĒ-lē-ăk dĩ-ZĒZ): A serious autoimmune disorder that can occur in genetically predisposed people where the ingestion of gluten leads to damage in the small intestine. ([Chapter 12.6](#))

Cholecystectomy (kō-lě-sis-TEK-tŏ-mē): Surgical removal of the gallbladder. ([Chapter 12.6](#))

Cholecystitis (kō-lě-sis-TĪT-ĭs): Inflammation of the gallbladder, often due to a gallstone blocking the cystic duct. ([Chapter 12.4](#), [Chapter 12.6](#))

Cholelithiasis (kō-li-lith-Ī-ă-sĭs): The formation of gallstones in the gallbladder. ([Chapter 12.4](#), [Chapter 12.6](#))

Chyme (KĪM): The pulpy acidic fluid that passes from the stomach to the small intestine, consisting of gastric juices and partly digested food. ([Chapter 12.4](#))

Cirrhosis (sĭr-RŌ-sĭs): A chronic disease of the liver marked by degeneration of cells, inflammation, and fibrous thickening of tissue. It is often caused by alcoholism or hepatitis. ([Chapter 12.6](#))

Colon cancer (KŌ-lŏn KAN-sĕr): A type of cancer that occurs in the colon or rectum, part of the large intestine, where malignant cells form in the tissues of the colon. ([Chapter 12.6](#))

Colon polyps (KŌ-lŏn PŎL-ĭps): Small clumps of cells that form on the lining of the colon, which can become cancerous over time. ([Chapter 12.6](#))

Colon resection surgery (KŌ-lŏn rĭ-SĔK-shŭn SUR-jĕr-ē): A surgical procedure to remove a section of the colon. ([Chapter 12.6](#))

Colon resection with colostomy (KŌ-lŏn rĭ-SĔK-shŭn wĭth kŏl-ŌS-tŏ-mē): A surgical procedure where part of the colon is removed and the remaining colon is brought to the abdominal surface. ([Chapter 12.6](#))

Colonoscopy (kŏl-ŏn-OS-kŏ-pē): A test that allows your doctor to look at

the inner lining of your large intestine (rectum and colon) using a thin, flexible tube called a colonoscope. ([Chapter 12.7](#))

Colorectal surgeon (kō-lō-REK-tāl SUR-jěn): A doctor who specializes in the surgical treatment of conditions of the colon, rectum, and anus. ([Chapter 12.7](#))

Colostomy (kō-LOS-tō-mē): A surgical procedure that brings one end of the large intestine out through the abdominal wall to carry stool out of the body. ([Chapter 12.6](#))

Crohn's disease (krōnz diz-ĒZ): A chronic inflammatory bowel disease that affects the lining of the digestive tract. ([Chapter 12.6](#))

Defecation (děf-ě-KĀ-shŏn): The final step in digestion when undigested materials are expelled from the body as feces. ([Chapter 12.5](#))

Descending colon (dě-SEN-ding KŌ-lŏn): The part of the colon that travels downward on the left side of the abdomen. ([Chapter 12.4](#))

Digestion (dī-JĒS-tion): The process by which food is broken down into absorbable units. ([Chapter 12.4](#))

Diverticula (dī-věr-TIK-yū-lă): Small, bulging pouches that can form in the lining of the digestive system. ([Chapter 12.6](#))

Diverticulitis (dī-věr-tik-yŭ-LĪT-ĭs): Inflammation or infection of one or more diverticula in the digestive tract. ([Chapter 12.6](#))

Diverticulosis (dī-věr-tik-yŭ-LŌ-sĭs): The condition of having diverticula in the colon. ([Chapter 12.6](#))

Duodenum (dū-ō-DE-nŭm): The first section of the small intestine, immediately beyond the stomach, leading to the jejunum. ([Chapter 12.4](#))

Dysentery (DIS-ĕn-ter-ē): An inflammatory disorder of the intestine, especially of the colon, that results in severe diarrhea containing blood and mucus in the feces with fever, abdominal pain, and rectal tenesmus. ([Chapter 12.5](#))

Dyspepsia (dĭs-PEP-sē-ă): Indigestion or upset stomach, marked by epigastric pain, burning, and nausea. ([Chapter 12.5](#))

Dysphagia (dĭs-FĀj-ē-ă): Difficulty or discomfort in swallowing. ([Chapter 12.4](#))

Emesis (ĔM-ĕ-sĭs): The act of vomiting or ejecting stomach contents through the mouth. ([Chapter 12.5](#))

Endocrine (EN-dŏ-krīn): Relating to glands which secrete hormones or other products directly into the blood. ([Chapter 12.4](#))

Endoscope (EN-dŏ-skōp): An instrument used for visual examination of the interior of a hollow body organ. ([Chapter 12.7](#))

Endoscopic retrograde cholangiopancreatography (en-dŏ-SKOP-ik rě-trō-grād kō-LAN-jē-ō-pan-krē-ă-TŎG-ră-fē) (ERCP): A procedure used to diagnose and treat problems in the liver, gallbladder, bile ducts, and pancreas. ([Chapter 12.6](#))

Enzymes (EN-zīmz): Substances produced by a living organism that act as a catalyst to bring about a specific biochemical reaction. ([Chapter 12.5](#))

Epiglottis (ěp-ĭ-GLŎT-ĭs): A flap of cartilage at the root of the tongue, which is depressed during swallowing to cover the opening of the windpipe. ([Chapter 12.4](#))

Esophageal cancer (ĭ-sŏf-ă-JĒ-ăl KAN-sěr): A type of cancer that occurs in the esophagus, the long, hollow tube that runs from the throat to the stomach. ([Chapter 12.6](#))

Esophageal varices (ě-sŏf-ă-JĒ-ăl VĀR-ĭ-sēz): Abnormally swollen veins in the lower part of the esophagus, often associated with liver disease. ([Chapter 12.4](#))

Esophagectomy (ě-sŏf-ă-JĚK-tŏ-mē): A surgical procedure to remove part or all of the esophagus. ([Chapter 12.6](#))

Esophagogastroduodenoscopy (ē-sof-ă-gō-gas-trō-doo-ŏ-dē-NOS-kŏ-pē) (EGD): A diagnostic test to examine the lining of the esophagus, stomach, and first part of the small intestine. ([Chapter 12.7](#))

Esophagus (ĭ-SOF-ă-gŭs): The muscular tube that conveys food and liquids from the throat to the stomach. ([Chapter 12.4](#))

Exocrine (ĚK-sŏ-krīn): Pertaining to the secretion of a substance out through a duct. ([Chapter 12.4](#))

Fecal immunochemical test (FĒ-kăl im-yŭn-Ō-kēm-ĭ-kăl tĕst): A test that checks stool for tiny amounts of blood released by polyps or colorectal cancer. ([Chapter 12.7](#))

Fecal occult blood test (FĒ-kăl ŏ-KULT blŭd tĕst) (gFOBT): A test that checks stool samples for hidden (occult) blood using a chemical called guaiac. ([Chapter 12.7](#))

Feces (FĒ-sēz): Waste matter discharged from the bowels after food has been digested. ([Chapter 12.4](#))

Flatus (FLĀ-tūs): Gas in the gastrointestinal tract, expelled through the anus. ([Chapter 12.4](#), [Chapter 12.5](#))

Gallbladder (GAWL-blād-ěr): A small organ where bile is stored, before it is released into the small intestine. ([Chapter 12.4](#))

Gallstone (GAWL-stōn): A small, hard crystalline mass formed abnormally in the gallbladder or bile ducts from bile pigments, cholesterol, and calcium salts. ([Chapter 12.6](#))

Gastric juice (GAS-trīk JOOS): A digestive fluid secreted by the stomach, containing hydrochloric acid, pepsin, and other enzymes. ([Chapter 12.4](#))

Gastroenteritis (GAS-trō-ěn-těr-Ī-tīs): Inflammation of the stomach and intestines, typically resulting from bacterial toxins or viral infection and causing vomiting and diarrhea. ([Chapter 12.5](#))

Gastroenterologist (gās-trō-ěn-těr-ŌL-ō-jīst): A physician who specializes in the diagnosis and treatment of diseases of the digestive system. ([Chapter 12.7](#))

Gastroenterology (gās-trō-ěn-těr-ŌL-ă-jē): The study of the digestive system and its disorders. ([Chapter 12.7](#))

Gastroesophageal reflux disease (GAS-trō-ě-sōf-ă-JĒ-ăl REE-flŭks dĩ-ZĒZ) (GERD): A chronic condition where stomach acid or bile flows into the food pipe (esophagus) and irritates the lining. ([Chapter 12.4](#), [Chapter 12.6](#))

Gingivitis (jin-jī-VĪT-īs): Inflammation of the gums. ([Chapter 12.4](#))

Glossitis (glo-SĪT-īs): Inflammation of the tongue. ([Chapter 12.4](#))

Hard palate (HARD PAL-āt): The bony front part of the palate. ([Chapter 12.4](#))

Hemorrhoid (HEM-ō-royd): A swollen vein or group of veins in the region of the anus. ([Chapter 12.4](#))

Hepatitis (hep-ă-TĪT-īs): Inflammation of the liver, usually caused by a viral infection or liver toxins. ([Chapter 12.6](#))

Hepatomegaly (hep-ăt-ō-MEG-ă-lē): An enlarged liver. ([Chapter 12.4](#))

Hernia (HUR-nē-ă): A condition in which part of an organ is displaced and protrudes through the wall of the cavity containing it, often involving the intestine at a weak point in the abdominal wall. ([Chapter 12.5](#), [Chapter 12.6](#))

Hiatal hernia (hī-Ā-tăl HĒR-nē-ă): A type of hernia in which abdominal

organs (typically the stomach) slip through the diaphragm into the middle compartment of the chest. ([Chapter 12.6](#))

Hydrochloric acid (HĪ-drō-klōr-ĪK AS-id): A component of gastric juice that helps create the acidic environment in the stomach. ([Chapter 12.4](#))

Ileocecal valve (ĪL-ē-ō-SĒ-kāl VALV): A sphincter muscle valve that separates the small intestine and the large intestine. ([Chapter 12.4](#))

Ileostomy (IL-ē-OS-tō-mē): A surgical opening constructed by bringing the end of the small intestine (the ileum) out onto the surface of the skin. ([Chapter 12.6](#))

Ileum (ĪL-ē-ŭm): The third portion of the small intestine, between the jejunum and the cecum of the large intestine. ([Chapter 12.4](#))

Irritable bowel syndrome (ĪR-ĭ-tă-bl BOWL SĪN-drōm) (IBS): A common disorder affecting the large intestine, causing cramping, abdominal pain, bloating, gas, diarrhea, and constipation. ([Chapter 12.6](#))

Jaundice (JAWN-dīs): A medical condition with yellowing of the skin or whites of the eyes, arising from excess of the pigment bilirubin. ([Chapter 12.4](#), [Chapter 12.6](#))

Jejunum (jĭ-JŪ-num): The part of the small intestine between the duodenum and ileum. ([Chapter 12.4](#))

Laparoscope (LAP-ă-rō-skōp): A thin tube with a camera and light at the end, used for viewing the interior of the abdominal or pelvic cavities. ([Chapter 12.6](#))

Large bowel resection (LARJ BOW-ěl rĭ-SĚK-shŭn): Surgical removal of part of the large intestine. ([Chapter 12.6](#))

Large intestine (LARJ IN-tēs-tĭn): The last part of the digestive system, absorbing water and electrolytes, forming and storing feces. ([Chapter 12.4](#))

Lipase (LĪ-pās): An enzyme that catalyzes the hydrolysis of fats (lipids). ([Chapter 12.4](#))

Liver (LIV-ěr): A large lobed glandular organ in the abdomen, involved in many metabolic processes. ([Chapter 12.4](#))

Lower esophageal sphincter (LOH-ěr ĭ-SOF-ă-gě-al SFINGK-těr): A ring of muscle at the end of the esophagus where it meets the stomach, which acts as a valve to prevent the backflow of stomach contents. ([Chapter 12.4](#))

Melena (mě-LĚ-nǎ): Dark sticky feces containing partly digested blood, indicative of gastrointestinal bleeding. ([Chapter 12.5](#))

Nausea (NAW-zē-ǎ): A feeling of sickness with an inclination to vomit. ([Chapter 12.5](#))

NPO (en-pē-ō): A commonly used medical abbreviation for “nil per os,” the Latin phrase that means “nothing by mouth.” ([Chapter 12.5](#))

Nutrients (NŪ-trē-ěntz): Substances that provide nourishment to cells. ([Chapter 12.5](#))

Obesity (ō-BĚ-sī-tē): A medical condition in which excess body fat has accumulated to an extent that it may have a negative effect on health. ([Chapter 12.5](#))

Oral cavity (ŌR-ǎl KAV-ī-tē): The mouth area, encompassing the lips, cheeks, palate, and floor of the mouth. ([Chapter 12.4](#))

Ostomy appliance (ŎS-tō-mē ǎ-PLĪ-ǎns): A device used to collect waste from a surgically diverted biological system (such as a colostomy, ileostomy). ([Chapter 12.6](#))

Palpate (PAL-pāt): Examine (a part of the body) by touch, especially for medical purposes. ([Chapter 12.5](#))

Pancreas (PAN-krē-ǎs): A large gland behind the stomach which secretes digestive enzymes into the duodenum. ([Chapter 12.4](#))

Pancreatitis (pǎn-krē-a-TĪT-īs): Inflammation of the pancreas. ([Chapter 12.6](#))

Paralytic Ileus (pǎr-ǎ-LĪT-īk Ī-lē-ūs): A condition in which the intestine does not work properly and there is no movement of food or waste in the intestine. ([Chapter 12.6](#))

Partial colectomy (pǎr-shul kō-LEK-tō-mē): A surgical procedure to remove part of the colon and is used to treat or prevent diseases and conditions that affect the colon. ([Chapter 12.6](#))

Peptic ulcer disease (PĚP-tĭk UL-sěr dĩ-ZĚZ) (PUD): A condition where ulcers form on the lining of the stomach, lower esophagus, or small intestine, typically caused by inflammation due to H. pylori bacteria and the use of NSAIDs. ([Chapter 12.6](#))

Percutaneous endoscopic gastrostomy (pûr-kû-TĀ-nē-ūs ěn-DŎS-kŏ-pĭk gǎs-TRŎS-tō-mē) (PEG): A medical procedure in which a tube is passed into a

patient's stomach through the abdominal wall, most commonly to provide a means of feeding when oral intake is not adequate. ([Chapter 12.5](#))

Peristalsis (pěr-ĭ-STAL-sĭs): The involuntary constriction and relaxation of the muscles in the intestine or another canal, creating wave-like movements that push the contents forward. ([Chapter 12.4](#), [Chapter 12.5](#))

Peritoneum (pěr-ĭ-tō-NĒ-ŭm): A serous membrane lining the cavity of the abdomen and covering the abdominal organs. ([Chapter 12.4](#))

Peritonitis (pěr-ĭt-ŏ-NĪT-ĭs): Inflammation of the peritoneum, the tissue that lines the inner wall of the abdomen and covers and supports most of your abdominal organs. ([Chapter 12.4](#), [Chapter 12.6](#))

Pharynx (FAR-ĭnks): The muscular tube extending from the back of the nasal cavities and the mouth to the esophagus, known as the throat. ([Chapter 12.4](#))

Polypectomy (pŏl-ĭ-PĚK-tŏ-mĕ): Surgical removal of polyps from the colon or rectum. ([Chapter 12.6](#))

Probiotics (prŏ-bĭ-OT-ĭks): Live bacteria and yeasts that are good for your health, especially your digestive system. ([Chapter 12.5](#))

Proctocolectomy (prŏk-tŏ-kŏ-LEK-tŏ-mĕ): Surgical removal of the rectum and all or part of the colon. ([Chapter 12.6](#))

Proctologist (prŏk-TOL-ŏ-jĭst): A physician who specializes in diagnosing and treating disorders of the rectum and anus. ([Chapter 12.7](#))

Proctoscope (PRŎK-tă-skŏp): An instrument for examining the rectum. ([Chapter 12.4](#))

Pyloric sphincter (pĭ-LOR-ĭk SFINGK-tĕr): A ring of smooth muscle at the end of the stomach, regulating the flow of partially digested food into the small intestine. ([Chapter 12.4](#))

Radiofrequency ablation (RĀ-dĕ-ŏ-FRĒ-kwĕn-sĕ ă-blā-shŭn): A medical procedure in which part of the electrical conduction system of a tumor or other dysfunctional tissue is ablated using the heat generated from high-frequency alternating current. ([Chapter 12.6](#))

Rectum (REK-tŭm): The final section of the large intestine, terminating at the anus. ([Chapter 12.4](#))

Reflux (RĒ-flŭks): The backward flow of stomach contents into the esophagus or throat, causing heartburn or acid indigestion. ([Chapter 12.5](#))

Salivary (SĀL-ĭ-vār-ē): Related to or producing saliva. ([Chapter 12.4](#))

Sigmoid colon (SIG-moyd KŌ-lŏn): The S-shaped last part of the colon, leading into the rectum. ([Chapter 12.4](#))

Sigmoidoscopy (sig-moy-DOS-kŏ-pē): A medical examination of the sigmoid colon by means of a sigmoidoscope. ([Chapter 12.7](#))

Small bowel resection (SMOL BOW-ĕl rĭ-SĚK-shŭn): Surgical removal of part of the small intestine. ([Chapter 12.6](#))

Small intestine (SMOL IN-tĕs-tĭn): The part of the intestine where most of the digestion and absorption of food occurs, extending between the stomach and large intestine. ([Chapter 12.4](#))

Soft palate (SOFT PAL-āt): The fleshy, flexible part towards the back of the roof of the mouth. ([Chapter 12.4](#))

Steatorrhea (stē-ăt-ŏ-RĒ-ă): The excretion of abnormal quantities of fat with the feces. ([Chapter 12.4](#))

Stoma (STŌ-mă): An artificial opening made into a hollow organ, especially one on the surface of the body leading to the gut or trachea. ([Chapter 12.6](#))

Stomach (STUM-ăk): A sac-like organ of the digestive system that mixes food with gastric juices to begin the digestion of proteins. ([Chapter 12.4](#))

Stomatitis (stō-mă-TĪT-ĭs): Inflammation of the mouth and lips. ([Chapter 12.4](#))

Stool culture (stōŏl KUL-chŭr): A test to detect and identify bacteria that cause infections of the lower digestive tract. ([Chapter 12.7](#))

Stool DNA test (stool dē-ĕn-ā tĕst): A test that checks stool samples for certain DNA markers that cells from colorectal cancer or polyps shed into the stool. ([Chapter 12.7](#))

Sublingual (sŭb-LING-gwăł): Underneath the tongue. ([Chapter 12.4](#))

Tongue (TUNG): A muscular organ in the mouth, aiding in tasting, swallowing, and speaking. ([Chapter 12.4](#))

Transverse colon (trans-VURS KŌ-lŏn): The middle part of the colon which travels across the abdomen. ([Chapter 12.4](#))

Ulcerative colitis (UL-sĕr-ă-tiv kŏ-LĪ-tĭs): A chronic, inflammatory bowel disease that causes inflammation in the digestive tract, specifically in the lining of the large intestine (colon) and rectum. ([Chapter 12.6](#))

Upper gastrointestinal series (ŬP-ĕr GAS-trŏ-in-TĚS-tĭ-năł SĪR-ĕz): A series

of X-rays of the patient's esophagus, stomach, and small intestine. ([Chapter 12.7](#))

Upper GI endoscopy (ŮP-ěr Jī ěn-DŮS-kŏ-pē en-DOS-kŏ-pē): A procedure in which a thin scope with a light and camera at its tip is used to look inside the upper digestive tract — the esophagus, stomach, and the first part of the small intestine, called the duodenum. ([Chapter 12.7](#))

Urea breath test (yoo-RĒ-ă brĕth tĕst): A diagnostic test for *Helicobacter pylori* using a special form of urea. ([Chapter 12.6](#))

Uvula (YŮ-vyŭ-lă): A fleshy extension at the back of the soft palate that hangs above the throat. ([Chapter 12.4](#))

Uvulitis (ŭ-vyŭ-LĪT-ĭs): Inflammation of the uvula. ([Chapter 12.4](#))

Villi (VĪL-ĭ): Small, finger-like projections that protrude from the epithelial lining of the intestinal wall, increasing the surface area for absorption. ([Chapter 12.4](#))

Visceral (VĪS-ěr-ăl): Relating to the internal organs of the body, especially those in the abdomen. ([Chapter 12.5](#))

Vomiting (VOM-ĭ-ting): Ejecting matter from the stomach through the mouth. ([Chapter 12.5](#))

Xerostomia (zēr-ŏ-STŌ-mē-ă): Dry mouth, often due to a decrease in saliva production. ([Chapter 12.4](#))

PART XIII

CHAPTER 13 SKELETAL SYSTEM TERMINOLOGY

13.1 Introduction to the Skeletal System

Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the skeletal system
- Identify meanings of key word components of the skeletal system
- Categorize diagnostic, therapeutic, procedural, or anatomic terms related to the skeletal system
- Use terms related to the skeletal system
- Use terms related to the diseases and disorders of the skeletal system

The skeletal system is composed of bones, cartilage, and ligaments. It performs several functions, including supporting the body, protecting internal organs, producing blood cells, and storing/releasing minerals.¹

This chapter will review common word components related to the skeletal

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system to assist learners in analyzing, building, and defining medical terms. Other terms, whose definitions cannot be easily built from word components, will be described in context based on the anatomy and physiology of the skeletal system and common diseases and disorders. Medical specialists, diagnostic tests, and procedures related to the skeletal system will also be discussed.

View a supplementary YouTube video² on the skeletal system: [The Skeletal System: Crash Course Anatomy & Physiology #19](https://www.youtube.com/watch?v=rDGqkMHPDqE)

2. CrashCourse. (2015, May 18). *The skeletal system: Crash Course Anatomy & Physiology #19* [Video]. YouTube. All rights reserved. <https://www.youtube.com/watch?v=rDGqkMHPDqE>

13.2 Word Components Related to the Skeletal System

This section will describe common word components related to the skeletal system. These word components help build definitions for many medical terms. Other common prefixes are described in [Chapter 1.3](#), and common suffixes are described in [Chapter 1.5](#).

PREFIXES RELATED TO THE SKELETAL SYSTEM

- **a-**: Absence of, without
- **ab-**: Away from
- **ad-**: Towards
- **brady-**: Slow
- **dys-**: Painful, difficult, abnormal, labored
- **hyper-**: Above, excessive
- **inter-**: Between
- **intra-**: Within, in
- **poly-**: Many, much
- **sub-**: Below, under
- **supra-**: Above
- **sym-**: Together, joined
- **syn-**: Together, joined

WORD ROOTS WITH A COMBINING VOWEL RELATED TO THE SKELETAL SYSTEM

- **ankyl/o**: Stiff, bent
- **aponeur/o**: Aponeurosis
- **arthr/o**: Joint
- **burs/o**: Bursa
- **carp/o**: Carpals, wrist
- **chondr/o**: Cartilage
- **clavic/o**: Clavicle, collarbone
- **clavicul/o**: Clavicle, collarbone
- **cost/o**: Ribs
- **crani/o**: Cranium
- **disk/o**: Intervertebral disk
- **femor/o**: Femur, upper leg bone
- **fibul/o**: Fibula, lower leg bone
- **humer/o**: Humerus, upper arm bone
- **ili/o**: Ilium
- **ischi/o**: Ischium
- **kines/o**: Movement, motion
- **kyph/o**: Increased convexity of the spine
- **lord/o**: Bent forward, increased concavity of the spine
- **lumb/o**: Loin, lumbar region of the spine
- **mandibul/o**: Mandible, lower jawbone
- **maxill/o**: Maxilla, upper jawbone
- **menisc/o**: Meniscus, crescent
- **myel/o**: Bone marrow, spinal cord
- **oste/o**: Bone
- **patell/o**: Patella, kneecap
- **pelv/i**: Pelvis, pelvic bone
- **petr/o**: Stone

- **phalang/o**: Bones of the finger and toes
- **pub/o**: Pubis
- **rachi/o**: Vertebral spine, vertebral column
- **radi/o**: Radius
- **sacr/o**: Sacrum
- **scapul/o**: Scapula, shoulder blade
- **scoli/o**: Crooked, curved
- **spondyl/o**: Vertebra, spine, vertebral column
- **stern/o**: Sternum, breastbone
- **synovi/o**: Synovia
- **tars/o**: Tarsals, ankle bones
- **ten/o**: Tendon
- **tend/o**: Tendon
- **tendin/o**: Tendon
- **tibi/o**: Tibia, lower leg bone
- **uln/o**: Ulna, lower arm bone
- **vertebr/o**: Vertebra, spine, vertebral column

SUFFIXES RELATED TO THE SKELETAL SYSTEM

- **-ad**: Towards
- **-al**: Pertaining to
- **-algia**: Pain
- **-ar**: Pertaining to
- **-asthenia**: Weakness
- **-blast**: Formative cell
- **-centesis**: Surgical puncture to aspirate fluid
- **-clasia**: Break
- **-clasis**: Break
- **-clast**: Break

- **-desis:** Surgical fixation, fusion
- **-ectomy:** Excision, surgical removal, cutting out
- **-gram:** The record, radiographic image
- **-graphy:** Process of recording, radiographic imaging
- **-ic:** Pertaining to
- **-itis:** Inflammation
- **-lysis:** Loosening, separating, dissolution
- **-malacia:** Softening
- **-oid:** Resembling
- **-oma:** Tumor
- **-osis:** Abnormal condition
- **-penia:** Abnormal reduction
- **-physis:** Growth
- **-plasty:** Surgical repair
- **-rrhaphy:** Suturing, repairing
- **-sarcoma:** Malignant tumor
- **-schisis:** Split, fissure
- **-scopy:** Process of viewing, visual examination
- **-tomy:** Incision, cut into
- **-trophy:** Nourishment, development

13.3 Examples of Skeletal Terms Easily Defined By Their Word Components

Here are examples of common medical terms related to the skeletal system that can be easily defined by breaking the terms into their word components.

Arthrocentesis

1. Break down the medical term into word components:
Arthr/o/centesis
2. Label the word components: **Arthr** = WR; **o** = CV; **centesis** = S
3. Define the word components: **Arthr** = joint; **centesis** = surgical puncture to aspirate fluid
4. Create a final definition of the medical term: **A surgical puncture to aspirate fluid from a joint**

Osteomyelitis

1. Break down the medical term into word components:
Oste/o/myel/itis
2. Label the word components: **Oste** = WR; **o** = CV; **myel** = WR; **itis** = S

3. Define the word components: **Oste** = bone; **myel** = bone marrow; **itis** = inflammation
4. Create a final definition of the medical term:
Inflammation of bone and bone marrow

Vertebroplasty

1. Break down the medical term into word components:
Vertebr/o/plasty
2. Label the word components: **Vertebr** = WR; **o** = CV; **plasty** = S
3. Define the word components: **Vertebr** = vertebral column; **plasty** = surgical repair
4. Create a final definition of the medical term: **Surgical repair of the vertebral column**



Interactive Learning Activity: Practice defining and pronouncing skeletal system medical terms by breaking them down into word parts.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://wtcs.pressbooks.pub/medterm/?p=4810#h5p-84>

▶ You can also print these flashcard activities as a [Chapter 13](#)

▶ [Student Companion Worksheet](#) and check your answers with this [Answer Key](#).

13.4 Anatomy of the Skeletal System

The skeleton system supports the body, facilitates movement with muscles, protects soft body parts, produces blood cells, and stores and releases calcium.¹ Muscles, movement and muscular disorders are discussed in the “[Muscular System Terminology](#)” chapter.

The skeletal system includes bones, joints, cartilages, and ligaments that support and give shape to the body. See Figure 13.1² for an illustration of the skeletal system. The skeletal system is subdivided into two major divisions called the axial skeleton and the appendicular skeleton. Each division is discussed in the following sections, along with related medical terms.

1. National Cancer Institute. (n.d.). *Introduction to the skeletal system*. National Institutes of Health. <https://training.seer.cancer.gov/anatomy/skeletal>
2. “[701_Axial_Skeleton-01.jpg](#)” by OpenStax College is licensed under [CC BY 3.0](#)

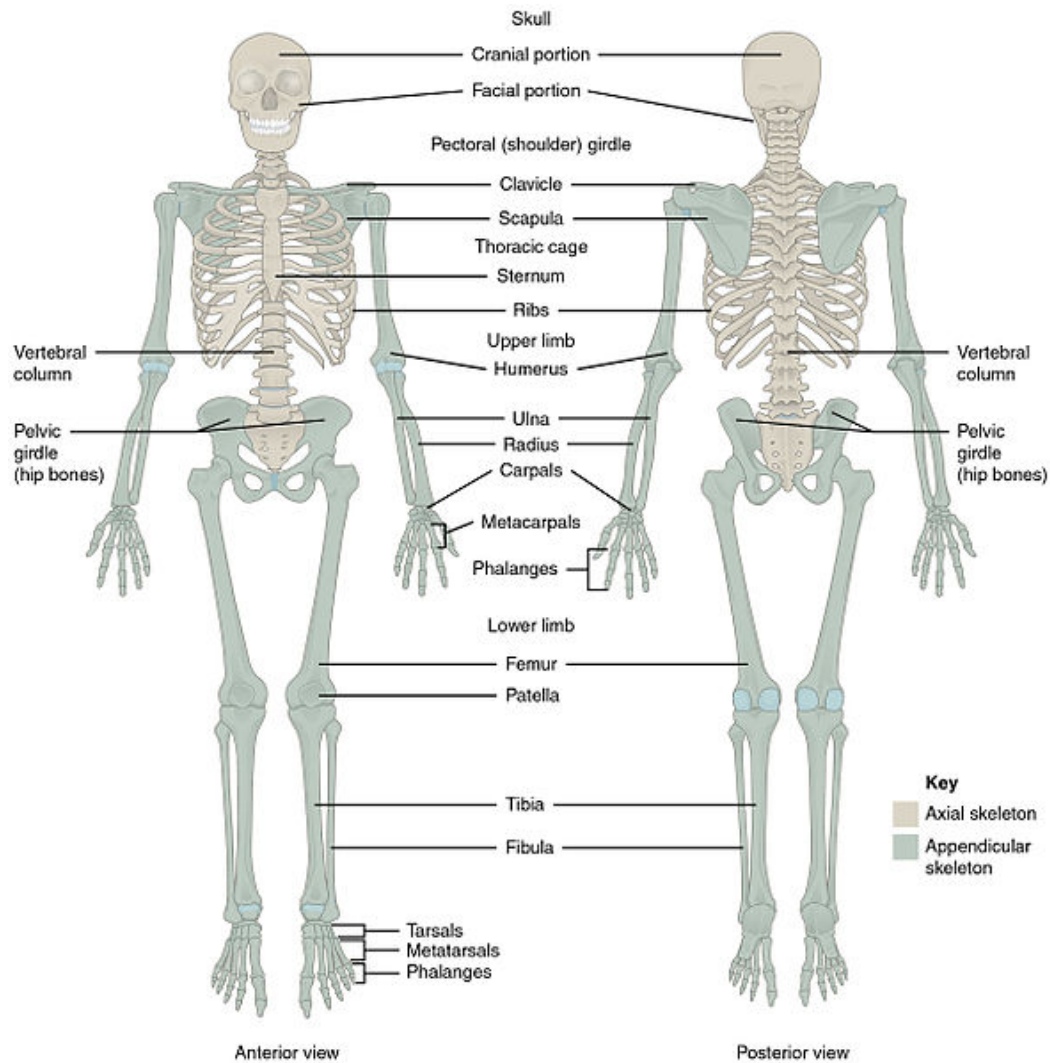


Figure 13.1 Axial and Appendicular Skeletal Systems

THE AXIAL SKELETON

The axial skeleton forms the central axis of the body and includes the bones of the head, neck, chest, and back. It serves to protect the brain, spinal cord, heart, and lungs. It also serves as the attachment site for muscles that move

the head, neck, back, shoulder, and hip joints. The axial skeleton includes the cranium, hyoid, vertebral column, and thoracic cage.³

Cranium

The **cranium** (KRĀ-nē-ŭm) is subdivided into the skull and the facial bones. It supports the face and protects the brain.⁴ See Figure 13.2⁵ for an illustration of the anterior bones of the skull and the face. A **craniotomy** (krā-nē-ŌT-ō-mē) refers to a surgical opening into the skull. A **cranioplasty** (KRĀ-nē-ō-plās-tē) refers to surgical repair of the cranium.

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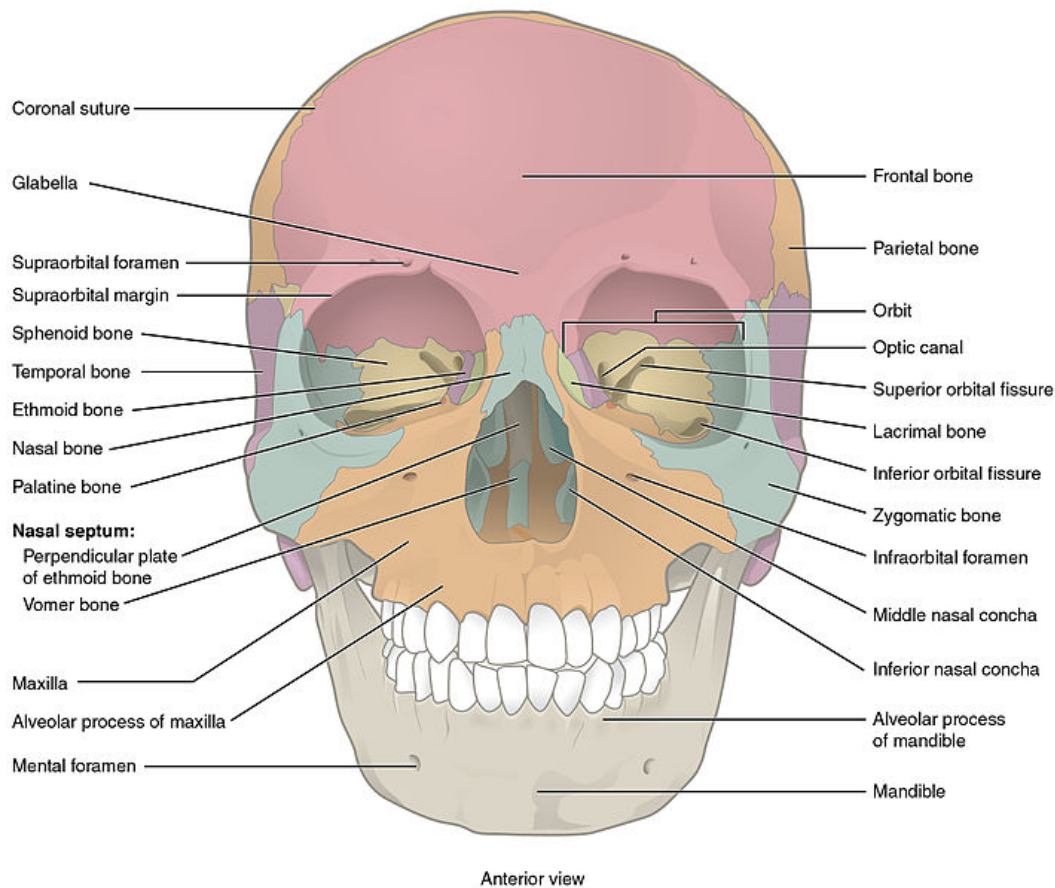


Figure 13.2 Bones of the Anterior Skull and Face

The major bones of the skull include the following⁶:

- **Frontal** (FRŮN-tăł): Forehead
- **Parietal** (pă-rĭ-ĖT-ăł): Upper lateral sides of the skull
- **Temporal** (TĖM-pō-răł): Lower lateral sides of the skull
- **Sphenoid** (SFĖ-noid): Posterior eye sockets and part of the base of the skull
- **Ethmoid** (ĖTH-moid): Part of the nose and base of the skull

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- **Occipital** (ŏk-SĪP-ĭ-tăĭ): Posterior skull and base of the skull (See Figure 13.3⁷ for an image of the occipital bone.)

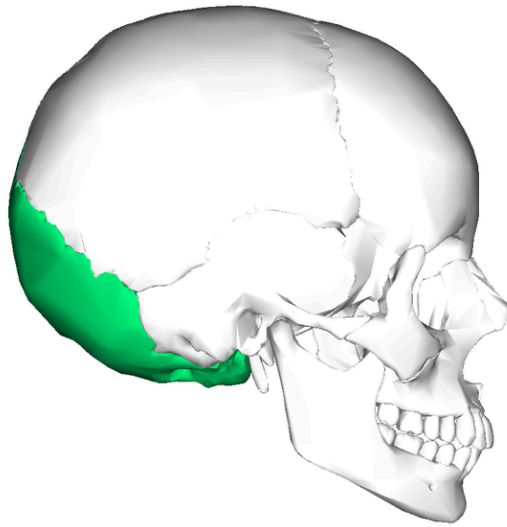


Figure 13.3 Occipital Bone

The facial bones form the upper and lower jaws, the nose, nasal cavity and nasal septum, and the orbit. The facial bones include 14 bones, with six paired bones and two unpaired bones. The paired bones are the maxillae, palatine, zygomatic, nasal, lacrimal, and inferior nasal conchae bones. The unpaired bones are the vomer and mandible bones⁸:

- **Zygomatic** (zī-gō-MĀT-ĭk): Pair of cheekbones
- **Maxillary** (MĀK-sĭ-lăĕ): Upper jaw and hard palate

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- **Palatine** (PĀL-ă-tīn): Pair of L-shaped bones between the maxilla and sphenoid that form the hard palate, walls of the nasal cavity, and the orbital floor of the eye
- **Nasal** (NĀ-zăl): Pair of bones that form the bridge of the nose
- **Lacrima** (LĀK-rī-măl): Walls of the inner (medial) orbit (i.e., eye socket)
- **Inferior conchae** (ĪN-fēr-ē-ŏr KŌN-kē): Lower lateral walls of the nasal cavity
- **Vomer** (VŌ-mēr): Bone that separates the left and right nasal cavity
- **Mandible** (MĀN-dī-bŭl): Lower jawbone and only movable bone of the skull

The **temporomandibular joint** (tēm-pō-rō-MĀN-dī-bŭ-lăr) (**TMJ**) is a hinge joint between the temporal bone and the mandible that allows for the opening, closing, protrusion, retraction, and lateral movement of the lower jaw. Protrusion moves the mandible forward, and retraction pulls the mandible backward towards the neck.⁹

Hyoid

The **hyoid** (HĪ-oid) bone is an independent bone that does not contact any other bone and thus is not part of the skull. It is a small U-shaped bone located in the upper neck near the level of the inferior mandible, with the tips of the “U” pointing posteriorly. The hyoid serves as the base for the tongue above and is attached to the larynx and the pharynx below. Movements of the hyoid are coordinated with movements of the tongue, larynx, and pharynx

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during swallowing and speaking.¹⁰ See Figure 13.4¹¹ for an illustration of the hyoid bone.

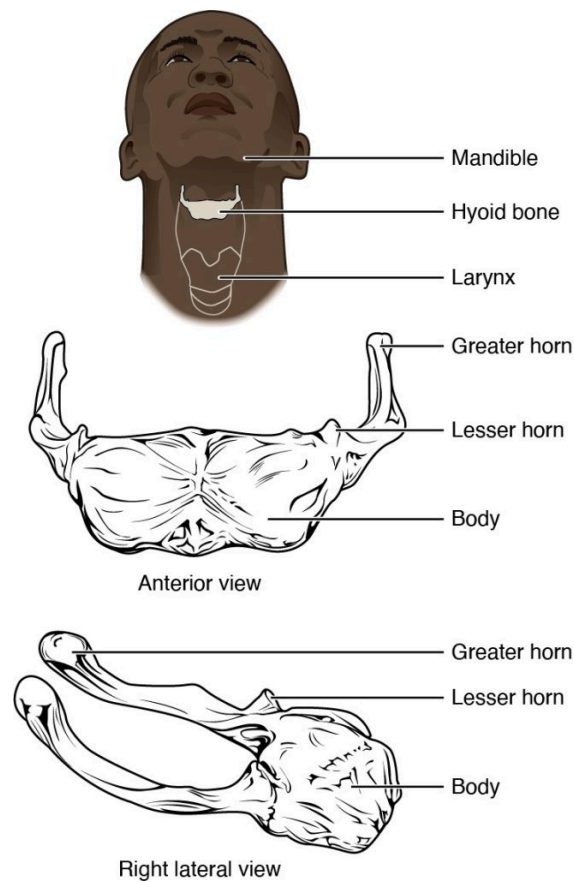


Figure 13.4 Hyoid

Vertebrae and Vertebral Column

The vertebral column consists of **vertebrae** (VŪR-tĭ-brā) that are separated by

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intervertebral disks (ĭn-tĕr-VĔRT-ĕ-brĕl dĭskz). The spinal cord runs through the center of the vertebrae. See Figure 13.5¹² for an illustration of the parts of a vertebra. **Diskitis** (dĭs-KĪ-tĭs) refers to inflammation of an intervertebral disk. A **herniated disk** (hûr-nĕ-Ā-tĭd dĭsk) refers to a condition in which a disk protrudes beyond the normal confines of the vertebrae. **Spondylosis** (spŏn-dĭ-LŌ-sĭs) is a painful condition of the spine resulting from the degeneration of the intervertebral disks. A **discectomy** (dis-KEK-tŏ-mĕ) refers to excision of an intervertebral disk. A **laminectomy** (lăm-ĭ-NĚK-tŏ-mĕ) refers to excision of all or part of the lamina to ease pressure on the spinal cord or the nerve roots that may be caused by injury, herniated disk, narrowing of the spinal canal, or tumors. The lamina is the area of the vertebra where spinous and transverse processes connect.¹³

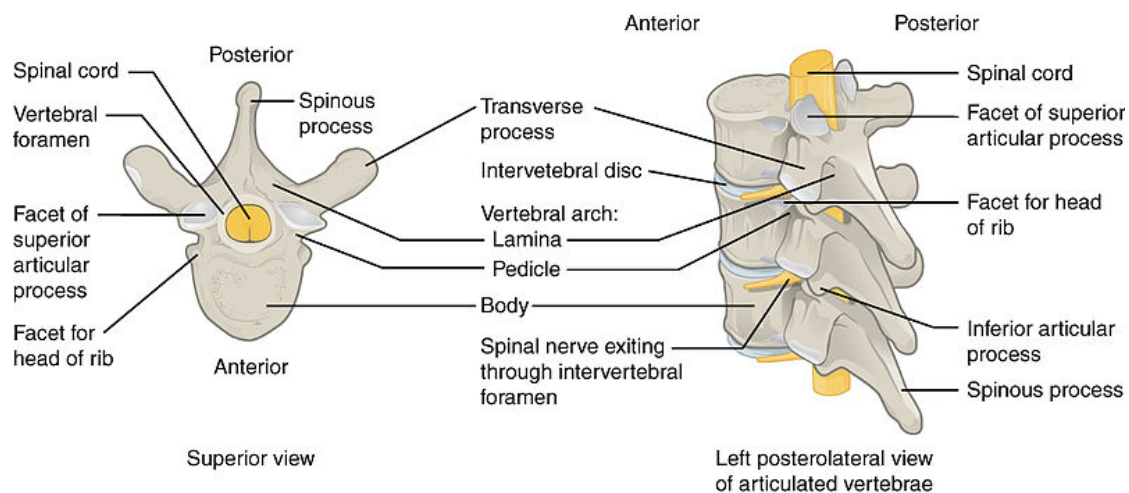


Figure 13.5 Vertebrae

Together, the vertebrae and intervertebral disks form the **vertebral column** (vŭr-TĒ-brăĭ KŌL-ŭm), also known as the spinal column. It is a flexible column

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that supports the head, neck, and body and allows for their movements. It also protects the spinal cord, which passes down the back through the vertebral foramen.¹⁴ View an illustration of the vertebral column in Figure 13.6.¹⁵

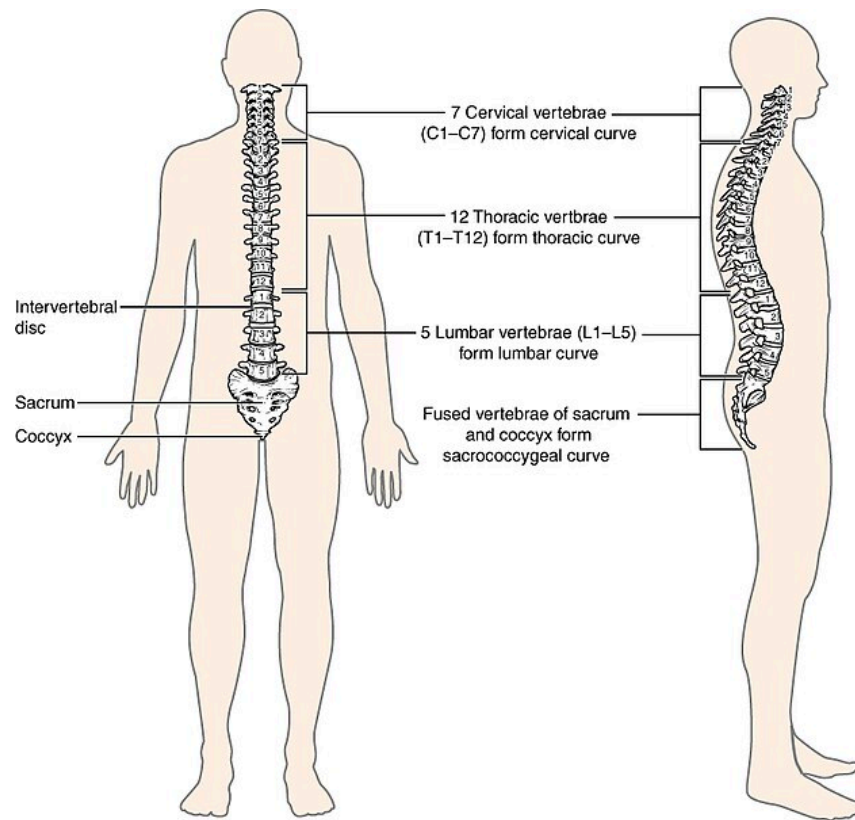


Figure 13.6 Vertebral Column

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Vertebrae Regions

The vertebrae are divided into five regions called the cervical, thoracic, lumbar, sacrum, and coccyx¹⁶:

- **Cervical** (SŮR-vĩ-kăl): The first 7 vertebrae in the neck region, C1 to C7
- **Thoracic** (thō-RĀS-ĭk): The next 12 vertebrae that form the outward curvature of the spine, T1 to T12
- **Lumbar** (LŮM-bär): The next 5 vertebrae that form the inner curvature of spine, L1 to L5
- **Sacrum** (SĀ-krŭm): The triangular-shaped bone at the base of the spine, formed by the fusion of five sacral vertebrae, a process that does not begin until after the age of 20. See Figure 13.7¹⁷ for an illustration of the sacrum.
- **Coccyx** (KÖK-sĭks): The tailbone, formed by the fusion of four very small coccygeal vertebrae. See Figure 13.8¹⁸ for an illustration of the coccyx.

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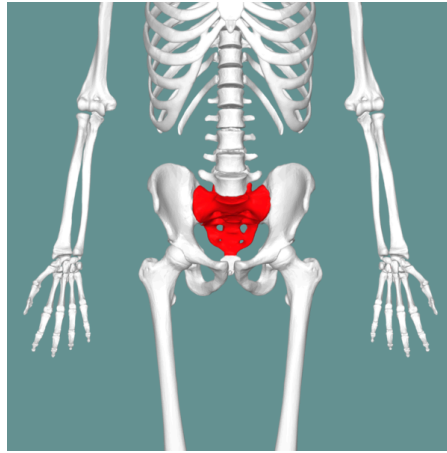


Figure 13.7 Sacrum

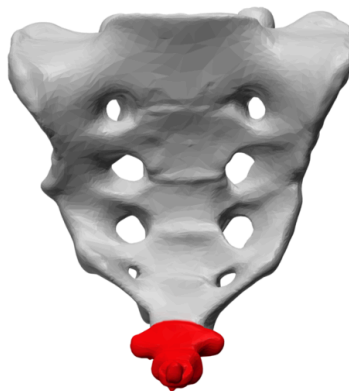


Figure 13.8 Coccyx

Vertebral Curvature

The vertebral column is normally curved, with two primary curvatures

(thoracic and sacrococcygeal curves) and two secondary curvatures (cervical and lumbar curves).¹⁹

Thoracic Cage

The thoracic cage, commonly known as the rib cage, forms the chest (thorax). It consists of the sternum and 12 pairs of ribs, along with their costal cartilages. The ribs are anchored posteriorly to the 12 thoracic vertebrae (T1–T12). See Figure 13.9²⁰ for an illustration of the thoracic cage. The thoracic cage protects the heart and lungs.²¹

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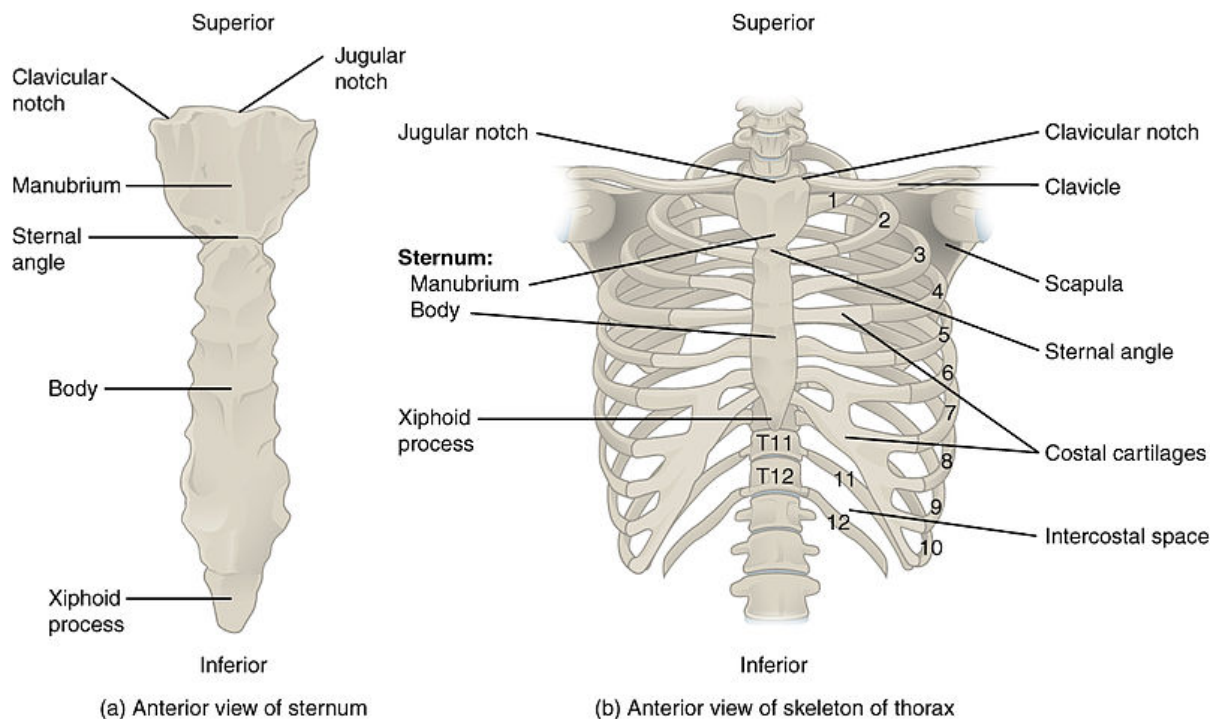


Figure 13.9 Thoracic Cage (a) sternum and (b) 12 pairs of ribs

The **sternum** (STŪR-nŭm), also known as the breastbone, is divided into three parts²²:

- **Manubrium** (mă-NŪ-brē-ŭm): The upper portion of the sternum
- **Body** (bŏd-ē): The middle portion of the sternum
- **Xiphoid process** (ZĪ-foïd PRŌ-sēs): The lower portion of the sternum made of cartilage

The 12 sets of ribs can be classified as true ribs, false ribs, and floating ribs²³:

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- **True ribs** (TRŌŌ řibz): Ribs 1-7 that are attached to the front of the sternum
- **False ribs** (FŌLS řibz): Ribs 8, 9, and 10 that are attached to the cartilage that joins the sternum
- **Floating ribs** (FLŌ-ă-tǐng řibz): Ribs 11 and 12 that are not attached to the front of the sternum

Intercostal (int-ěr-KOS-tăl) means between the ribs. In clinical practice, **intercostal retractions** (ĩn-těr-KŌS-tăl rē-trăk-SHŏnz) may be observed in individuals experiencing labored breathing, where the muscles pull in between the ribs.

THE APPENDICULAR SKELETON

The appendicular skeleton includes the upper and lower limbs, plus the bones that attach each limb to the axial skeleton.²⁴

Upper Limbs

The bones of the upper limbs include the bones of the arms, wrists, and hands. The shoulder attaches the upper limbs to the axial skeleton. See Figure

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13.10²⁵ for an illustration of the upper limbs and pectoral girdle, the bony support of the shoulder consisting of the clavicle and scapula.²⁶

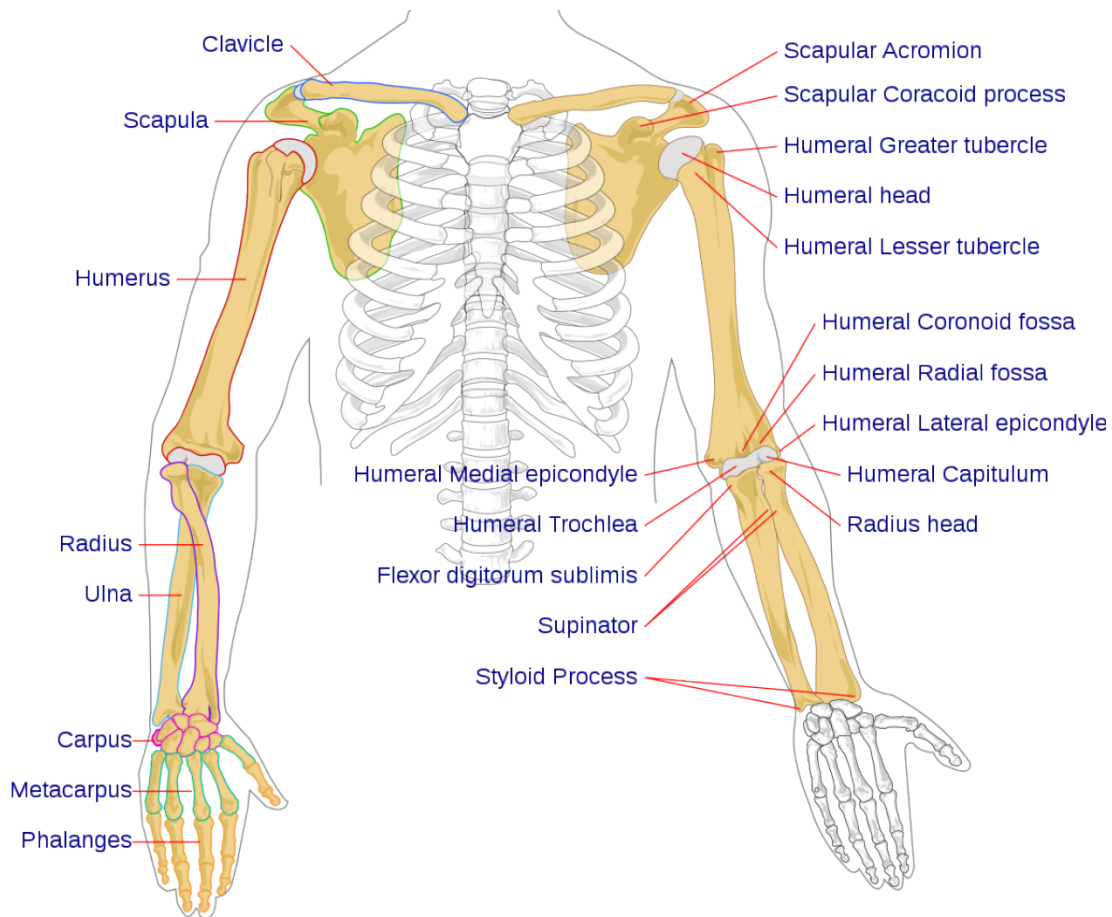


Figure 13.10 Upper Limbs and Shoulder

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Arms

There are three bones in each arm²⁷:

- **Humerus** (HYŌŌ-mēr-ŭs): Upper arm
- **Radius** (RĀ-dē-ŭs): The thumb side of the forearm
- **Ulna** (ŬL-nă): The fifth finger side of the forearm



View a YouTube video²⁸ from UCDenver Anatomy Lab:
[Radius & Ulna](#)

Wrists, Hands, and Fingers

See Figure 13.11²⁹ for an illustration of the bones of the wrist, hand, and fingers. The bones of the hand and wrist include the carpals, metacarpals, and phalanges³⁰:

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28. UCDenver Anatomy Lab 3244. (2013, August 31). *Radius & Ulna*. [Video]. YouTube. All rights reserved. <https://www.youtube.com/watch?v=ThmvWFvHOMl>
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- **Carpals** (KÄR-pälz): Wrist bones
- **Metacarpals** (mět-ă-KÄR-pälz): Bones of the palm of hand
- **Phalanges** (fă-LÄN-jēz): Fingers (and toes)

A single finger is called a **phalanx** (FÄ-längks) and is composed of three bones called the distal phalanx, medial phalanx, and proximal phalanx. The exception is the thumb, which only has two bones, the distal and proximal.³¹

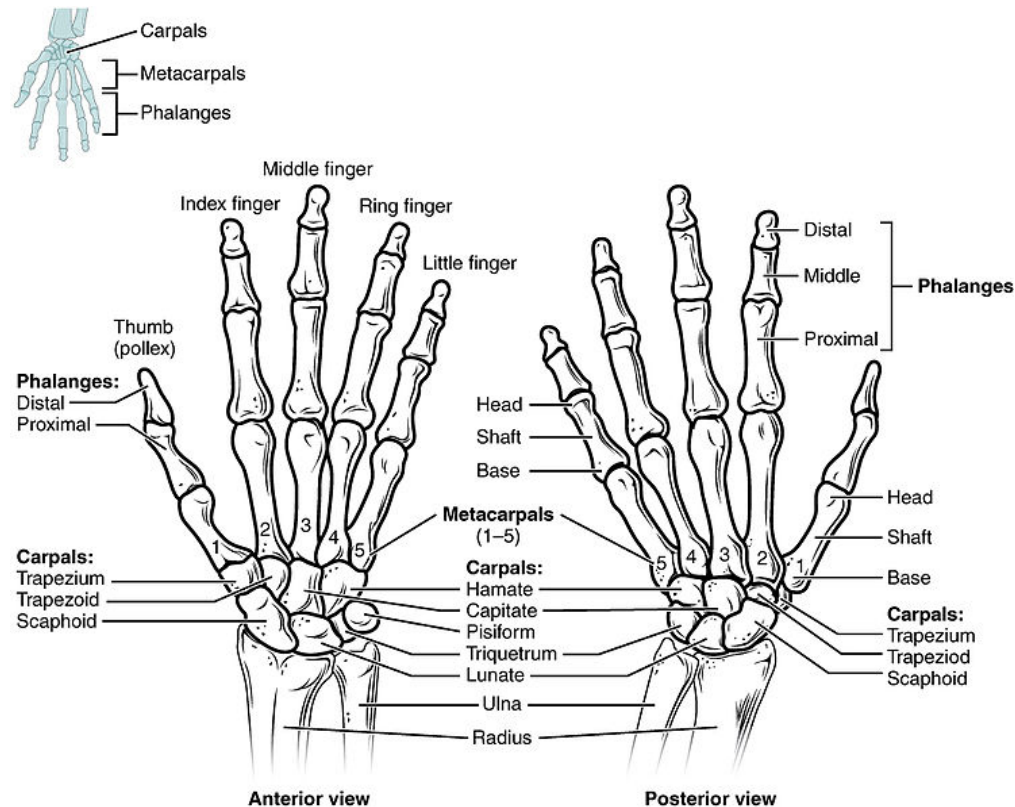


Figure 13.11 Hands, Wrist, and Fingers

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The Shoulder

Refer back to Figure 13.10 to view the bones of the shoulder that connect the arms to the axial skeleton to form the pectoral girdle and include the clavicle, scapula, and acromion³²:

- **Clavicle** (KLÄV-ĭ-kŭl): Connect the sternum to the scapula, also known as the collarbone
- **Scapula** (SKÄP-yŭ-lă): Shoulder blade
- **Acromion** (ă-KRŌ-mē-ŏn): An extension from the scapula that forms the bony tip of the shoulder

Together, the clavicle, acromion, and spine of the scapula form a V-shaped bony line that provides for the attachment of neck and back muscles that act on the shoulder, as well as muscles that pass across the shoulder joint to act on the arm.³³

Lower Limbs

The bones of the lower limb include bones of the leg and the feet. The hip attaches the lower limbs to the axial skeleton.

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Leg

See Figure 13.12³⁴ for an illustration of the leg bones, including the femur, patella, tibia, and fibula³⁵:

- **Femur** (FĒ-mŭr): Thigh bone, the longest and strongest bone in the human body
- **Patella** (pă-TĚL-ă): Kneecap
- **Tibia** (TĬB-ē-ă): The medial bone and main weight-bearing bone of the lower leg, commonly called the shin. The distal end of the tibia forms the **medial malleolus** (MĒ -dē-ăl MĂL-ē-ŏ-lŭs), which forms the bony protrusion on the medial side of the ankle.
- **Fibula** (FĬB-yŭ-lă): The smaller, lateral bone of the lower leg. The distal end of the fibula forms the **lateral malleolus** (LĂT-ěr-ăl MĂL-ē-ŏ-lŭs), which forms the bony protrusion on the lateral side of the ankle.

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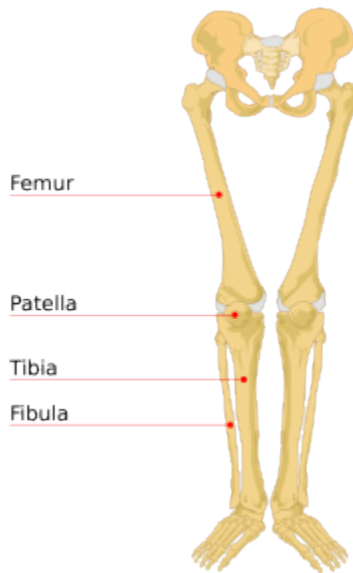


Figure 13.12 Leg Bones

Feet

See Figure 13.13³⁶ for an illustration of the bones of the ankles and feet. There are several foot bones, but the major bones include the tarsals, metatarsals, phalanges, and calcaneus³⁷:

- **Tarsals** (TÄR-sälz): Bones of the posterior half of the foot
- **Metatarsals** (mět-ă-TÄR-sälz): Bones of the anterior half of the foot
- **Phalanges** (fă-LÄN-jēz): Toes (and fingers). The **hallux** (HÄL-lüks) is the great toe.
- **Calcaneus** (käl-KÄ-nē-ūs): Heel bone

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Like the fingers, the toes are composed of three bones called the distal phalanx, medial phalanx, and proximal phalanx, with the exception of the great toe, which only has two bones, the distal and proximal.³⁸

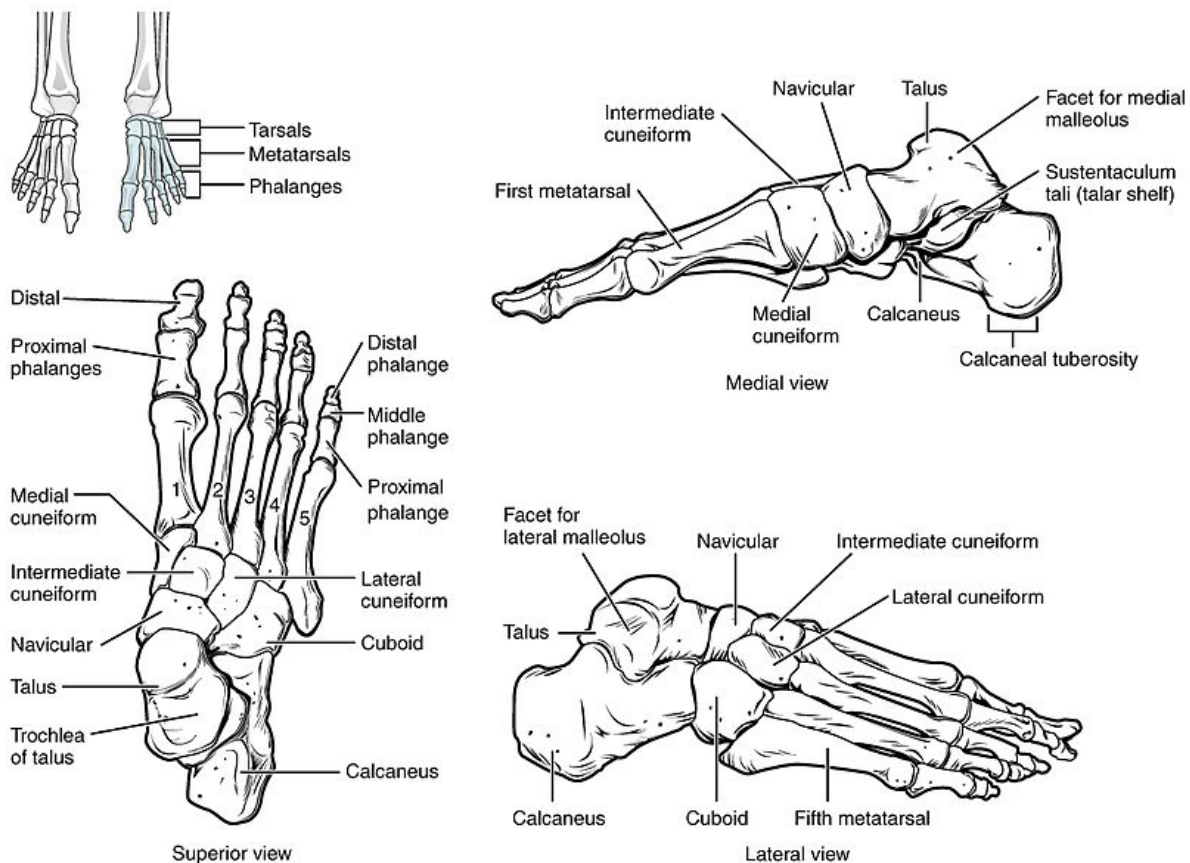


Figure 13.13 Bones of the Feet

The Hip

The hip serves as the attachment point for each lower limb at the **acetabulum** (ă-s-ě-TĂB-yŭ-lŭm), the large socket that holds the head of the femur. Each adult hip bone is formed by three separate pelvic bones, called

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the ilium, ischium, and pubis, that fuse together during the late teenage years.³⁹ See Figure 13.14⁴⁰ for an image of the hip and pelvis.

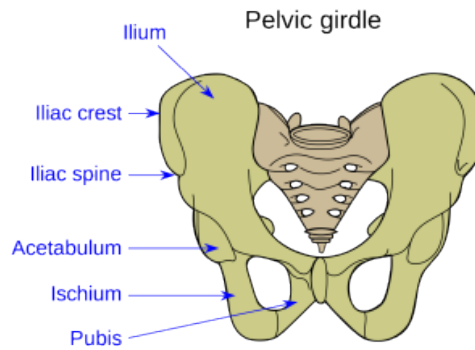


Figure 13.14 Hip and Pelvis

The **ilium** (ĪL-ē-ŭm) is the superior region that forms the largest part of the hip bone. It is attached to the sacrum at the sacroiliac joint. The **ischium** (ĪS-kē-ŭm) forms the posteroinferior region of each hip bone and supports the body when sitting. The **pubis** (PYŪ-bīs) forms the anterior portion of the hip bone. The pubis curves medially, where it joins to the pubis of the opposite hip bone at a specialized joint called the **pubic symphysis** (PYŪ-bīk SĪM-fī-sīs). The **pelvis** (PĒL-vīs) refers to the entire structure formed by the two hip bones,

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40. “*Pelvic girdle illustration.svg*” by U.S. National Cancer Institute is licensed under CC BY-SA 4.0

the sacrum, and the coccyx.⁴¹ See Figure 13.15⁴² for an illustration of the parts of the pelvis.

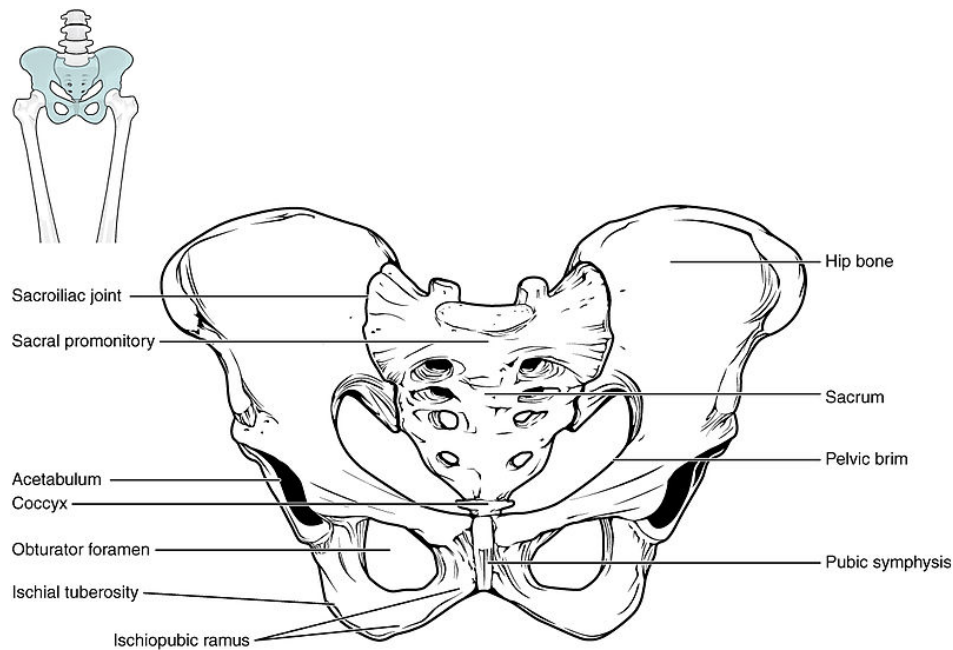


Figure 13.15 Pelvis

The shape of the pelvis is different for males and females. In general, the bones of the male pelvis are thicker and heavier because they have adapted to support a male's typically heavier physical build. Because the female pelvis has adapted for childbirth, it is wider than the male pelvis. The shape and size of the pelvis can be used during forensic assessment to identify if skeletal

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42. "[807_Pelvis.jpg](#)" by OpenStax College is licensed under [CC BY 3.0](#)

remains are male or female.⁴³ See Figure 13.16⁴⁴ for a comparison of the female and male pelvis.

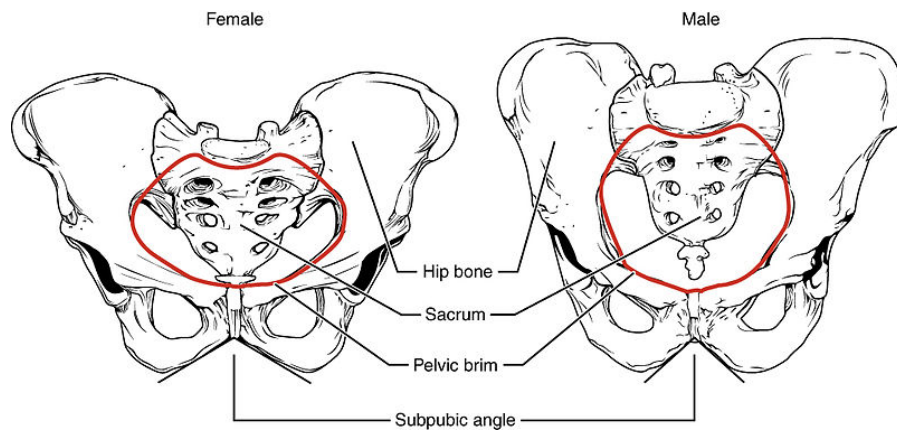


Figure 13.16 Comparison of Female and Male Pelvis

JOINTS

Joints (jōyntz), also called articulations, are places where two bones or bone and cartilage come together and form a connection. **Dislocation** (dīs-lō-KĀ-shōn) refers to displacement of a bone from its normal position in a joint. Joints are categorized based on their form and amount of movement and are referred to as fibrous joints, cartilaginous joints, or synovial joints.⁴⁵

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44. “809_Male_Female_Pelvic_Girdle.jpg” by OpenStax College is licensed under CC BY 3.0

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Fibrous Joints, Ligaments, and Tendons

Fibrous joints (FĪ-brūs joints), also called synarthrosis or nonmoveable joints, occur when bones are attached by fibrous connective tissue. There are three types of fibrous joints: suture, gomphosis, and syndesmosis. A suture is the narrow fibrous joint found between most bones of the skull. A gomphosis is the narrow fibrous joint between the roots of a tooth and the bony socket in the jaw into which the tooth fits. A syndesmosis is a joint held together by a ligament, a type of connective tissue that connects bones.⁴⁶

Other fibrous connective tissues in the musculoskeletal system include ligaments and tendons. **Ligaments** (LĪG-ă-měnts) are narrow bands of fibrous connective tissue that connect a bone to a bone. A **tendon** (TĚN-dŏn) is a fibrous connective tissue that attaches muscle to bone.⁴⁷ See Figure 13.17⁴⁸ for an image that compares ligaments and tendons.

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48. “tendon-lig.jpg” by unknown author is licensed under [CC BY-SA 4.0](https://pressbooks.ccconline.org/bio106). Access for free at <https://pressbooks.ccconline.org/bio106>

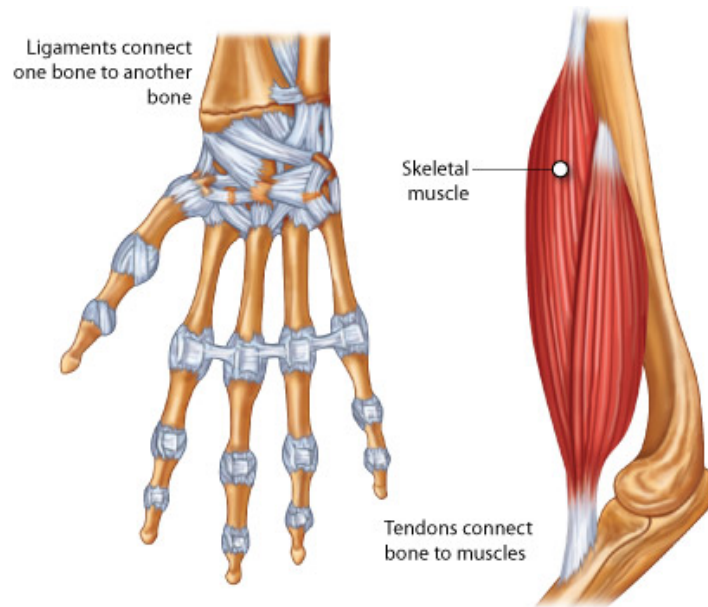


Figure 13.17 Comparison of Ligaments and Tendons

Cartilaginous Joints

Cartilaginous joints (kär-tĭ-LĀJ-ĭ-nŭs joints), also called amphiarthrosis or slightly moveable joints, occur when two bones are connected by **cartilage** (KĀR-tĭ-lĭj), a tough but flexible type of connective tissue. Examples of cartilaginous joints include the pubic synthesis and intervertebral disks.⁴⁹

Synovial Joints

Synovial joints (sĭ-NŌ-vē-ăl joints), also called diarthroses or fully movable joints, have a fluid-filled space where two bones come together, called a joint cavity. Because the bones in a synovial joint are not directly connected to each other with fibrous connective tissue or cartilage, they are able to move freely against each other, allowing for increased joint mobility. Synovial joints

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are the most common type of joint in the body. A **synovial membrane** (sĭ-NŌ-vē-ăl MĚM-brān) is the lining or covering of synovial joints, and **synovial fluid** (sĭ-NŌ-vē-ăl FLŌŌ-id) is the lubricating fluid found between synovial joints. A **synovectomy** (sĭn-ŏ-VĚK-tō-mē) refers to excision of the synovial membrane.⁵⁰ See Figure 13.18⁵¹ for an illustration of a synovial joint.

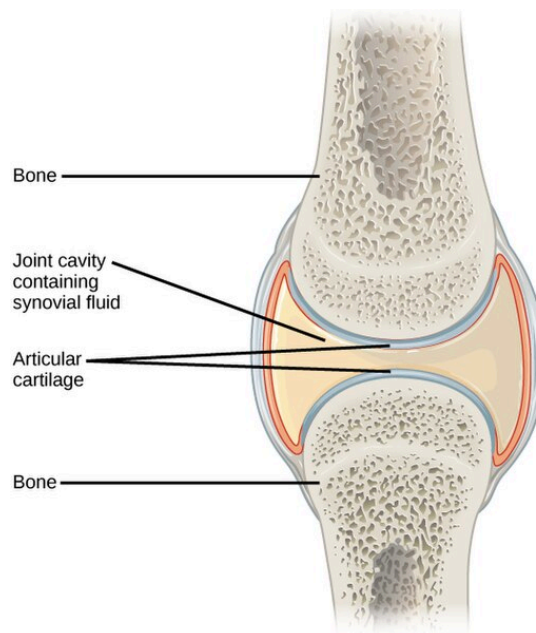


Figure 13.18 Synovial Joint

Types of Synovial Joints

Synovial joints are categorized based on the shapes of the articulating surfaces of the bones that form each joint. The six types of synovial joints are

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51. "[Figure_38_03_03.jpg](#)" by CNX OpenStax is licensed under [CC BY 4.0](#)

pivot, hinge, condyloid, saddle, plane, and ball-and-socket joints.⁵² See Figure 13.19⁵³ for an illustration of the various types of synovial joints.

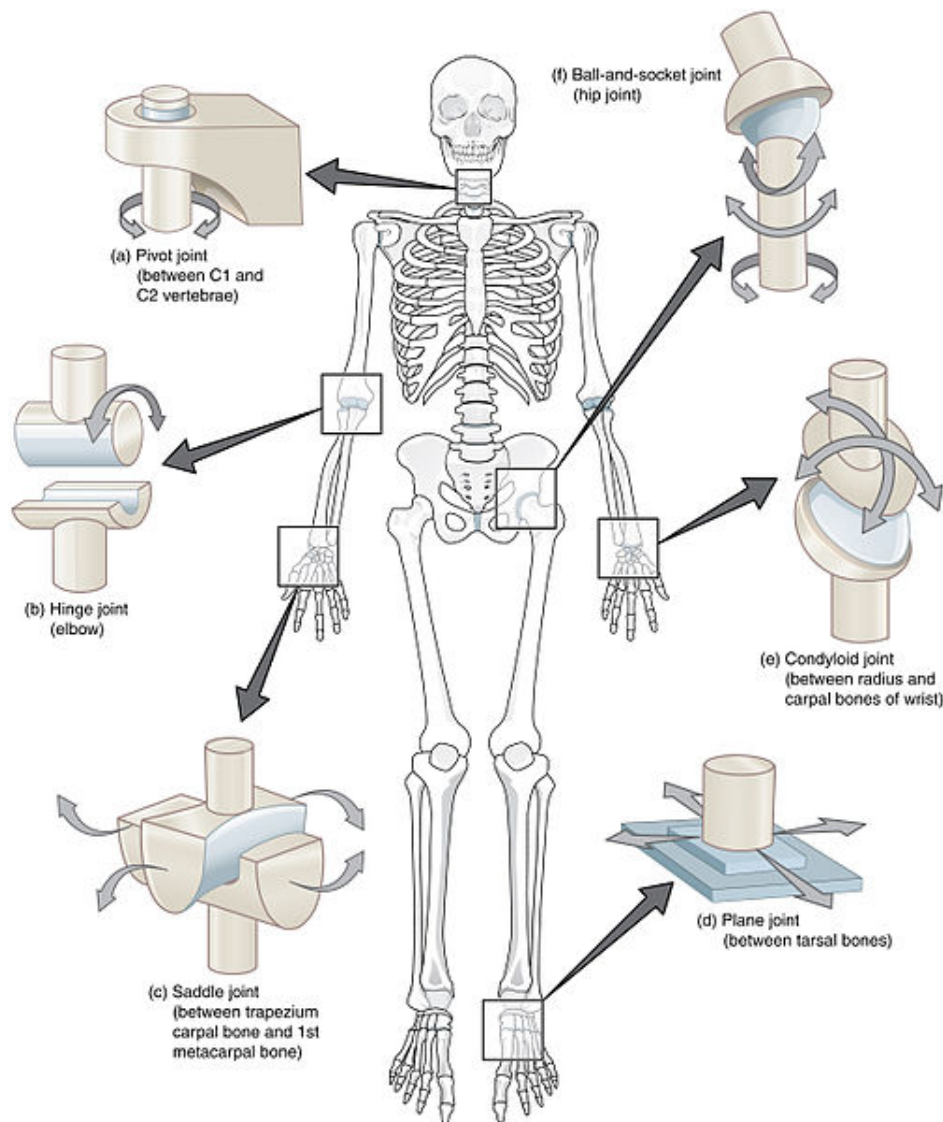


Figure 13.19 Types of Synovial Joints

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53. "909 Types of Synovial Joints.jpg" by OpenStax College is licensed under CC BY 3.0

A few synovial joints of the body have a fibrocartilage structure located between the articulating bones called an articular disk or meniscus. **Articular disks** (är-TĪK-yŭ-lär dĭsk) are generally small and oval-shaped whereas a **meniscus** (mě-NĪS-kŭs) is larger and C-shaped. For example, the knee connects the femur (upper leg bone) to the tibia (one of the lower leg bones) with a piece of fibrous cartilage called the meniscus. **Meniscitis** (men-ĭ-SĪT-ĭs) refers to inflammation of the meniscus. A **meniscectomy** (měn-ĭ-SĔK-tō-mē) refers to excision of the meniscus.

In addition to the meniscus, the knee also contains ligaments, tendons, and additional cartilage. Ligaments in the knee include the **anterior cruciate ligament** (ăn-TĪR-ē-ör KRŪ-shē-āt LĪG-ă-měnt) (**ACL**), **lateral collateral ligament** (LĂT-ēr-ăl KÖL-ă-TĔR-ăl LĪG-ă-měnt) (**LCL**), **medial collateral ligament** (MĔ-dē-ăl KÖL-ă-TĔR-ăl LĪG-ă-měnt) (**MCL**), and **posterior cruciate ligament** (pös-TĪR-ē-ör KRŪ-shē-āt LĪG-ă-měnt) (**PCL**). See Figure 13.20⁵⁴ for an illustration of these structures in the knee joint.

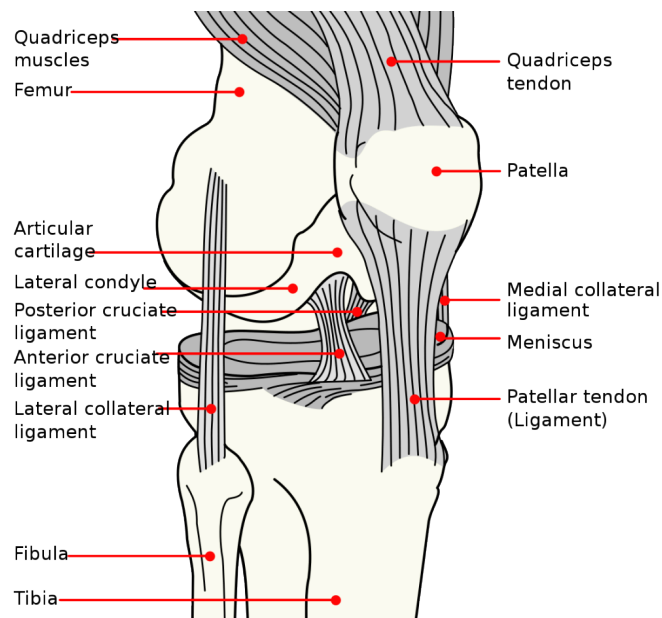


Figure 13.20 The Knee Joint Contains Ligaments, Tendons, Cartilage, and a Meniscus

54. “[Knee_diagram.svg](#)” by [Mysid](#) is licensed in the [Public Domain](#).

An additional structure located outside of a synovial joint is a bursa. A **bursa** (BŪR-să) is a thin connective tissue sac filled with lubricating fluid located in regions where skin, ligaments, muscles, or tendons rub against each other. Bursae are classified by their location. For example, a subcutaneous bursa is located between the skin and an underlying bone and allows skin to move smoothly over the bone.⁵⁵ Examples of a subcutaneous bursa are the suprapatellar bursa, prepatellar bursa, and infrapatellar bursa located in the knee, as seen in Figure 13.21.⁵⁶ **Bursitis** (bŭr-SĪ-tīs) refers to inflammation of a bursa, typically one in the knee, elbow, or shoulder. **Bursectomy** (bŭr-SĚK-tō-mē) refers to excision of a bursa.

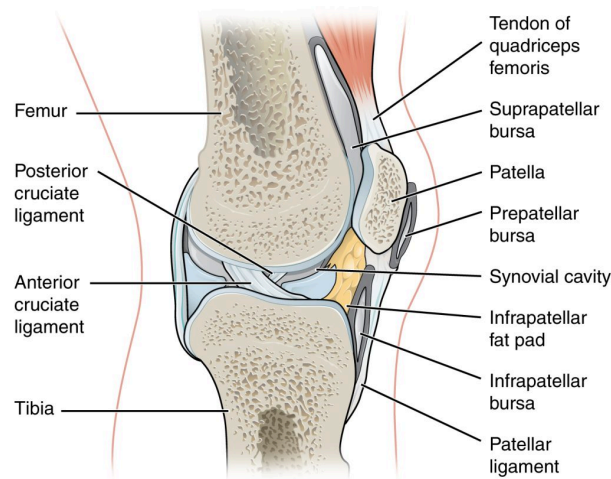


Figure 13.21 Bursa in the Knee

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56. “908_Bursa.jpg” by OpenStax College is licensed under [CC BY 3.0](#)



View a supplementary YouTube video⁵⁷ on joints: [Joints: Crash Course Anatomy & Physiology #20](#)

BONES

There are three types of cells related to the growth and breakdown of bone. **Osteoblasts** (OS-tē-ō-blastz) are bone-forming cells, and **osteocytes** (OS-tē-ō-sītz) are mature bone cells. The dynamic nature of bone means that new bone tissue is constantly being formed, and old, injured, or unnecessary bone is dissolved for repair or for calcium release. The cells responsible for bone breakdown are **osteoclasts** (ös-tē-ō-KLÄTZ). An equilibrium between osteoblasts and osteoclasts maintains healthy bone tissue.⁵⁸

Bones contain more **calcium** (KÄL-sē-ŭm) (**Ca+**) than any other organ. When blood calcium levels decrease below normal levels, calcium is released from the bones by the osteoclasts so there is an adequate supply for metabolic needs. In contrast, when blood calcium levels are increased, excess

57. CrashCourse. (2015, May 26). *Joints: Crash Course Anatomy & Physiology #20* [Video]. YouTube. All rights reserved.
<https://www.youtube.com/watch?v=DLxYDoN634c>

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calcium is stored in bone by the osteoblasts. This dynamic process of releasing and storing calcium goes on continuously.⁵⁹

The bones of the skeletal system are comprised of an inner spongy tissue referred to as bone marrow. There are two types of bone marrow called red and yellow. Red bone marrow produces the red blood cells, white blood cells, and platelets. Yellow bone marrow contains adipose tissue, which can serve as a source of energy. **Myeloma** (mī-ě-LŌ-mă)⁶⁰ is a type of cancer that forms in the bone marrow.

There are several medical terms related to bones:

- **Osteomalacia** (ös-tē-ō-mă-LĀ-sē-ă) refers to the softening of bone.
- **Osteomyelitis** (os-tē-ō-mī-ě-LĪT-īs) refers to the inflammation of bone and bone marrow.
- **Osteonecrosis** (os-tē-ō-ně-KRŌ-sīs) refers to bone death due to lack of adequate blood supply.
- **Osteosarcoma** (ös-tē-ō-săr-KŌ-mă) refers to a malignant tumor of bone.
- **Osteopenia** (os-tē-ō-PĒ-nē-ă) refers to abnormal reduction of bone mass.
- **Osteoporosis** (ös-tē-ō-pō-RŌ-sīs) refers to a medical condition in which bones become weak, brittle, and prone to fractures.

Read more information about osteopenia and osteoporosis in the “[Diseases and Disorders of the Skeletal System](#)” section.

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Review additional information about bone marrow and the production of red blood cells, white blood cells, and platelets in the “[Anatomy of the Hematology System](#)” in the “Blood Terminology” chapter.

13.5 Physiology of the Skeletal System

The primary functions of the skeleton are to provide a rigid, internal structure that can support the weight of the body against the force of gravity, protect internal organs, and move the body with the help of muscles.¹

Synovial joints provide most of the movement of the body when bones and muscles work together at these joints. Movements created by synovial joints include flexion, extension, abduction, adduction, circumduction, and rotation.

Additional information about body movements is found in the “[Physiology of the Muscular System](#)” section of the “Muscular System Terminology chapter.

In addition to providing support and movements of the body, the skeleton has protective and storage functions. It protects the internal organs, including the brain, spinal cord, heart, lungs, and pelvic organs. The bones of the skeleton serve as the primary storage site for important minerals such as calcium and phosphate. Additionally, the bone marrow found within bones stores fat and houses the blood-cell producing tissue of the body.²

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View a supplementary YouTube video³ demonstrating movement at synovial joints:



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/medterm/?p=447#oembed-1>

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3. RegisteredNurseRN. (2021, June 7). *Body movement terms anatomy / Body planes of motion / Synovial joint movement terminology* [Video]. YouTube. All rights reserved. Reused with permission. <https://www.youtube.com/watch?v=KO4nUzO7xoo>

13.6 Diseases and Disorders of the Skeletal System

This section will discuss common diseases and disorders of the skeletal system.

ABNORMAL CURVATURES OF THE SPINE

The vertebral column normally has curvatures, but abnormal or excessive curvatures can develop due to diseases and disorders of the spine. Disorders associated with the curvature of the spine include scoliosis, kyphosis, and lordosis¹:

- **Scoliosis** (skō-lē-ō-sīs): Scoliosis is an abnormal, lateral curvature, accompanied by twisting of the vertebral column. See Figure 13.22a for an illustration of scoliosis. Scoliosis is the most common vertebral abnormality among girls. When present, scoliosis tends to worsen during adolescent growth spurts. A back brace may be recommended for growing children with scoliosis, and in severe cases, surgery may be required.
- **Kyphosis** (kī-Fō-sīs): Kyphosis, commonly referred to as humpback, is an excessive posterior curvature of the thoracic region. This can develop when osteoporosis causes weakening and erosion of the anterior portions

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of the upper thoracic vertebrae, resulting in their gradual collapse. See Figure 13.22b for an illustration of kyphosis.

- **Lordosis** (lor-DŌ-sīs): Lordosis, commonly referred to as swayback, is an excessive anterior curvature of the lumbar region and is most commonly associated with obesity or late pregnancy. See Figure 13.22c² for an illustration of lordosis. The accumulation of weight in the abdominal region results in an anterior shift in the line of gravity that carries the weight of the body. This causes an anterior tilt of the pelvis and a pronounced enhancement of the lumbar curve.

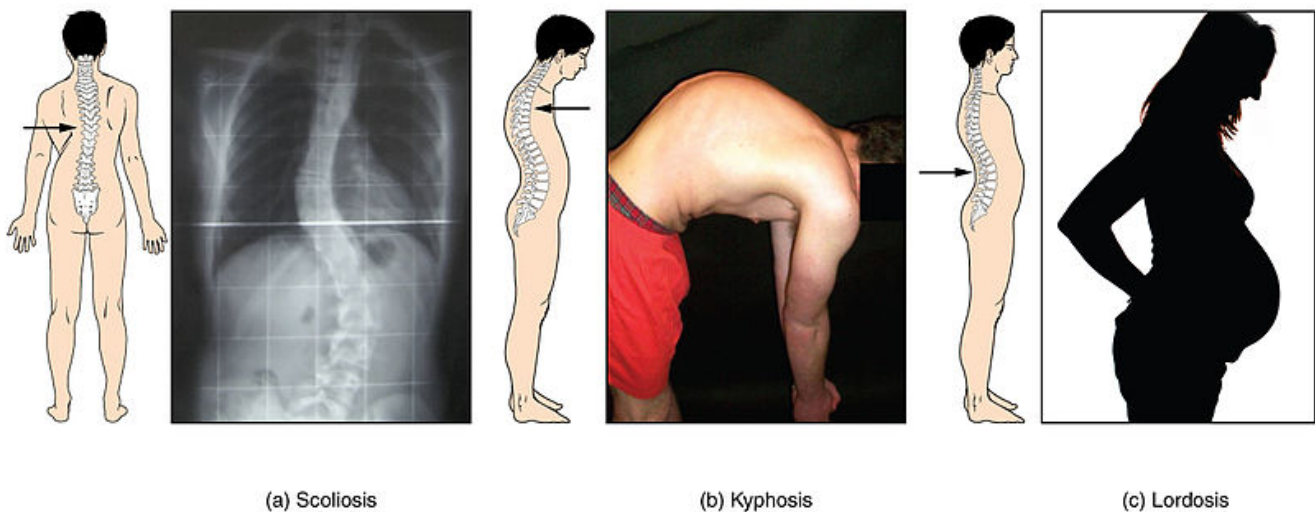


Figure 13.22 Abnormal Curvatures of the Vertebral Column. (a) Scoliosis (b) Kyphosis. (c) Lordosis

ARTHRITIS

Common types of **arthritis** (är-THRĪ-tīs) are osteoarthritis (OA), rheumatoid

2. “717_Abnormal_Curves_of_Vertebral_Column.jpg ” by OpenStax College is licensed under [CC BY 3.0](#)

arthritis (RA), and gout. Read more about these conditions in the corresponding subsections.

BONE CANCER

There are three types of primary bone cancers: osteosarcoma, Ewing sarcoma, and chondrosarcoma. These are considered primary cancers because they originate in the bones. Osteosarcoma and Ewing sarcomas are cancers found in children, teenagers, and young adults. Ewing sarcoma is considered to be the more aggressive of the two cancers because it tends to metastasize quickly. Osteosarcoma is the most common type of bone cancer, and it begins in the tissues of growing bones. Chondrosarcoma develops in cells that produce cartilage and affects adults. Symptoms of bone cancer may include fatigue, unintended weight loss, bone pain, swelling, tenderness, and weakened bone leading to fractures. Diagnostic testing may include a bone scan, X-ray, CT scan, MRI, PET scan, and bone biopsies. Treatment is based on the type of cancer, the stage of the cancer, and the patient's overall health and preferences. For example, some bone cancers are treated with surgery; some are treated with surgery and chemotherapy; and others are treated with surgery, chemotherapy, and radiation therapy.³

CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome is a disorder that occurs when the median nerve, which runs from the forearm into the palm of the hand, becomes pressed or

3. Mayo Clinic. (2023, May 11). *Bone cancer*. <https://www.mayoclinic.org/diseases-conditions/bone-cancer/symptoms-causes/syc-20350217>

squeezed at the wrist. Read more information about carpal tunnel syndrome in the “[Diseases and Disorders Related of the Nervous System](#).”

FRACTURE

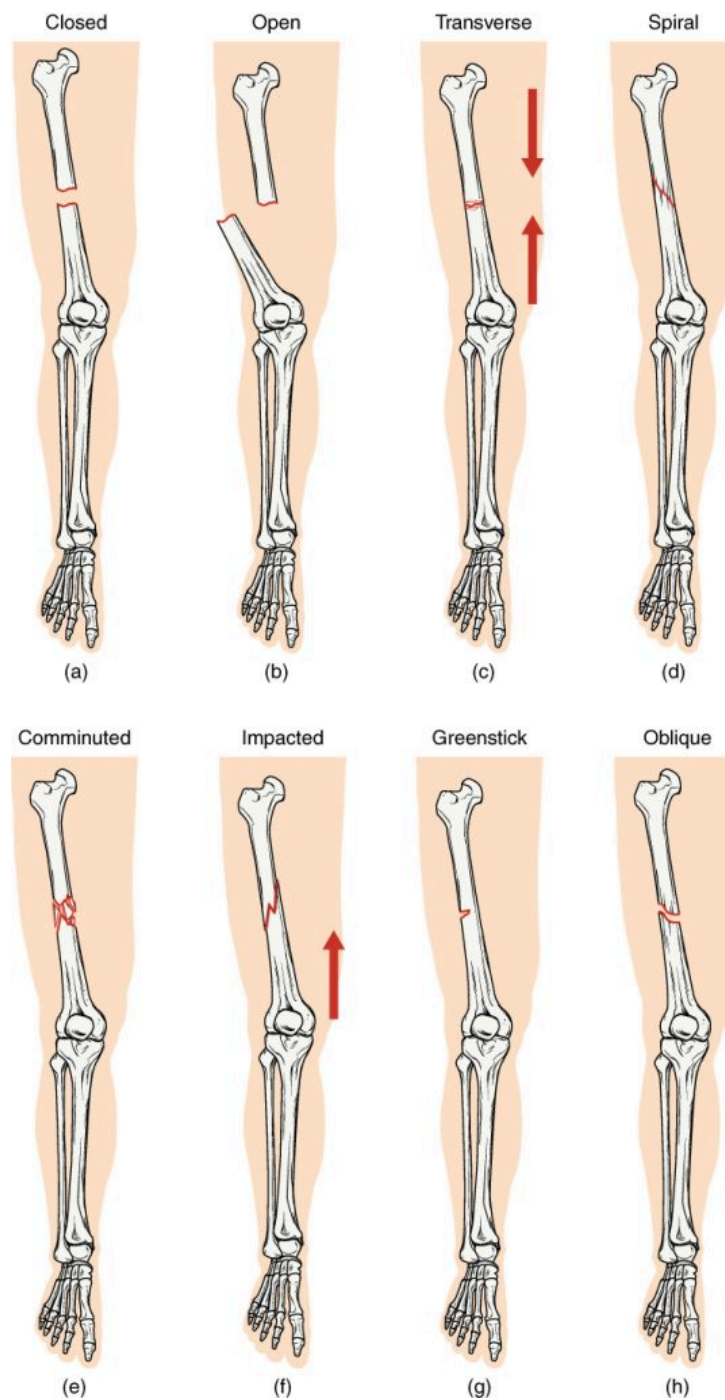
A **fracture** (FRÄK-chŭr) (**fx**) is a broken bone. It will heal automatically due to the action of osteoclasts and osteoblasts, but if the bone is not reset and aligned correctly, it will remain in a dislocated position. Fractures are classified by their complexity, location, and other features. Some fractures may be described using more than one term (e.g., an open transverse fracture) because it may have the features of more than one type. See Figure 13.23⁴ for an illustration of different types of fractures that include the following⁵:

- **Closed or simple** (klōzd ōr sĭm-pŭl frāk-chŭr): Bone is broken but does not protrude the skin
- **Open or compound** (ō-pĕn ōr kŏm-pound frāk-chŭr): Bone is broken and pierces through the skin
- **Transverse** (trăns-vûrs): Bone is broken straight across
- **Spiral** (spĭ-răl): Bone has twisted apart
- **Comminuted** (kŏm-ĭ-nŭ-tĕd): A bone is crushed into pieces
- **Impacted** (ĭm-păk-tĕd): One fragment of the bone is driven into the other, usually as a result of compression
- **Greenstick** (grĕn-stĭk): Bone is partially broken, a condition that occurs in children
- **Oblique** (ō-blĕk): Bone is broken at an angle

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- **Stress** (strěs): Small crack in a bone



13.23 Types of Fractures

GOUT

Gout (gowt) is a type of inflammatory arthritis that causes pain and swelling in the joints, usually as flares that last for one or two weeks and then resolve. Gout flares often begin in the big toe or a lower limb. Gout occurs when high levels of serum uric acid build up in the body, which can form needle-shaped crystals in and around the joint and cause inflammation. Uric acid is a waste product produced by the breakdown of purine, a type of molecule found in many foods we eat. Gout is diagnosed with blood tests for uric acid. It is commonly treated with medications like nonsteroidal anti-inflammatories (NSAIDs) and colchicine.⁶ See Figure 13.24⁷ for an illustration of gout.



Figure 13.24 Gout

6. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2020, February). *Gout*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/gout>

7. “Gout_Signs_and_Symptoms.jpg” by www.scientificanimations.com is licensed under [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

LUPUS

Systemic lupus erythematosus (sīs-tēm-ĭk lū-pŭs ěr-ěth-ěm-ă-tō-sŭs), commonly referred to as **lupus** (lū-pŭs), is a chronic autoimmune disease that can affect many parts of the body. Lupus occurs when the immune system attacks its own tissues, causing inflammation and in some cases permanent tissue damage. Tissue damage can be widespread and affect the joints, skin, heart, lung, kidneys, blood cells, and brain.⁸

The symptoms of lupus vary from person to person. They can range from mild to severe, and they may come and go. Common symptoms can include arthritis, fatigue, and a classic rash that appears on the face across the nose and cheeks called a “butterfly rash.” See Figure 13.25⁹ for an image of a butterfly rash associated with lupus. No single test can be used to diagnose lupus, but a blood test called antinuclear antibodies (ANA) may be performed. There is no cure for lupus, but medications are prescribed to manage inflammation, and immunosuppressants may be used to curb the overactive immune system.¹⁰

8. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2022, October). *Systemic lupus erythematosus (lupus)*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/lupus>

9. “Lupusfoto.jpg” by [Doktorinternet](#) is licensed under [CC BY-SA 4.0](#)

10. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2022, October). *Systemic lupus erythematosus (lupus)*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/lupus>



*Figure 13.25 Butterfly
Rash on the Face
Associated With Lupus*

OSTEOARTHRITIS

Osteoarthritis (ös-tē-ō-är-THRĪ-tīs) is a degenerative joint disease in which the tissues in the joint break down over several years. It is the most common type of arthritis and frequently occurs as people age. People with osteoarthritis usually have joint pain or stiffness after rest or inactivity for a short period of time. The most commonly affected joints include the hands, knees, hips, neck, and lower back. See Figure 13.26¹¹ for an image of a person with osteoarthritis in their finger. Osteoarthritis affects each person differently. For some people, osteoarthritis is relatively mild and does not affect day-to-day activities. For others, it causes significant pain and disability.¹²

Crepitus (krěp-ĭ-tūs) describes a popping, clicking, or crackling sound when

11. "[Osteoarthritis_in_the_left_hand_index_finger.jpg](#)" by [Whoisjohngalt](#) is licensed under [CC BY-SA 4.0](#)

12. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2023, September). *Osteoarthritis*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/osteoarthritis>

moving a joint that is associated with osteoarthritis. It typically reflects air movement in the joint and is harmless.¹³



Figure 13.26
Osteoarthritis in the
Hand

Osteoarthritis is initially treated with lifestyle changes like exercise and weight management. Braces may be used to support the affected joints. Oral and topical pain relievers may be prescribed. If joint damage is severe, joint replacement surgery may be required.¹⁴

¹³. Drum, E. E., Kovats, A., Jones, M. D., Dennis, S., Naylor, J., Mills, K., & Thom, J. M. (2023). Creaky knees: Is there a reason for concern? A qualitative study of the perspectives of people with knee crepitus. *Musculoskeletal Care*, 21(4), 1114–1124. <https://doi.org/10.1002/msc.1793>

¹⁴. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2023, September). *Osteoarthritis*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/osteoarthritis>

OSTEOMYELITIS

Osteomyelitis (ŏs-tē-ō-mī-ĕ-LĪT-ĭs) is an infection in a bone. Infections can reach a bone by traveling through the bloodstream or spreading from nearby tissue. Infections can also begin in the bone itself if an injury exposes the bone to bacteria. Smokers and people with chronic health conditions, such as diabetes or kidney failure, are at higher risk of developing osteomyelitis. People who have diabetes may develop osteomyelitis in their feet if they develop foot ulcers. Although once considered incurable, osteomyelitis can now be successfully treated with surgery and strong intravenous antibiotics.¹⁵

OSTEOPENIA AND OSTEOPOROSIS

Osteopenia (os-tē-ō-PĒ-nē-ă) is an abnormal reduction of bone mass that can lead to osteoporosis. **Osteoporosis** (ŏs-tē-ō-pō-RŌ-sĭs) is a condition where the bones become weak and brittle. Osteoporosis increases the risk of fractures and can also cause kyphosis as vertebrae gradually collapse. See Figure 13.27¹⁶ for an illustration of osteoporosis resulting in kyphosis. Osteoporosis is a “silent” disease because people typically do not have symptoms and do not know they have the disease until they break a bone. Osteoporosis is the major cause of fractures in postmenopausal women and in older men. Fractures due to osteoporosis can occur in any bone but happen most frequently in bones of the hip, vertebrae, and wrist.¹⁷ See Figure

15. Mayo Clinic. (2022, November 8). *Osteomyelitis*. <https://www.mayoclinic.org/diseases-conditions/osteomyelitis/symptoms-causes/syc-20375913>

16. “*Osteoporosis_Locations.png*” by [BruceBlaus](#) is licensed under [CC BY-SA 4.0](#)

17. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2023,

13.27 for an illustration of osteoporosis compared to normal bone in the hip and spine.

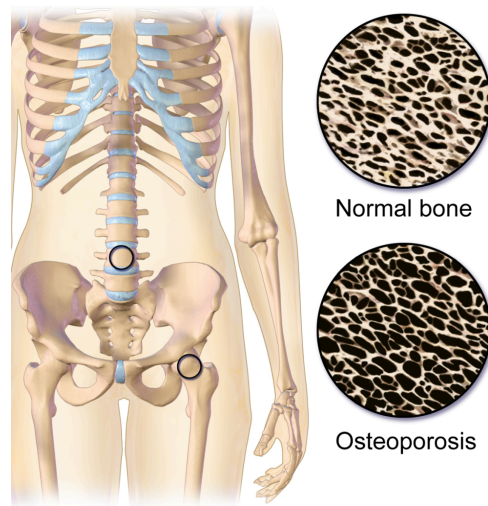


Figure 13.27 Osteoporosis in the Hip and Spine

The most common test for measuring bone mineral density is dual-energy X-ray absorptiometry (DEXA scan). Read more about this test in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Skeletal System](#)” section of this chapter. Lifestyle changes like weight-bearing exercise and a nutritious diet rich in calcium and vitamin D can help prevent and treat osteoporosis. Medications that enhance bone density and strength are generally prescribed for people with osteoporosis.¹⁸

September). *Osteoarthritis*. National Institutes of Health.
<https://www.niams.nih.gov/health-topics/osteoarthritis>

18. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2023, September). *Osteoarthritis*. National Institutes of Health.
<https://www.niams.nih.gov/health-topics/osteoarthritis>

RHEUMATOID ARTHRITIS

Rheumatoid arthritis (rū-mă-toid är-thrī-tīs) (**RA**) is a chronic autoimmune disease that affects the joints. RA occurs in a symmetrical pattern, meaning that if one knee or hand has the condition, the other hand or knee is also affected. It can affect the joints in the wrists, hands, elbows, shoulders, feet, spine, knees, and jaw. RA causes pain, swelling, stiffness, deformity, and loss of function. See Figure 13.28¹⁹ for an illustration of rheumatoid arthritis in the hands causing a common “swan-like” deformity.²⁰

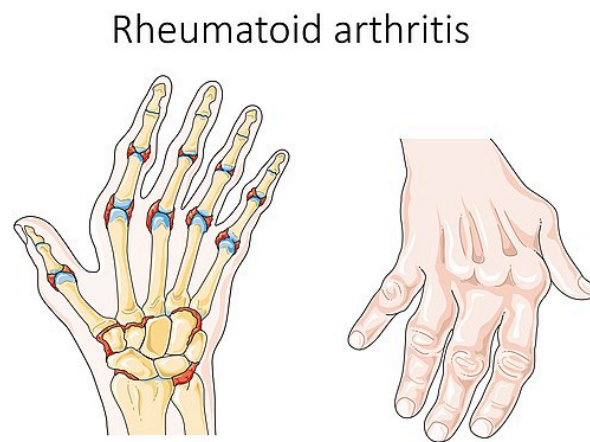


Figure 13.28 Rheumatoid Arthritis

Rheumatoid arthritis may be diagnosed with blood tests like rheumatoid

19. “[Rheumatoid_arthritis_-_Smart-Servier_\(cropped\).jpg](#)” by [Laboratoires Servier](#) is licensed under [CC BY-SA 3.0](#)

20. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2022, November). *Rheumatoid arthritis*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/rheumatoid-arthritis>

factor or anti-CCP antibodies. It is treated with medications, physical and occupational therapy, and in some cases, joint repair or replacement.²¹

Rickets

Rickets (RĬK-ĭts) is a disease in children caused by extreme and prolonged vitamin D deficiency, characterized by softening and distortion of the bones. It typically results in a bow-legged appearance. See Figure 13.29²² for an image of children with rickets.



Figure 13.29 Rickets

21. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2022, November). *Rheumatoid arthritis*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/rheumatoid-arthritis>
22. “[Photograph; three children with rickets Wellcome L0014375.jpg](#)” by unknown author from [Wellcome Collection Gallery](#) is licensed under [CC BY 4.0](#)

13.7 Medical Specialists, Diagnostic Testing, and Procedures Related to the Skeletal System

MEDICAL SPECIALISTS

Orthopedists and Orthopedic Surgeons

Orthopedics (or-thō-pē-dīks) is a branch of medicine that treats disorders and diseases related to the musculoskeletal system. **Orthopedists** (or-thō-pē-dīsts) are medical doctors who specialize in the prevention, diagnosis, treatment, and surgery of disorders and diseases related to the musculoskeletal system. Some orthopedists are generalists, whereas others specialize in certain areas of the body, such as the hip and knee, foot and ankle, shoulder and elbow, hand, or spine. Orthopedic surgeons perform surgery to repair a musculoskeletal injury or condition. They treat patients of all ages, from newborns to the elderly, and treat conditions such as fractures, sports injuries, joint replacements, and spinal deformities.¹

1. American Academy of Orthopaedic Surgeons. (n.d.). *Orthopaedic surgeons: Restoring mobility and keeping our nation in motion*. <https://www.aaos.org/about/what-is-an-orthopaedic-surgeon>

- ▶ For more details about orthopedists, see the [American Academy of Orthopaedic Surgeons' web page](#).

Rheumatologist

Rheumatology (rū-mă-tōl-ō-jē) is the study of inflammatory or infectious conditions of the joints and other parts of the musculoskeletal system.

Rheumatologists (rū-mă-tōl-ō-jists) are physicians who specialize in the diagnosis and treatment of musculoskeletal diseases and systemic autoimmune conditions, commonly referred to as rheumatic diseases. These diseases, such as rheumatoid arthritis, can potentially cause joint deformities.

- ▶ For more information, see the [American College of Rheumatology's web page called "What is a Rheumatologist?"](#)

Doctor of Osteopathy

Osteopathy (ōs-tē-OP-ă-thē) is a branch of medical practice that emphasizes the treatment of medical disorders through the manipulation and massage of the bones, joints, and muscles. A **Doctor of Osteopathic Medicine** (dōk-tōr ōf ōs-tē-ō-PĀTH-ĭk mēd-ĭ-sĭn) (**DO**) uses a whole-person approach to help prevent illness and injury. DOs look beyond symptoms to understand how lifestyle and environmental factors impact a person's well-being. They practice medicine according to science and technology, but also consider options to complement medications and surgery. As part of their education,

DOs receive special training in the musculoskeletal system, the body's interconnected system of nerves, muscles, and bones.²

- ▶ For more information, go to the American Osteopathic Association's [About Us web page](#).

Radiologist

A **radiologist** (RĀ-dē-ŏ-jĭst) is a physician who specializes in diagnosing and treating injuries and diseases using medical imaging (radiology) procedures such as X-rays, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine, positron emission tomography (PET), and ultrasound. Diagnostic radiologists use a variety of imaging procedures to see inside the body and assess or diagnose the patient's condition. Interventional radiologists diagnose and treat patients using image-guided, minimally invasive techniques such as X-rays and MRI. They carefully guide instruments through tiny incisions in the body and deliver targeted treatments for conditions such as heart disease, stroke, cancer, and uterine fibroids. Radiation oncologists use radiation therapy to treat cancer.

- ▶ Read more information about radiologists on the American College of Radiology's web page [What is a Radiologist?](#)

Radiology Technologist

A **radiology technologist** (rā-dē-ŎL-ŏ-jē tĕk-nŎL-ŏ-jĭst), commonly called an

2. American Osteopathic Association. (n.d.). *About us*. <https://osteopathic.org/about/>

X-ray tech, is a health care professional who is specially trained to perform medical imaging like X-rays, CT scans, MRIs, and PET scans. To become a radiology technologist or MRI technologist, a person completes an associate degree and passes a certification exam.

- ▶ Read more information about the occupational outlook for radiology technologists on the U.S. Bureau of Labor Statistics' [Radiologic and MRI Technologists web page](#).

DIAGNOSTIC TESTING

Common diagnostic procedures related to the skeletal system are discussed in this section.

X-rays

X-rays (ěks-rāz) use a form of radiation that travels through the body and strikes an X-ray detector (such as radiographic film or a digital X-ray detector) on the other side of the patient, forming an image that represents the “shadows” of objects inside the body. Bones readily absorb X-rays and, therefore, produce high contrast on the X-ray detector. As a result, bony structures appear whiter than other tissues against the black background of a

radiograph. X-rays are used to detect bone fractures, tumors, and dental problems.³ See Figure 13.30⁴ for an image of a normal hip X-ray.



Figure 13.30 Normal Hip X-Ray

When used appropriately, the diagnostic benefits of X-ray scans significantly outweigh the risks. However, X-rays produce ionizing radiation, a form of radiation that has the potential to harm living tissue. This risk increases with the number of X-ray exposures added up over the lifetime of an individual. However, the risk of developing cancer from radiation exposure is generally

3. National Institute of Biomedical Imaging and Bioengineering. (2022, June). X-rays. National Institutes of Health. <https://www.nibib.nih.gov/science-education/science-topics/x-rays>
4. “X-ray of a normal hip.jpg” by Mikael Häggström, M.D. is licensed under [CC0, Public Domain](#)

small. Children are more sensitive to ionizing radiation and have a long life expectancy, so machine settings can be adjusted according to the patient's age.⁵

Bone Mineral Density Testing

A **bone mineral density** (bōn mīn-ēr-āl dēn-sī-tē) is a test that measures calcium and other minerals in bone. Bones can become less dense as people age or if certain medical conditions occur. When too much bone is lost, osteopenia or osteoporosis can develop, causing bones to become weak and brittle and increasing the risk of fractures.⁶

The most common bone mineral density test is a central dual energy X-ray absorptiometry or also called a **DEXA scan** (DĚK-să skăn). DEXA scans use radiation to measure how much calcium and other minerals are in a specific area of the bone. Because the weakest bones that break most often due to osteoporosis are the hip and spine, DEXA scans typically measure bone mineral density in these bones.⁷ See Figure 13.31⁸ for an image of a DEXA scan.

5. National Institute of Biomedical Imaging and Bioengineering. (2022, June). X-rays. National Institutes of Health. <https://www.nibib.nih.gov/science-education/science-topics/x-rays>
6. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2023, May). *Bone mineral density tests: What the numbers mean*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/bone-mineral-density-tests-what-numbers-mean>
7. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2023, May). *Bone mineral density tests: What the numbers mean*. National Institutes of Health. <https://www.niams.nih.gov/health-topics/bone-mineral-density-tests-what-numbers-mean>
8. "4371556142_3aeb50e381_b.jpg" by [ActiveSteve](#) is licensed under [CC BY-NC-ND 2.0](#)



Figure 13.31 DEXA Scan

Postmenopausal women and men over age 50 receive bone mineral density test results as a “T-score.” A T-score is the difference between their bone mineral density and 0, which represents the bone mineral density of a healthy young adult. The lower the T-score, the higher the risk of bone fracture⁹:

9. National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2023, May). *Bone mineral density tests: What the numbers mean*. National

- 1 or higher indicates the bone is healthy
- -1 to -2.5 indicates osteopenia
- -2.5 or lower indicates osteoporosis

PROCEDURES

Arthrocentesis

Arthrocentesis (ar-thrō-sen-TĒ-sīs) is a surgical puncture to aspirate fluid from a joint, such as the knee. It can help the health care provider find the cause of swollen, painful joints and can also provide symptom relief. After aspiration, the health care provider may inject medications into the joint to temporarily ease pain and inflammation.



View a supplementary YouTube video¹⁰ from Stanford EdTech on arthrocentesis: [Arthrocentesis – What to Expect](#)

Arthrodesis

Arthrodesis (ar-THROD-ě-sīs) is the surgical immobilization of a joint by fusion of the adjacent bones. This procedure is performed to relieve unrelenting pain in a joint that cannot be appropriately managed by

Institutes of Health. <https://www.niams.nih.gov/health-topics/bone-mineral-density-tests-what-numbers-mean>

10. Stanford EdTech. (2019, April 8). *Arthrocentesis – What to expect* [Video]. YouTube. All rights reserved. <https://www.youtube.com/watch?v=onbA5nPYKqU>

traditional treatments, physical therapy, splints, or pain medication. It is commonly performed on joints in the foot, ankle, spine, and wrist.¹¹

Arthroscopy

Arthroscopy (är-THRŌ-skō-pē) is a common procedure performed by orthopedic surgeons to view the inside of a joint to diagnose and/or to repair joint problems. The patient is given a local anesthetic, and the surgeon inserts an arthroscope through an incision in the skin. **Arthroplasty** (AR-thrŏ-plas-tē), surgical repair of a joint, may take place during the procedure.¹² See Figure 13.32¹³ for an illustration of a shoulder arthroscopy.

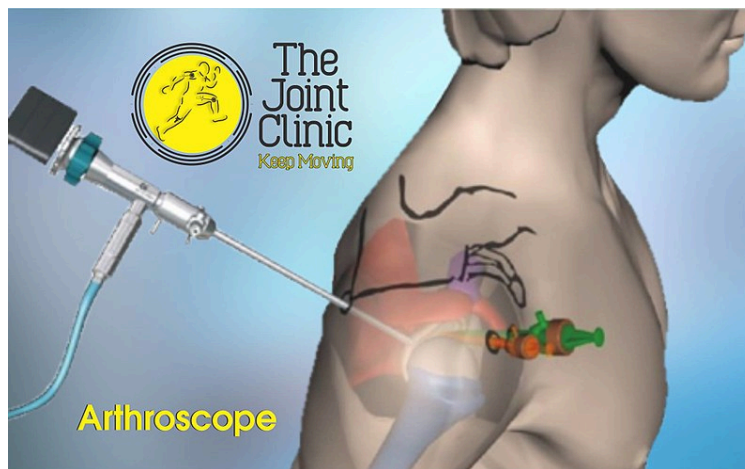


Figure 13.32 Shoulder Arthroscopy

11. This work is a derivative of [StatPearls](#) by Jimenez & Anand and is licensed under [CC BY 4.0](#)
12. Cleveland Clinic. (2021, June 23). *Arthrocentesis (joint aspiration)*. <https://my.clevelandclinic.org/health/treatments/14512-arthrocentesis-joint-aspiration>
13. “[Shoulder_Arthroscopy.jpg](#)” by [The Joint Clinic](#) is licensed under [CC BY-SA 4.0](#)

Below-the-Knee Amputation

A **below-the-knee amputation** (bĭ-lō-thē-nē ăm-pyū-TĀ-shŏn (**BKA**) is performed by an orthopedic surgeon who removes the foot, ankle, part of the tibia, fibula, and corresponding soft tissue structures. It is considered a life-saving procedure for patients who have decreased blood flow and/or infection of the lower extremity. It is typically performed due to trauma, severe peripheral arterial disease, and/or severe infection related to diabetes. After the procedure, the patient receives an artificial body part called a **prosthesis** (PRŌS-thē-sĭs) and participates in restorative care. Restorative care includes physical therapy and occupational therapy with the goal to achieve optimal functioning and independence in completing daily activities.¹⁴ See Figure 13.33¹⁵ for an image of a man with a leg prosthesis. Read more about physical therapy and occupational therapy in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Muscular System](#)” in the “Muscular System Terminology” chapter.



Figure 13.33 Leg Prosthesis

- ¹⁴. This work is a derivative of [StatPearls](#) by Adams & Lakra and is licensed under [CC BY 4.0](#)
- ¹⁵. “[pexels-kampus-production-8346699.jpg](#)” by [Kampus Production](#) via [Pexels](#), is licensed under [CC0](#)

Joint Replacement Surgery

Arthroplasty (ÄR-thrō-plās-tē) refers to surgical repair or replacement of a joint. Common joint replacement surgeries include hip replacement, knee replacement, and shoulder replacement. See Figure 13.34¹⁶ for an illustration of joint replacement surgeries. During joint replacement surgery, an orthopedic surgeon removes the diseased parts of the joint and replaces them with new, artificial parts that mimic the function of the normal joint.

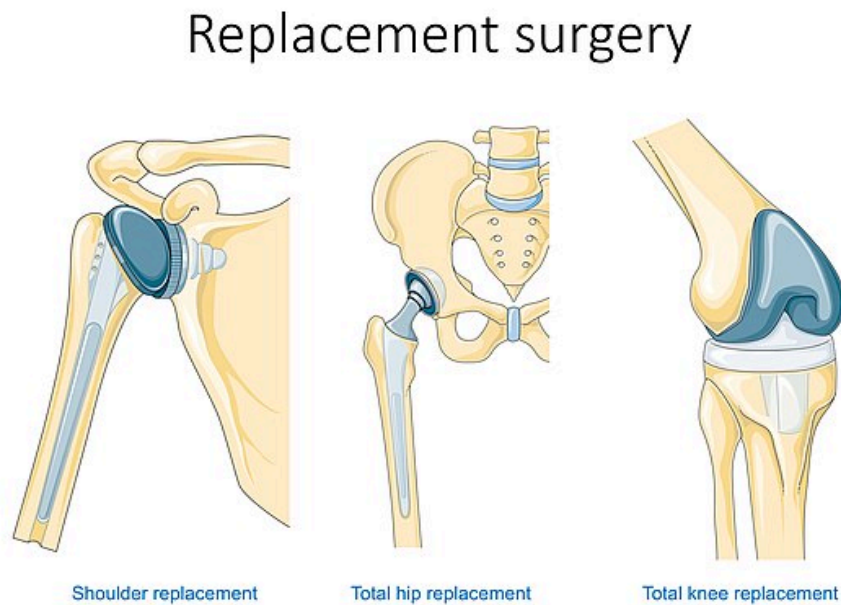


Figure 13.34 Joint Replacement Surgeries

A **total hip replacement** (tō-tāl hīp rē-plās-měnt) (**THR**), also called a **total**

¹⁶. [“Replacement surgery - Shoulder total hip and total knee replacement – Smart-Servier.jpg”](#) by [Laboratoires Servier](#) is licensed under [CC BY-SA 3.0](#)

hip arthroplasty (tō-tāl hĭp är-thrō-plās-tē) (**THA**), refers to replacement of the head of the femur and acetabulum with replacement parts that are either metal, ceramic, or hard plastic. THR may be required due to osteoarthritis, **osteonecrosis** (when parts of a bone die due to decreased blood supply), or a hip fracture from an injury or fall.¹⁷

A **total knee replacement** (tō-tāl nē rē-plās-měnt) (**TKR**), also called **total knee arthroplasty** (tō-tāl nē är-thrō-plās-tē) (**TKA**), refers to surgical removal of worn surfaces of the knee joint due to severe osteoarthritis. During the surgery, damaged bone and cartilage are replaced with parts made of metal and plastic.

Open and Closed Reduction and Internal Fixation

Open reduction and internal fixation (ō-pěn rĭ-DŮK-shŏn ānd ĭn-těr-nāl fĭk-SĀ-shŏn) (**ORIF**) is a type of surgery used to stabilize and heal a broken bone. During an open reduction, orthopedic surgeons expose the bone and reposition the pieces of fractured bone, so they are back in their proper alignment and heal correctly. In contrast, during closed reduction surgery, a doctor physically moves the bones back into place without surgically exposing the bone. Internal fixation refers to physically reconnecting the bones using screws, plates, wires, or nails. See Figure 13.35¹⁸ for an X-ray illustration of femur fracture repaired with internal fixation using screws.

17. National Institute of Arthritis and Musculoskeletal and Skin Disease. (2023, August). *Hip replacement surgery*. National Institutes of Health.
<https://www.niams.nih.gov/health-topics/hip-replacement-surgery>

18. “[Femur-fractura-nail-artificial-bone.png](#)” by [Fry72](#) Karel Frydryšek is licensed under [CC BY-SA 4.0](#)

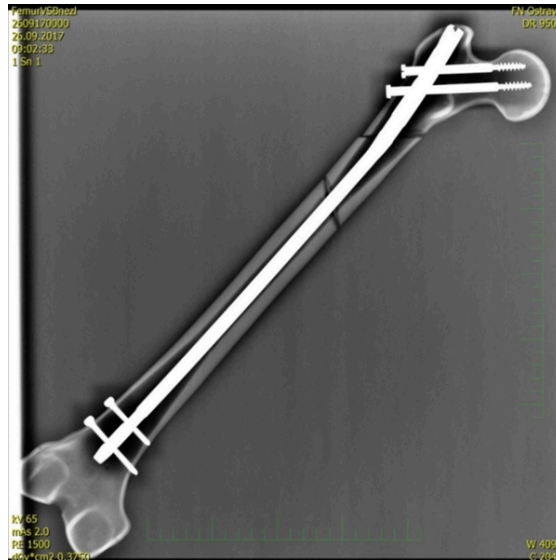


Figure 13.35 Internal Fixation of a Femur Fracture

13.8 Skeletal System

Learning Activities

Interactive Learning Activity: Practice labeling the skeletal system.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=451#h5p-87>

Interactive Learning Activity: Study skeletal system medical terms discussed in this chapter using these flashcards.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=451#h5p-187>

Interactive Learning Activity: Test your knowledge on these skeletal system terms and concepts.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=451#h5p-93>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



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<https://wtcs.pressbooks.pub/medterm/?p=451#h5p-89>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=451#h5p-90>



Interactive Learning Activity: Practice identifying and defining word parts for terms discussed in this chapter.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=451#h5p-206>

▶ You can also print this as a [Chapter 13 Practice Worksheet](#) and check your answers with this [Answer Key PDF](#).

13.9 Glossary

Acetabulum (ăs-ě-TĀB-yŭ-lŭm): The socket of the hip bone, into which the head of the femur fits. ([Chapter 13.4](#))

Acromion (ă-KRŌ-mē-ŏn): An extension of the scapula that forms the high point of the shoulder. ([Chapter 13.4](#))

Anterior cruciate ligament (ăn-TĪR-ē-ŏr KRŪ-shē-āt LĪG-ă-měnt) (ACL): A ligament in the knee joint that connects the femur to the tibia and crosses in front of the PCL that provides stability to the knee. ([Chapter 13.4](#))

Arthritis (är-THRĪ-tīs): A general term for conditions affecting the joints and surrounding tissues, leading to pain, swelling, stiffness, and limited movement. It includes various types such as osteoarthritis and rheumatoid arthritis. ([Chapter 13.6](#))

Arthrocentesis (ar-thrō-sen-TĒ-sīs): A surgical puncture to aspirate fluid from a joint, such as the knee. ([Chapter 13.7](#))

Arthrodesis (ar-THROD-ě-sīs): The surgical immobilization of a joint by fusion of the adjacent bones. ([Chapter 13.7](#))

Arthroplasty (AR-thrŏ-plas-tē): Surgical repair of a joint. ([Chapter 13.7](#))

Arthroscopy (är-THRŌ-skō-pē): A common procedure performed by orthopedic surgeons to view the inside of a joint to diagnose and/or to repair joint problems. ([Chapter 13.7](#))

Articular disks (är-TĪK-yŭ-lăr dĭsk): Fibrocartilage structures in some synovial joints that act as cushions and improve the fit between the bones. ([Chapter 13.4](#))

Below-the-knee amputation (bĭ-lŏ-thē-nē âm-pyŭ-TĀ-shŏn) (BKA): A procedure performed by an orthopedic surgeon who removes the foot, ankle, part of the tibia, fibula, and corresponding soft tissue structures. ([Chapter 13.7](#))

Body (bŏd-ē): The middle portion of the sternum ([Chapter 13.4](#))

Bone mineral density (bŏn mĭn-ěr-ăl dĕn-sĭ-tē): A test that measures calcium and other minerals in bone. ([Chapter 13.7](#))

Bursa (BŪR-să): A small fluid-filled sac that acts as a cushion between a bone and other moving parts, such as muscles, tendons, or skin. ([Chapter 13.4](#))

- Bursectomy (bŭr-SĚK-tō-mē):** Surgical removal of a bursa. ([Chapter 13.4](#))
- Bursitis (bŭr-SĪ-tīs):** Inflammation of a bursa, usually occurring in the knee, elbow, or shoulder. ([Chapter 13.4](#))
- Calcaneus (kāl-KĀ-nē-ŭs):** The heel bone. ([Chapter 13.4](#))
- Calcium (KĀL-sē-ŭm) (Ca+):** A mineral essential for developing and maintaining healthy bones and teeth. ([Chapter 13.4](#))
- Carpals (KĀR-pālz):** The bones of the wrist. ([Chapter 13.4](#))
- Cartilage (KĀR-tī-līj):** A resilient and smooth elastic tissue that covers and protects the ends of bones at joints. ([Chapter 13.4](#))
- Cartilaginous joints (kär-tī-LĀJ-ī-nŭs joints):** Joints where bones are connected by cartilage, allowing more movement than fibrous joints but less than synovial joints. ([Chapter 13.4](#))
- Cervical (SŬR-vī-kāl):** Pertaining to the neck or the cervical vertebrae in the neck region. ([Chapter 13.4](#))
- Clavicle (KLĀV-ī-kŭl):** The collarbone, a long bone that serves as a strut between the shoulder blade and the sternum. ([Chapter 13.4](#))
- Closed or simple fracture (klōzd ōr sīm-pŭl):** A type of bone fracture where the skin over the fracture site remains intact, and the bone does not pierce through the skin. ([Chapter 13.6](#))
- Coccyx (KÖK-sĭks):** The tailbone, formed by the fusion of coccygeal vertebrae. ([Chapter 13.4](#))
- Comminuted (kōm-ī-nŭ-těd):** A bone is crushed into pieces. ([Chapter 13.6](#))
- Cranioplasty (KRĀ-nē-ō-plās-tē):** Surgical repair of the skull. ([Chapter 13.4](#))
- Craniotomy (krā-nē-ŌT-ō-mē):** A surgical procedure involving an incision through the cranium to access the brain. ([Chapter 13.4](#))
- Cranium (KRĀ-nē-ŭm):** The skull, especially the part encasing the brain. ([Chapter 13.4](#))
- Crepitus (krĕp-ī-tŭs):** Describes a popping, clicking, or crackling sound when moving a joint that is associated with osteoarthritis. It typically reflects air movement in the joint and is harmless. ([Chapter 13.6](#))
- DEXA scan (DĚK-să skăn):** Shortened name for a central dual energy X-ray absorptiometry scan. These scans use radiation to measure how much calcium and other minerals are in a specific area of the bone. ([Chapter 13.7](#))

Disectomy (dīs-KEK-tō-mē): Surgical removal of an intervertebral disk. ([Chapter 13.4](#))

Diskitis (dīs-KĪ-tīs): Inflammation of an intervertebral disk. ([Chapter 13.4](#))

Dislocation (dīs-lō-KĀ-shōn): A condition where the bones in a joint become displaced from their normal alignment. ([Chapter 13.4](#))

Doctor of Osteopathic Medicine (dōk-tōr ōf ōs-tē-ō-PĀTH-ĭk mēd-ĭ-sĭn (DO): A medical specialist who uses a whole-person approach to help prevent illness and injury by looking beyond symptoms to understand how lifestyle and environmental factors impact a person's well-being. They practice medicine according to science and technology, but also consider options to complement medications and surgery. ([Chapter 13.7](#))

Ethmoid (ĒTH-moid): Related to the ethmoid bone, located between the eyes and forming part of the nasal cavity. ([Chapter 13.4](#))

False ribs (FÔLS rĭbz): Ribs 8-10, which are connected to the sternum via cartilage. ([Chapter 13.4](#))

Femur (FĒ-mŭr): The thigh bone, the longest and strongest bone in the body. ([Chapter 13.4](#))

Fibrous joints (FĪ-brŭs joints): Joints where bones are joined by fibrous tissue, typically allowing very little movement. ([Chapter 13.4](#))

Fibula (FĪB-yŭ-lă): The smaller and thinner bone of the lower leg located on the lateral side. ([Chapter 13.4](#))

Floating ribs (FLŌ-ă-tĭng rĭbz): The last two pairs of ribs, which are not attached to the sternum. ([Chapter 13.4](#))

Fracture (FRĀK-chŭr): A medical condition where there is a break in the continuity of the bone. It can range from minor cracks to complete breaks and can occur in any bone in the body. ([Chapter 13.6](#))

Frontal (FRŪN-tăĭ): Pertaining to the forehead or the frontal bone of the skull. ([Chapter 13.4](#))

Gout (gowt): A type of inflammatory arthritis that causes pain and swelling in the joints, usually as flares that last for one or two weeks and then resolve. Gout flares often begin in the big toe or a lower limb when high levels of serum uric acid build up in the body. ([Chapter 13.6](#))

Greenstick (grĕn-stĭk): Bone is partially broken, a condition that occurs in children. ([Chapter 13.6](#))

- Hallux (HĀL-lŭks):** The big toe. ([Chapter 13.4](#))
- Herniated disk (hŭr-nē-Ā-tīd dĭsk):** A condition where a disk protrudes beyond the normal confines of the vertebrae. ([Chapter 13.4](#))
- Humerus (HYŌŌ-mēr-ŭs):** The upper arm bone, extending from the shoulder to the elbow. ([Chapter 13.4](#))
- Hyoid (HĪ-oid):** A U-shaped bone in the neck that supports the tongue. ([Chapter 13.4](#))
- Ilium (ĪL-ē-ŭm):** The large, broad bone forming the upper part of each half of the pelvis. ([Chapter 13.4](#))
- Impacted (īm-pāk-tĕd):** One fragment of the bone is driven into the other, usually as a result of compression. ([Chapter 13.6](#))
- Inferior conchae (ĪN-fēr-ē-ŏr KŌN-kē):** Referring to the lowermost scroll-like bones on the lateral walls of the nasal cavity. ([Chapter 13.4](#))
- Intercostal (ĭn-tĕr-KŌS-tāl):** Located between the ribs. ([Chapter 13.4](#))
- Intercostal retractions (ĭn-tĕr-KŌS-tāl rē-trāk-SHŏnz):** The inward movement of the muscles between the ribs, typically a sign of respiratory distress. ([Chapter 13.4](#))
- Intervertebral disks (ĭn-tĕr-VĒRT-ĕ-brāl dĭsks):** Pertaining to the space or structure between two vertebrae. ([Chapter 13.4](#))
- Ischium (ĪS-kē-ŭm):** The curved bone forming the base of each half of the pelvis. ([Chapter 13.4](#))
- Joints (jŏyntz):** The locations where two or more bones meet, allowing for movement or stability in the skeleton. ([Chapter 13.4](#))
- Kyphosis (kī-FŌ-sīs):** An excessive outward curvature of the spine, causing a hunching of the back. It can result from degenerative diseases, developmental problems, osteoporosis, or trauma. ([Chapter 13.6](#))
- Lacrimal (LĀK-rĭ-māl):** Related to the lacrimal bones, small bones forming part of the eye socket. ([Chapter 13.4](#))
- Laminectomy (lām-ĭ-NĒK-tō-mē):** Surgical removal of a portion of the vertebral bone called the lamina. ([Chapter 13.4](#))
- Lateral collateral ligament (LĀT-ĕr-āl KŌL-ă-TĒR-āl LĪG-ă-mĕnt) (LCL):** A ligament on the outer side of the knee joint connecting the femur to the fibula. ([Chapter 13.4](#))

Lateral malleolus (LĀT-ēr-ăl MĀL-ē-ō-lūs): The bony prominence on the outside of the ankle, formed by the lower end of the fibula. ([Chapter 13.4](#))

Ligaments (LĪG-ă-měnts): Bands of tough, fibrous connective tissue that connect bones to other bones at joints. ([Chapter 13.4](#))

Lordosis (lor-DŌ-sīs): An excessive inward curvature of the spine, often affecting the lower back. It can be caused by obesity, poor posture, or other underlying conditions. ([Chapter 13.6](#))

Lumbar (LŪM-bār): Related to the lower back or the lumbar vertebrae. ([Chapter 13.4](#))

Lupus (lū-pūs): Common name for systemic lupus erythematosus; a chronic autoimmune disease that can affect many parts of the body. ([Chapter 13.6](#))

Mandible (MĀN-dī-bŭl): The lower jawbone. ([Chapter 13.4](#))

Manubrium (mă-NŪ-brē-ŭm): The upper part of the sternum. ([Chapter 13.4](#))

Maxillary (MĀK-sī-lār-ē): Pertaining to the maxilla or the upper jawbone. ([Chapter 13.4](#))

Medial collateral ligament (MĒ-dē-ăl KŌL-ă-TĚR-ăl LĪG-ă-měnt) (MCL): A ligament on the inner side of the knee, connecting the femur to the tibia. ([Chapter 13.4](#))

Medial malleolus (MĒ -dē-ăl MĀL-ē-ō-lūs): The bony prominence on the inside of the ankle, formed by the lower end of the tibia. ([Chapter 13.4](#))

Meniscectomy (měn-ī-SĚK-tō-mē): Surgical removal of all or part of a torn meniscus. ([Chapter 13.4](#))

Meniscitis (men-ī-SĪT-īs): Inflammation of a meniscus, typically in the knee. ([Chapter 13.4](#))

Meniscus (mě-NĪS-kŭs): A C-shaped piece of cartilage in the knee joint that acts as a shock absorber between the femur and tibia. ([Chapter 13.4](#))

Metacarpals (mět-ă-KĀR-pălz): The bones of the hand between the wrist and the fingers. ([Chapter 13.4](#))

Metatarsals (mět-ă-TĀR-sălz): The bones in the midfoot and forefoot. ([Chapter 13.4](#))

Myeloma (mī-ě-LŌ-mă): A type of cancer that originates in the bone marrow. ([Chapter 13.4](#))

Nasal (NĀ-zăl): Pertaining to the nasal bones of the nose. ([Chapter 13.4](#))

Oblique (ō-blēk): Bone is broken at an angle. ([Chapter 13.6](#))

Occipital (ōk-SĪP-ĭ-tāl): Pertaining to the occipital bone at the back and base of the skull. ([Chapter 13.4](#))

Open or compound fracture (ō-pěn ōr kōm-pound): A severe type of bone fracture where the broken bone pierces through the skin, creating an open wound. This type increases the risk of infection. ([Chapter 13.6](#))

Open reduction and internal fixation (ō-pěn rĭ-DŪK-shōn ānd ĭn-tēr-nāl fĭk-SĀ-shōn) (ORIF): A type of surgery used to stabilize and heal a broken bone using screws, plates, wires, or nails to reconnect bones. ([Chapter 13.7](#))

Orthopedics (or-thō-pē-dĭks): A branch of medicine that treats disorders and diseases related to the musculoskeletal system. ([Chapter 13.7](#))

Orthopedists (or-thō-pē-dĭsts): Medical doctors who specialize in the prevention, diagnosis, treatment, and surgery of disorders and diseases related to the musculoskeletal system. ([Chapter 13.7](#))

Osteoarthritis (ōs-tē-ō-ār-THRĪ-tĭs): A degenerative joint disease in which the tissues in the joint break down over several years. It is the most common type of arthritis and frequently occurs as people age. ([Chapter 13.6](#))

Osteoblasts (ōs-tē-ō-BLĀSTS): Cells that form new bone tissue. ([Chapter 13.4](#))

Osteoclasts (ōs-tē-ō-KLĀSTS): Cells that break down and resorb bone tissue. ([Chapter 13.4](#))

Osteocytes (ōs-tē-ō-SĪTS): Mature bone cells that maintain bone tissue. ([Chapter 13.4](#))

Osteomalacia (ōs-tē-ō-mă-LĀ-sē-ă): Softening of bones due to a deficiency of vitamin D or calcium. ([Chapter 13.4](#))

Osteomyelitis (ōs-tē-ō-mĭ-ĕ-LĪT-ĭs): Inflammation of bone and bone marrow, usually caused by infection. ([Chapter 13.4](#), [Chapter 13.6](#))

Osteonecrosis (ōs-tē-ō-nĕ-KRŌ-sĭs): Death of bone tissue due to a lack of blood supply. ([Chapter 13.4](#), [Chapter 13.7](#))

Osteopathy (ōs-tē-ō-pă-thē): A branch of medical practice that emphasizes the treatment of medical disorders through the manipulation and massage of the bones, joints, and muscles. ([Chapter 13.7](#))

Osteopenia (ōs-tē-ō-PĒ-nē-ă): Reduced bone mass of lesser severity than osteoporosis. ([Chapter 13.4](#), [Chapter 13.6](#))

Osteoporosis (ös-tē-ō-pō-RŌ-sīs): A condition where bones become weak and brittle, often due to loss of tissue as a result of hormonal changes or deficiency of calcium or vitamin D. It increases the risk of fractures. ([Chapter 13.4](#), [Chapter 13.6](#))

Osteosarcoma (ös-tē-ō-sär-KŌ-mă): A type of malignant bone tumor. ([Chapter 13.4](#))

Palatine (PĀL-ă-tīn): Related to the palatine bones of the skull, forming parts of the nasal cavity and hard palate. ([Chapter 13.4](#))

Parietal (pă-rī-ĒT-ăl): Pertaining to the parietal bones of the skull, located at the sides and top of the cranium. ([Chapter 13.4](#))

Patella (pă-TĒL-ă): The kneecap, a small bone in front of the knee joint. ([Chapter 13.4](#))

Pelvis (PĒL-vīs): The large bony structure near the base of the spine which includes the two hip bones, the sacrum, and the coccyx to which the legs are attached. ([Chapter 13.4](#))

Phalanges (fă-LĀN-jēz): The bones of the fingers and toes. ([Chapter 13.4](#))

Phalanx (FĀ-lăngks): A single bone of the fingers or toes. ([Chapter 13.4](#))

Posterior cruciate ligament (pös-TĪR-ē-ör KRŪ-shē-āt LĪG-ă-měnt) (PCL): A ligament in the knee that crosses behind the ACL and connects the femur to the tibia. ([Chapter 13.4](#))

Prosthesis (PRŌS-thē-sīs): An artificial body part. ([Chapter 13.7](#))

Pubic symphysis (PYŪ-bīk SĪM-fī-sīs): The joint between the two pubic bones at the front of the pelvis. ([Chapter 13.4](#))

Pubis (PYŪ-bīs): The front part of the pelvic girdle, situated at the anterior part of the pelvis. ([Chapter 13.4](#))

Radiologist (RĀ-dē-ō-jīst): A physician who specializes in diagnosing and treating injuries and diseases using medical imaging (radiology) procedures such as X-rays, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine, positron emission tomography (PET), and ultrasound. ([Chapter 13.7](#))

Radiology technologist (rā-dē-ŌL-ō-jē tēk-nŌL-ō-jīst): Commonly called an X-ray tech, is a health care professional who is specially trained to perform medical imaging like X-rays, CT scans, MRIs, and PET scans. ([Chapter 13.7](#))

Radius (RĀ-dē-ūs): The lateral bone of the forearm, on the same side as the thumb. ([Chapter 13.4](#))

Rheumatoid arthritis (rū-mă-toid är-thrī-tīs) (RA): A chronic autoimmune disease that affects the joints. ([Chapter 13.6](#))

Rheumatologists (rū-mă-tōl-ō-jīsts): Physicians who specialize in the diagnosis and treatment of musculoskeletal diseases and systemic autoimmune conditions commonly referred to as rheumatic diseases. ([Chapter 13.7](#))

Rheumatology (rū-mă-tōl-ō-jē): The study of inflammatory or infectious conditions of the joints and other parts of the musculoskeletal system. ([Chapter 13.7](#))

Rickets (RĪK-īts): A disease in children caused by extreme and prolonged vitamin D deficiency. ([Chapter 13.6](#))

Sacrum (SĀ-krŭm): A triangular bone at the base of the spine, formed by the fusion of sacral vertebrae. ([Chapter 13.4](#))

Scapula (SKĀP-yŭ-lă): The shoulder blade, a large triangular bone on the back of the shoulder. ([Chapter 13.4](#))

Scoliosis (skō-lē-ō-sīs): An abnormal lateral curvature of the spine, often diagnosed in childhood or adolescence. It can vary in severity and may require treatments such as bracing or surgery in more severe cases. ([Chapter 13.6](#))

Sphenoid (SFĒ-noid): Pertaining to the sphenoid bone, a complex bone at the base of the skull. ([Chapter 13.4](#))

Spiral (spī-răl): Bone has twisted apart. ([Chapter 13.6](#))

Spondylosis (spŏn-dī-LŌ-sīs): A painful condition of the spine resulting from the degeneration of intervertebral disks. ([Chapter 13.4](#))

Sternum (STŪR-nŭm): The breastbone, a long flat bone in the center of the chest. ([Chapter 13.4](#))

Stress (strēs): Small crack in a bone. ([Chapter 13.6](#))

Synovectomy (sĭn-ō-VĔK-tō-mē): Surgical removal of the synovial membrane from a joint. ([Chapter 13.4](#))

Synovial fluid (sĭ-NŌ-vē-ăl FLŌŌ-id): A viscous fluid found in the cavities of synovial joints, reducing friction between the articular cartilage during movement. ([Chapter 13.4](#))

Synovial joints (sĭ-NŌ-vē-ăl joints): Highly movable joints where two bones are separated by a joint cavity containing synovial fluid. ([Chapter 13.4](#))

Synovial membrane (sĭ-NŌ-vē-ăl MĚM-brān): The lining of the inner surface of capsules of synovial joints, secreting synovial fluid for lubrication. ([Chapter 13.4](#))

Systemic lupus erythematosus (sĭs-tēm-ĭk lū-pŭs ěr-ĕth-ĕm-ă-tō-sŭs): Commonly referred to as lupus; a chronic autoimmune disease that can affect many parts of the body. ([Chapter 13.6](#))

Tarsals (TĀR-sălz): The bones in the rear part of the foot (the heel and the instep). ([Chapter 13.4](#))

Temporal (TĚM-pō-răl): Related to the temporal bones of the skull, located at the lower sides. ([Chapter 13.4](#))

Temporomandibular joint (tēm-pō-rō-MĀN-dĭ-bŭ-lăr) (TMJ): The hinge joint connecting the temporal bone of the skull with the mandible. ([Chapter 13.4](#))

Tendon (TĚN-dŏn): A fibrous connective tissue that attaches muscle to bone. ([Chapter 13.4](#))

Thoracic (thō-RĀS-ĭk): Pertaining to the thorax or the thoracic vertebrae in the upper back. ([Chapter 13.4](#))

Tibia (TĪB-ē-ă): The shin bone, the larger and stronger of the two bones in the lower leg located on the medial side. ([Chapter 13.4](#))

Total hip arthroplasty (tō-tăl hĭp ār-thrŏ-plăs-tē) (THA): Also called a total hip replacement (THR), the replacement of the head of the femur and acetabulum with replacement parts that are either metal, ceramic, or hard plastic. ([Chapter 13.7](#))

Total hip replacement (tō-tăl hĭp rē-plăs-mĕnt) (THR): Also called a total hip arthroplasty (THA), the replacement of the head of the femur and acetabulum with replacement parts that are either metal, ceramic, or hard plastic. ([Chapter 13.7](#))

Total knee arthroplasty (tō-tăl nē ār-thrŏ-plăs-tē) (TKA): Also called total knee replacement (TKR), surgical removal of worn surfaces of the knee joint due to severe osteoarthritis. ([Chapter 13.7](#))

Total knee replacement (tō-tăl nē rē-plăs-mĕnt) (TKR): Also called total

knee arthroplasty (TKA), surgical removal of worn surfaces of the knee joint due to severe osteoarthritis. ([Chapter 13.7](#))

Transverse (trăns-vûrs): Bone is broken straight across. ([Chapter 13.6](#))

True ribs (TRŌŌ rîbz): The first seven pairs of ribs, which attach directly to the sternum. ([Chapter 13.4](#))

Ulna (ŮL-nă): The medial bone of the forearm, on the same side as the pinky finger. ([Chapter 13.4](#))

Vertebrae (VŮR-tĭ-brā): The individual bones that make up the vertebral column (spine). ([Chapter 13.4](#))

Vertebral column (vŭr-TĒ-brāl KŌL-ŭm): The spinal column or backbone, consisting of multiple vertebrae. ([Chapter 13.4](#))

Vomer (VŌ-měr): A thin, flat bone forming the lower part of the nasal septum. ([Chapter 13.4](#))

Xiphoid process (Zĭ-foïd PRŌ-sēs): The small, cartilaginous projection at the lower end of the sternum. ([Chapter 13.4](#))

X-rays (ěks-rāz): Use a form of radiation that travels through the body and strikes an X-ray detector, forming an image that represents the “shadows” of objects inside the body. ([Chapter 13.7](#))

Zygomatic (zĭ-gō-MĀT-ĭk): Related to the cheekbone or zygomatic bone. ([Chapter 13.4](#))

PART XIV

CHAPTER 14 MUSCULAR SYSTEM TERMINOLOGY

14.1 Muscular System

Introduction

Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the muscular system
- Identify meanings of key word components of the muscular system
- Categorize diagnostic, therapeutic, procedural, or anatomic terms related to the muscular system
- Use terms related to the muscular system
- Use terms related to the diseases and disorders of the muscular system

Introduction to the Muscular System

When most people think of muscles, they think of the muscles that move our arms and legs. These are called skeletal muscles because they move the skeleton. However, there are two additional types of muscles, including smooth muscle and the cardiac muscle. The basic function of all types of muscle is to create movement.

This chapter will review common word components related to the muscular system to assist learners in analyzing, building, and defining medical terms. Other terms, whose definitions cannot be easily built from word components,

will be described in context based on the anatomy and physiology of the muscular system and common diseases and disorders. Medical specialists, diagnostic tests, and procedures related to the muscular system will also be discussed.

View a supplementary YouTube video¹ on muscles:

▶◀ [Muscles, Part 2 – Organismal Level: Crash Course Anatomy & Physiology #22](https://www.youtube.com/watch?v=l80Xx7pA9hQ)

1. CrashCourse. (2015, June 15). *Muscles, Part 2 – Organismal level: Crash Course Anatomy & Physiology #22* [Video]. YouTube. All rights reserved. <https://www.youtube.com/watch?v=l80Xx7pA9hQ>

14.2 Word Components Related To The Muscular System

This section will describe common word components related to the muscular system. These word components help build definitions for many medical terms. Other common prefixes are described in [Chapter 1.3](#), and common suffixes are described in [Chapter 1.5](#).

PREFIXES RELATED TO THE MUSCULAR SYSTEM

- **a-**: Absence of, without
- **ab-**: Away from
- **ad-**: Towards
- **brady-**: Slow
- **dys-**: Painful, difficult, abnormal, labored
- **hyper-**: Above, excessive
- **inter-**: Between
- **intra-**: Within, in
- **poly-**: Many, much
- **sub-**: Below, under
- **supra-**: Above
- **sym-**: Together, joined
- **syn-**: Together, joined

WORD ROOTS WITH A COMBINING VOWEL RELATED TO THE MUSCULAR SYSTEM

- **ankyl/o**: Stiff or bent
- **electr/o**: Electricity; electrical activity
- **fasci/o**: Fascia
- **fibr/o**: Fibrous connective tissue
- **kinesi/o**: Movement, motion
- **kyph/o**: Hump
- **lamin/o**: Lamina (thin, flat plate or layer)
- **leimy/o**: Smooth (visceral) muscle that lines the walls of internal organs
- **my/o**: Muscle
- **myel/o**: Spinal cord, bone marrow
- **myos/o**: Muscle
- **myocardi/o**: Heart muscle
- **plant/o**: Sole of the foot
- **rhabd/o**: Rod-shaped, striated
- **sarc/o**: Flesh, connective tissue
- **ten/o**: Tendon
- **tend/o**: Tendon
- **tendin/o**: Tendon

SUFFIXES RELATED TO THE MUSCULAR SYSTEM

- **-ad**: Toward
- **-al**: Pertaining to
- **-algia**: Pain

- **-ar**: Pertaining to
- **-asthenia**: Weakness
- **-centesis**: Surgical puncture to aspirate fluid
- **-desis**: Surgical fixation, fusion
- **-ectomy**: Excision, surgical removal, cutting out
- **-gram**: The record, radiographic image
- **-graphy**: Process of recording, radiographic imaging
- **-ic**: Pertaining to
- **-itis**: Inflammation
- **-lysis**: Loosening, separating, dissolution
- **-oid**: Resembling
- **-oma**: Tumor
- **-osis**: Abnormal condition
- **-penia**: Abnormal reduction
- **-physis**: Growth
- **-plasty**: Surgical repair
- **-rrhaphy**: Suturing, repairing
- **-sarcoma**: Malignant tumor
- **-schisis**: Split, fissure
- **-scopy**: Process of viewing, visual examination
- **-tome**: Instrument used to cut
- **-tomy**: Incision, cut into
- **-trophy**: Nourishment, development

14.3 Examples of Muscular Terms Easily Defined By Their Word Components

Here are examples of common medical terms related to the muscular system that can be easily defined by breaking the terms into their word components.

Bradykinesia

1. Break down the medical term into word components:
Brady/kines/ia
2. Label the word components: **Brady** = P; **kines** = WR; **ia** = S
3. Define the word components: **Brady** = slow; **kines** = movement; **ia** = condition of
4. Create a final definition of the medical term:
The condition of slow movement

Fibromyalgia

1. Break down the medical term into word components:
Fibr/o/my/algia
2. Label the word components: **Fibr** = WR; **o** = CV; **my** = WR; **algia** = S
3. Define the word components: **Fibr** = fibrous connective

tissue; **my** = muscle; **algia** = pain

4. Create a final definition of the medical term: **Pain in the fibrous connective tissue of muscles**

Rhabdomyolysis

1. Break down the medical term into word components:
Rhabd/o/my/o/lysis
2. Label the word components: **Rhabd** = WR; **o** = CV; **my** = WR; **o** = CV; **lysis** = S
3. Define the word components: **Rhabd** = striated (skeletal); **my** = muscle; **lysis** = dissolution
4. Create a final definition of the medical term: **Dissolution of striated skeletal muscle**



Interactive Learning Activity: Practice defining and pronouncing medical terms related to the muscular system by breaking them down into word parts.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=4833#h5p-76>

- ▶ You can also print these flashcard activities as a [Chapter 14](#)

▶ [Student Companion Worksheet](#) and check your answers with this [Answer Key](#).

14.4 Anatomy of the Muscular System

There are three major types of muscle tissue categorized as smooth, cardiac, and skeletal muscle. See Figure 14.1¹ for an illustration of these three types of muscle. Cardiac and skeletal muscles are **striated** (STRĪ-ā-těd), meaning they contain functional units called sarcomeres. Sarcomeres are composed of two protein filaments called **actin** (ĀK-tin)² and **myosin** (MĪ-ō-sin) that are responsible for muscular contraction.

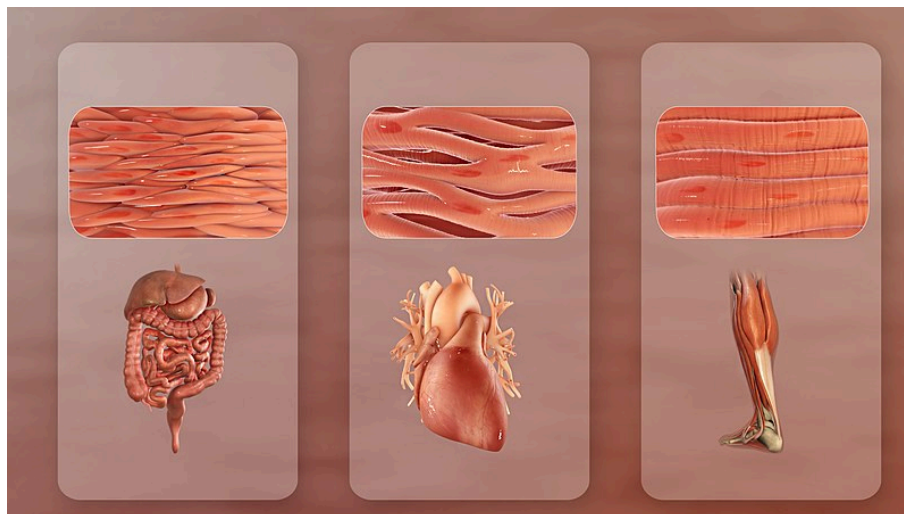


Figure 14.1 Muscle Types a) Smooth Muscle b) Cardiac Muscle c) Skeletal Muscle

1. “Types_Of_Muscle.jpg” by www.scientificanimations.com is licensed under [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)
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SMOOTH MUSCLE

Smooth muscle (SMŎŎTH MŬS-ăl) is responsible for involuntary muscle movement. Smooth muscle is present in the following areas³:

- Walls of hollow organs, like the urinary bladder, uterus, stomach, and intestines, where muscle contractions cause the movement of fluids and other substances
- Walls of passageways, such as the arteries and veins of the circulatory system, where it causes vasodilation and vasoconstriction
- Tracts of the respiratory, urinary, and reproductive systems, where contraction and relaxation affect the movement of air, urine, and reproductive fluids
- Eyes, where it functions to change the size of the pupil
- Skin, where it causes hair to stand erect in response to cold temperature or fear, commonly called goose bumps

CARDIAC MUSCLE

Cardiac muscle (KÄR-dē-ăk MŬS-ăl) is only found in the heart. Highly coordinated contractions of cardiac muscle pump blood throughout the circulatory system. Cardiac muscle fiber cells are extensively branched and connected to one another at their ends to allow the heart to contract in a wavelike pattern and work as a pump.⁴

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SKELETAL MUSCLE

Skeletal muscles (SKĚL-ě-tăl MŮS-ălz) are located throughout the body. They are under voluntary control and primarily produce movement of the arms, legs, back, and neck and maintain posture by resisting gravity. Small, constant adjustments of the skeletal muscles are needed to hold the body upright or balanced in any position.⁵

Skeletal muscles also have several additional functions. Ring-shaped skeletal muscles called sphincters are located throughout the body at the openings of internal tracts to control the movement of substances. These skeletal muscles allow voluntary control of functions such as swallowing, defecation, and urination in the digestive and urinary systems.⁶

Skeletal muscles, such as the rectus abdominus, protect internal organs (particularly abdominal and pelvic organs) by acting as an external barrier against trauma and supporting the weight of the organs.⁷

Skeletal muscles also contribute to maintaining homeostasis by generating heat. This heat generation is very noticeable during exercise, when sustained muscle movement causes a person's body temperature to rise, or conversely

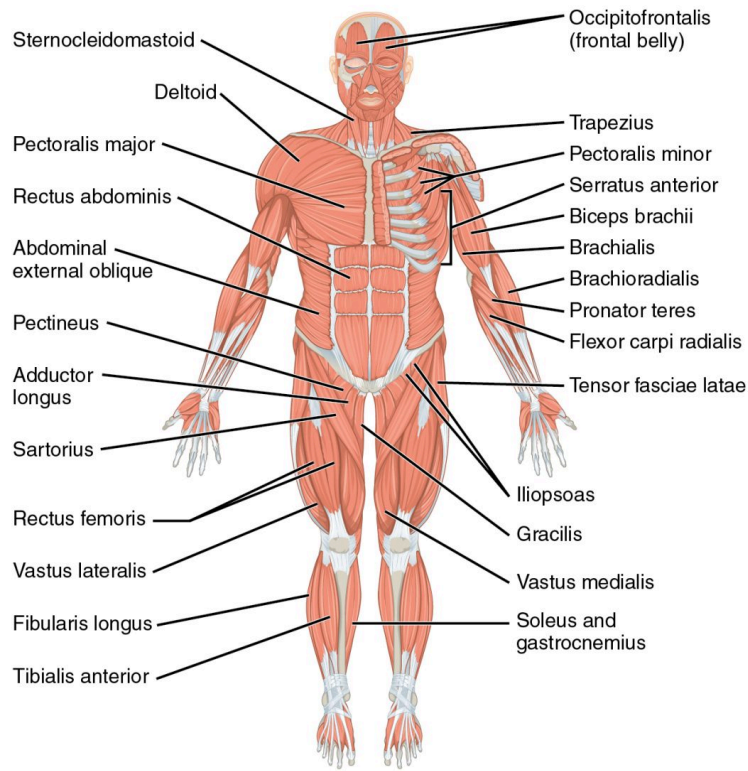
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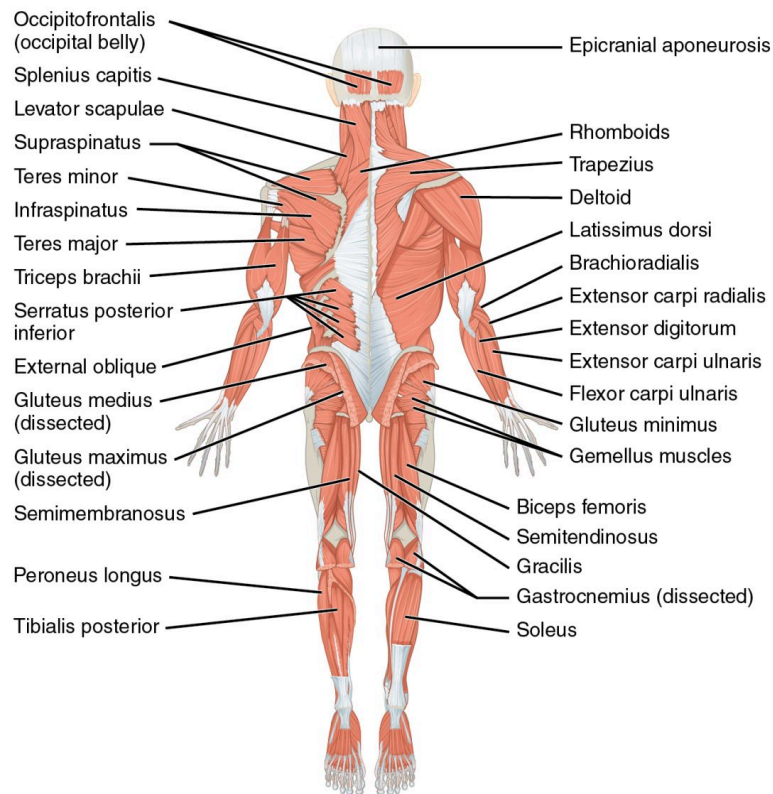
during cold environmental temperatures when shivering produces random skeletal muscle contractions to generate heat.⁸

See Figure 14.2⁹ for an illustration of the major skeletal muscles of the body. For the anterior and posterior views in this figure, superficial muscles are shown on the right side of the body, and deep muscles are shown on the left side of the body. For the legs, superficial muscles are shown in the anterior view while the posterior view shows both superficial and deep muscles.¹⁰

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9. "[1105_Anterior_and_Posterior_Views_of_Muscles.jpg](#)" by OpenStax is licensed under [CC BY 4.0](#)
10. This work is a derivative of [Anatomy and Physiology](#) by [OpenStax](#) licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>



Major muscles of the body.
Right side: superficial; left side:
deep (anterior view)



Major muscles of the body.
Right side: superficial; left side:
deep (posterior view)

Figure 14.2 Muscular System

Muscles are named based on various characteristics, such as the following¹¹:

- **Body location:** The area of the body, for example, biceps, triceps, and quadriceps
- **Size:** The size of the muscle, such as maximus (largest) and minimus (smallest)
- **Shape:** The shape of the muscle, such as deltoid (triangular) or trapezius (trapezoid)
- **Action:** The action of the muscle, such as flexor (i.e., to flex) or adductor (i.e., towards midline of body)
- **Fiber direction:** The direction of the muscle fibers (such as external oblique)

Major Skeletal Muscles

Major skeletal muscles include the following¹²:

- **Biceps brachii** (BĪ-sěps bră-ki): Muscle on the anterior upper arm.
- **Biceps brachialis** (bră-kē-ĀL-īs): Muscle located in the upper and lower arm that flexes the elbow joint and rotates the forearm.
- **Deltoid** (DĒL-toid): A large triangular muscle covering the shoulder joint.
- **Gastrocnemius** (găs-trök-NĒ-mē-ūs): The chief muscle of the calf of the

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12. This work is a derivative of [Anatomy and Physiology](#) by [OpenStax](#) licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

leg.

- **Gluteus maximus** (glŪ-tē-ŭs MÄK-sĭ-mŭs): The largest and outermost of the three gluteal muscles in the buttocks.
- **Latissimus dorsi** (lă-tĭs-ĭ-mŭs DŌR-sĭ): A large muscle in the back.
- **Pectoralis major** (pĕk-tŏr-ÄL-ĭs MÄ-jŏr): A thick, fan-shaped muscle situated on the chest.
- **Quadriceps** (kwŎD-rĭ-sĕps): A large muscle group on the front of the thigh.
- **Rectus abdominis** (RĚK-tŭs äb-DŎM-ĭ-nĭs): A paired muscle running vertically on each side of the anterior wall of the abdomen.
- **Triceps brachii** (TRĭ-sĕps bră-ki): Muscle on the posterior of the upper arm.

TENDONS

Muscles attach to bones via **tendons** (TĚN-dŏnz). A tendon is a flexible but inelastic cord of strong fibrous collagen tissue. For example, consider the Achilles tendon, hamstring, and rotator cuff. The **Achilles tendon** (ə-KĭL-ēz TĚN-dŏn) attaches the calf muscles to the heel bone. The **hamstring** (HÄM-strĭng) tendons refer to five tendons at the back of a person's knee that connect a group of three hamstring muscles to bones in the pelvis, knee, and lower leg. The **rotator cuff** (rŏ-TÄ-tŏr KŬF) is a group of muscles and tendons that stabilize the shoulder.¹³ See Figure 14.3¹⁴ for an illustration of the tendon that attaches the quadriceps muscle to the top of the patella.

13. This work is a derivative of [Anatomy and Physiology](#) by [OpenStax](#) licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

14. "[Quadriceps tendon.svg](#)" by InjuryMap is licensed under [CC BY-SA 4.0](#)

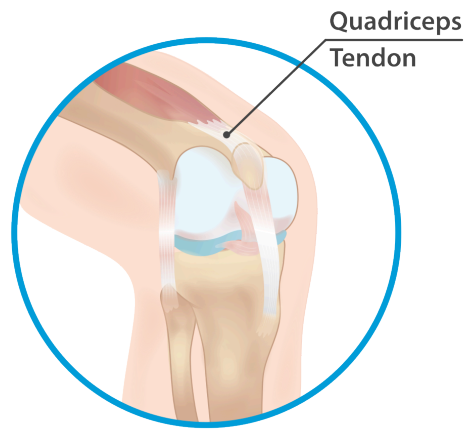


Figure 14.3 Tendon

14.5 Physiology of the Muscular System

The main function of the muscular system is movement. Muscles work as antagonistic (opposing) pairs. As one muscle contracts, another muscle relaxes. This contraction pulls on the bones and assists with movement. Contraction is the shortening of muscle fibers whereas relaxation is the lengthening of fibers. This sequence of relaxation and contraction is stimulated by the nervous system.¹

There are many types of actions that are caused by the contraction and relaxation of muscles, such as flexion, extension, abduction, adduction, rotation, dorsiflexion, plantar flexion, supination, and pronation. These muscle actions are summarized in Table 14.5. See Figures 14.4² and 14.5³ for illustrations of these movements.

Table 14.5 Muscle Actions

1. This work is a derivative of [Anatomy and Physiology](#) by [OpenStax](#) licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>
2. "[Body_Movements_I.jpg](#)" by Tonye Ogele CNX is licensed under [CC BY-SA 3.0](#)
3. "[Body_Movements_II.jpg](#)" by Tonye Ogele CNX is licensed under [CC BY-SA 3.0](#)

Action	Description
Flexion (FLĚK-shŏn)	Movement that decreases the angle between two bones, such as bending the arm at the elbow.
Extension (ěk-STĚN-shŏn)	Movement that increases the angle between two bones, such as straightening the arm at the elbow.
Abduction (ăb-DŮK-shŏn)	Movement of a limb away from the midline of the body.
Adduction (ă-DŮK-shŏn)	Movement of a limb toward the midline of the body.
Rotation (rō-TĀ-shŏn)	Circular movement around a central point. Internal rotation is toward the center of the body, and external rotation is away from the center of the body.
Dorsiflexion (dôr-sĭ-FLĚK-shŏn)	Decreasing the angle of the foot and the leg (i.e., the foot moves upward toward the knee). This movement is the opposite of plantar flexion.
Plantar Flexion (PLĀN-tăR FLĚK-shŏn)	Increasing the angle of the foot and leg (i.e., the foot moves downward toward the ground, such as when pressing down on a gas pedal in a car).
Supination (sū-pi- NĀ-shŭn)	Movement of the hand or foot turning upward. When applied to the hand, it is the act of turning the palm upwards. When applied to the foot, it is the outward roll of the foot/ankle during normal movement.
Pronation (prō-NĀ-shŭn)	Movement of the hand or foot turning downward. When applied to the hand, it is the act of turning the palm downward. When applied to the foot, it is the inward roll of the foot/ankle during normal movement.
Eversion (ē-VĚR-zhŭn)	Excessive movement involving turning outward the sole of the foot away from the body's midline, a common cause of an ankle sprain.
Inversion (in-VĚR-zhŭn)	Excessive movement involving turning inward the sole of the foot towards the median plane, a common cause of an ankle sprain.

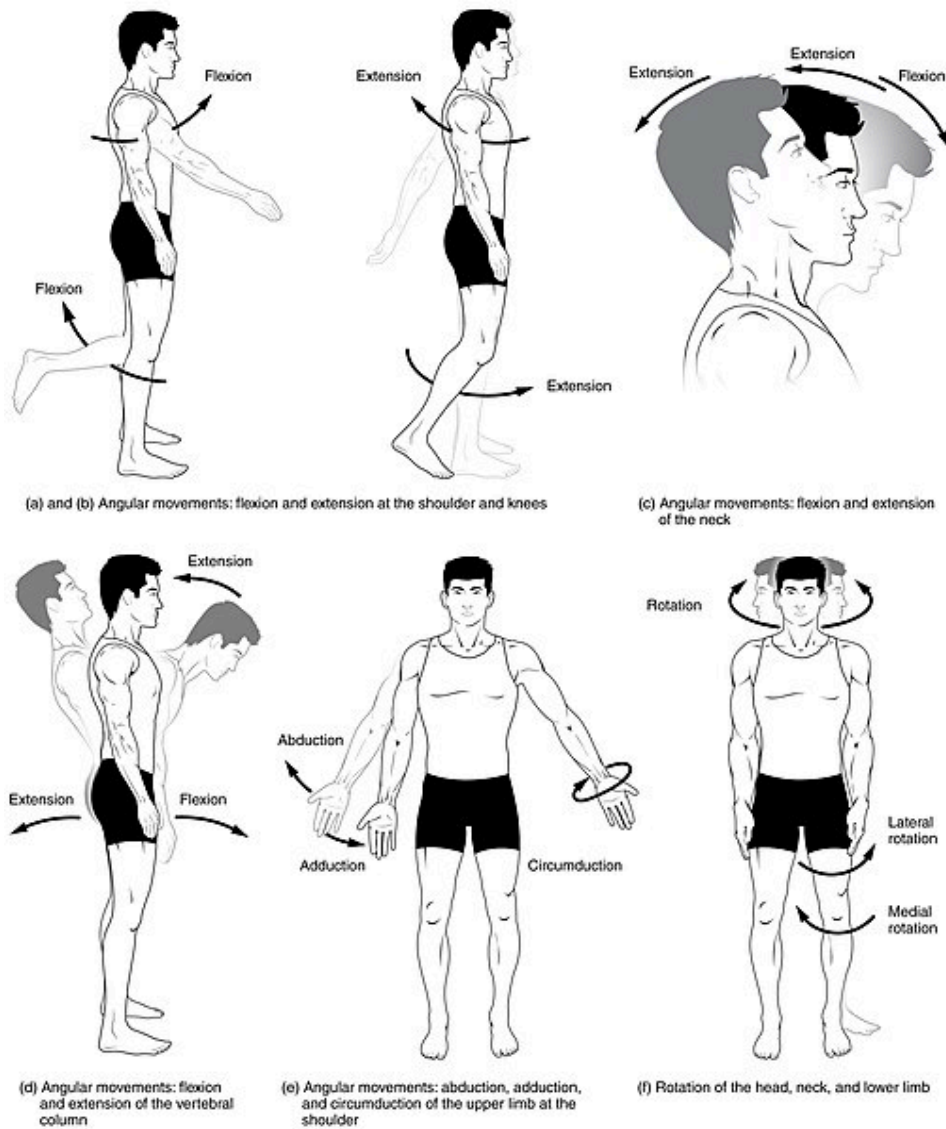


Figure 14.4 Flexion, Extension, Adduction, Abduction, Circumduction, and Rotation

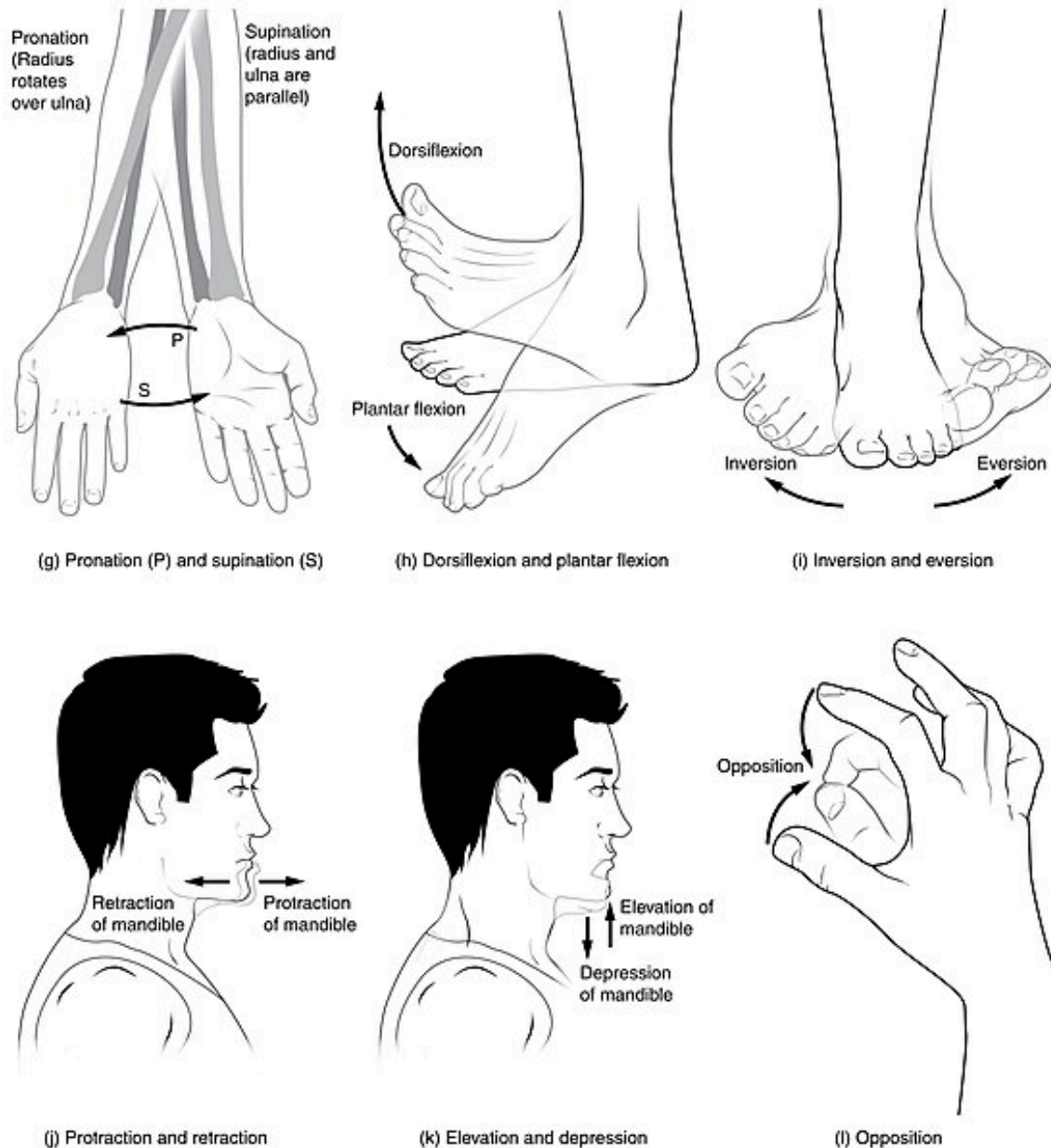


Figure 14.5 Pronation, Supination, Dorsiflexion, Plantar Flexion, Inversion, Eversion, Protraction, Retraction, Elevation, Depression, and Opposition



View a supplementary YouTube video⁴ demonstrating flexion and extension:



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/medterm/?p=420#oembed-1>



View a supplementary YouTube video⁵ demonstrating abduction and adduction:



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/medterm/?p=420#oembed-2>

4. RegisteredNurseRN. (2021, March 3). *Flexion and extension anatomy: Shoulder, hip, forearm, neck, leg, thumb, wrist, spine, finger* [Video]. YouTube. All rights reserved. Reused with permission.
<https://www.youtube.com/watch?v=p4xbehGmkmk>
5. RegisteredNurseRN. (2021, March 29). *Abduction and adduction of wrist, thigh, fingers, thumb, arm | Anatomy body movement terms* [Video]. YouTube. All rights reserved. Reused with permission.
<https://www.youtube.com/watch?v=qcxE9uql8g4>



View a supplementary YouTube video⁶ demonstrating eversion and inversion of the foot:



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/medterm/?p=420#oembed-3>



View a supplementary YouTube video⁷ demonstrating plantar flexion and dorsiflexion of the foot:



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/medterm/?p=420#oembed-4>

6. RegisteredNurseRN. (2021, January 11). *Inversion and eversion of the foot, ankle | Body movement terms anatomy* [Video]. YouTube. All rights reserved. Reused with permission. <https://www.youtube.com/watch?v=4HuxLWQykxk>
7. RegisteredNurseRN. (2020, December 29). *Dorsiflexion and plantar flexion of the foot | Anatomy body movement terms* [Video]. YouTube. All rights reserved. Reused with permission. <https://www.youtube.com/watch?v=e6WugOzgFIM>



View a supplementary YouTube video⁸ by Dr. Mike that summarizes joint movements: [Joint Movements](#)

Other terms related to the muscular system include the following:

- **Bradykinesia** (brăd-ē-kĭ-NĒ-sē-ă): Slow movement
- **Dyskinesia** (DIS-kĭ-NĒ-sē-ă): Difficult movement
- **Dystrophy** (DIS-trŏ-fē): Abnormal development
- **Hyperkinesia** (hī-pĕr-kĭ-NĒ-zh(ē-)ă): Excessive movement
- **Hypertrophy** (hī-PĔR-trŏ-fē): Excessive development
- **Myalgia** (mī-AL-j(ē-)ă): Painful muscles
- **Myasthenia** (mī-ăs-THĒ-nē-ă): Muscle weakness
- **Polymyositis** (pol-ē-mī-ŏ-SĪ-tĭs): Inflammation of many muscles

8. Dr Matt & Dr Mike. (2021, February 7). *Joint movements* [Video]. YouTube. All rights reserved. <https://www.youtube.com/watch?v=tAJjXvumL7E>

14.6 Diseases and Disorders of the Muscular System

This section will provide an overview of common diseases and disorders of the muscular system.

CEREBRAL PALSY

Cerebral palsy (sĕr-Ē-brăĭ pŏl-zē) (**CP**) is a group of disorders that affects the ability to move and maintain balance and posture. CP is the most common motor disability in childhood. “Cerebral” means having to do with the brain, and “palsy” means weakness or problems with using the muscles. CP is caused by abnormal brain development or damage to the developing brain that affects the ability to control muscles.¹

The symptoms of CP vary from person to person. A person with severe CP might require the use of special equipment to walk or might not be able to walk at all and need lifelong care. A person with mild CP, on the other hand, might walk a little awkwardly, but otherwise not require specialized care. Doctors classify CP according to the main type of movement disorder involved. Depending on which areas of the brain are affected, one or more of the following movement disorders can occur:²

1. Centers for Disease Control and Prevention. (2023, October 6). *What is cerebral palsy?* <https://www.cdc.gov/ncbddd/cp/facts.html>
2. Centers for Disease Control and Prevention. (2023, October 6). *What is cerebral palsy?* <https://www.cdc.gov/ncbddd/cp/facts.html>

- **Spasticity** (spās-TĪS-ĭ-tē): Stiff muscles
- **Dyskinesia** (dĭs-kĭ-NĒ-zē-ă): Uncontrollable movements
- **Ataxia** (ă-TĀK-sē-ă): Poor balance and coordination

There is no cure for CP, but treatment can improve the quality of life for people who have the condition. After CP is diagnosed, a team of health professionals works with the child and family to develop a plan to help the child reach their optimal potential. Common treatments include medications; surgery; braces; and physical, occupational, and speech therapy.³

See Figure 14.6⁴ for an image of David Smith who has cerebral palsy and has won several Paralympian awards. Paralympians are athletes with a range of impairments who compete in the Paralympics, a competition similar to the Olympics. Paralympic athletes inspire people around the world with their performance and focus on moving forward and never giving up.⁵

3. Centers for Disease Control and Prevention. (2023, October 6). *What is cerebral palsy?* <https://www.cdc.gov/ncbddd/cp/facts.html>

4. “[David Smith and his Boccia medals \(cropped\).jpg](#)” by [Richard Gillin](#) from St Albans, UK is licensed under [CC BY-SA 2.0](#)

5. International Paralympic Committee. (n.d.). *FAQ*. <https://www.paralympic.org/frequently-asked-questions>



Figure 14.6 David Smith, a Paralympian With Cerebral Palsy

CONTRACTURE

A **contracture** (kŏn-TRÄK-chŭr) is a condition of shortening and hardening of muscles, tendons, or other tissue, often leading to deformity and rigidity of joints. Contractures are caused by immobility and can be the result of several disorders such as a stroke, cerebral palsy, or muscular dystrophy. Contractures may be prevented and/or treated with braces, physical therapy, and range-of-motion exercises. See Figure 14.7⁶ for an image of a hand contracture.

6. “[Freeman-Sheldon_syndrome.JPG](#)” by [MI Poling](#) at [English Wikipedia](#) is licensed under [CC BY-SA 2.5](#)



Figure 14.7 Hand Contracture

FIBROMYALGIA

Fibromyalgia (fī-brō-mī-AL-jē-ă) is defined as pain in muscle fibers. It is a condition that causes widespread pain, sleep problems, fatigue, and often emotional distress. Fibromyalgia affects about 2% of the adult population in the United States. The cause of fibromyalgia is not known, but it can be effectively treated and managed. Fibromyalgia is diagnosed by health care providers based on the patient's history, physical examination, X-rays, and blood work.⁷

Fibromyalgia is treated by a doctor or team of health care professionals who specialize in the treatment of fibromyalgia. A combination of treatments is typically prescribed, which may include the following⁸:

7. Centers for Disease Control and Prevention. (2020, January 6). *Fibromyalgia*. <https://www.cdc.gov/arthritis/basics/fibromyalgia.htm>

8. Centers for Disease Control and Prevention. (2020, January 6). *Fibromyalgia*. <https://www.cdc.gov/arthritis/basics/fibromyalgia.htm>

- Medications, including prescription drugs and over-the-counter pain relievers
- Aerobic exercise and muscle strengthening exercise
- Patient education classes
- Stress management techniques such as meditation, yoga, and massage
- Good sleep habits to improve the quality of sleep
- Cognitive behavioral therapy, a type of talk therapy that helps people change the way they think about their life circumstances

MUSCULAR DYSTROPHY

Muscular dystrophy (mŭs'kyŭ-lăř DĪS-trŏ-fē) (**MD**) refers to group of diseases caused by abnormal muscle development due to gene mutations. Muscular dystrophy can run in families, or a person can be the first in their family to have muscular dystrophy. Over time, muscle weakness decreases mobility and makes it difficult to perform everyday tasks. There are many types of muscular dystrophy, each affecting specific muscle groups. Each type has signs and symptoms that appear at different ages and vary in severity.⁹

An example of one type of MD is Duchenne muscular dystrophy (DMD), a genetic disorder characterized by progressive muscle degeneration and weakness due to the alterations of a muscle protein called dystrophin. DMD symptom onset is in early childhood, usually between the ages 2 and 3. The disease primarily affects boys. Muscle weakness is the principal symptom of DMD and begins by first affecting the proximal muscles (those closest to the core of the body) and later affecting the distal limb muscles. The child with DMD might have difficulty jumping, running, and walking. Other symptoms

9. Centers for Disease Control and Prevention. (2022, November 21). *What is muscular dystrophy?* <https://www.cdc.gov/ncbddd/musculardystrophy/facts.html>

include enlargement of the calves, a waddling gait, and lumbar lordosis (an inward curve of the spine). The heart and respiratory muscles are affected as well. Progressive weakness and scoliosis result in impaired pulmonary function, which can eventually cause acute respiratory failure. Treatment of DMD requires multidisciplinary care to coordinate specialized assessments and interventions needed to maximize function and quality of life. Due to recent advances in cardiology and pulmonology, people with DMD are living longer than ever and often well into adulthood.¹⁰

The impact of DMD can be significantly minimized by keeping the body as flexible, upright, and mobile as possible. As muscle deteriorates, a person with muscular dystrophy often develops contractures. If not treated, contractures can become severe, causing discomfort and restricting mobility and flexibility. Contractures can affect the knees, hips, feet, elbows, wrists, and fingers. However, there are many ways to minimize and postpone contractures. Range-of-motion exercises, performed on a regular schedule, help delay contractures by keeping tendons from shortening prematurely. Braces on the lower legs also can help keep the limbs stretched and flexible, delaying the onset of contractures. Eventually, a wheelchair is needed, typically by about age 12. Although a child and parents may dread using a wheelchair, many people find that when they start to use one, they are more mobile, energetic, and independent than when trying to walk without assistance.¹¹ See Figure 14.8¹² for an image of child with MD using a specialized wheelchair called an “Easy Stand” that supports him while sitting and also allows him to stand for periods of time.

¹⁰. Muscular Dystrophy Association. (n.d.). *Duchenne muscular dystrophy*. <https://www.mda.org/disease/duchenne-muscular-dystrophy>

¹¹. Muscular Dystrophy Association. (n.d.). *Duchenne muscular dystrophy*. <https://www.mda.org/disease/duchenne-muscular-dystrophy>

¹². “3576255511_4c36222845_b.jpg” by EasyStand is licensed under [CC BY-NC-ND 2.0](#)



Figure 14.8 Child With MD in an EasyStand Wheelchair

MYASTHENIA GRAVIS

Myasthenia gravis (mī-ās-THĒ-nē-ă GRĂ-vīs) (**MG**) is a chronic, autoimmune neuromuscular disease that causes weakness in voluntary muscles, including those required for breathing and swallowing. Onset of symptoms can be rapid and include the following¹³:

- **Myasthenia** (mī-ās-THĒ-nē-ă): Abnormal weakness of voluntary muscles
- **Ocular myasthenia** (Ō-kyŭ-lăr mī-ās-THĒ-nē-ă): Weakness of the eye muscles
- **Ptosis** (TŌ-sīs): Drooping of one or both eyelids (See Figure 14.9¹⁴ for an image of ptosis.)

13. National Institute of Neurological Disorders and Stroke. (2023, November). *Myasthenia gravis*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/myasthenia-gravis>

- **Diplopia** (dĭ-PLŌ-pē-ă): Blurred or double vision
- **Dysphagia** (dĭs-FĀ-jē-ă): Difficulty swallowing
- **Dyspnea** (dĭsp-NĒ-ă): Shortness of breath
- **Dysarthria** (dĭs-ĀR-thrē-ă): Impaired speech



Figure 14.9 Ptosis Related to Myasthenia Gravis

Sometimes the muscles that control breathing weaken to the point where a person needs a ventilator to breathe. This is called a myasthenic crisis and requires immediate emergency medical care. A myasthenic crisis may be triggered by infection, stress, surgery, or an adverse reaction to medication.¹⁵

MG is diagnosed by health care providers based on a physical exam, blood tests, and electromyography (EMG). Read more about EMG in the “[Medical Specialists, Diagnostic Testing, and Procedures Related to the Muscular System](#)” section. MG is treated with medications that improve neuromuscular transmission and increase muscle strength. Immunosuppressive medications may be prescribed to impact the autoimmune response. In some cases, a

14. “[Ptosis_myasthenia_gravis.jpg](#)” by Mohankumar Kurukumbi, Roger L Weir, Janaki Kalyanam, Mansoor Nasim, Annapurni Jayam-Trouth is licensed under [CC BY 2.0](#)

15. National Institute of Neurological Disorders and Stroke. (2023, November). *Myasthenia gravis*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/myasthenia-gravis>

thymectomy (i.e., removal of the thymus) may be performed to rebalance the immune system and decrease MG symptoms.¹⁶

PARALYSIS

Paralysis (păr-ă-LĪ-sīs) occurs when an injury or medical condition disrupts the nerve signals to the muscles, resulting in being unable to make voluntary movements. Common causes of paralysis include spinal cord injuries and strokes. Paralysis can be localized, where it affects specific areas of the body, such as the face. For example, Bell's palsy temporarily paralyzes facial muscles. Paralysis can also be generalized where it affects a larger area of the body. There are categories of generalized paralysis based on its extent. Common categories include hemiplegia, paraplegia, and quadriplegia/¹⁷tetraplegia

- **Hemiplegia** (hēm-ē-PLĒ-jē-ă): Paralysis affects one side of the body, for example, an arm and a leg on the same side.
- **Paraplegia** (păr-ă-PLĒ-jē-ă): Paralysis affects both legs and sometimes the torso.
- **Quadriplegia or Tetraplegia** (kwöd-rĭ-PLĒ-jē-ă or tět-ră-PLĒ-jē-ă): Paralysis involves all limbs, with little or no movement from the neck down.

¹⁶. National Institute of Neurological Disorders and Stroke. (2023, November). *Myasthenia gravis*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/myasthenia-gravis>

¹⁷. Cleveland Clinic. (2021, June 10). *Paralysis*. <https://my.clevelandclinic.org/health/diseases/15345-paralysis>

See Figure 14.10¹⁸ for an illustration of paraplegia, hemiplegia, and tetraplegia (quadriplegia), where pink indicates the area of muscle paralysis. Because muscle paralysis is caused by disruption of nerve signals, the cervical (C), thoracic (T), and lumbar (L) nerves are labelled in the image.

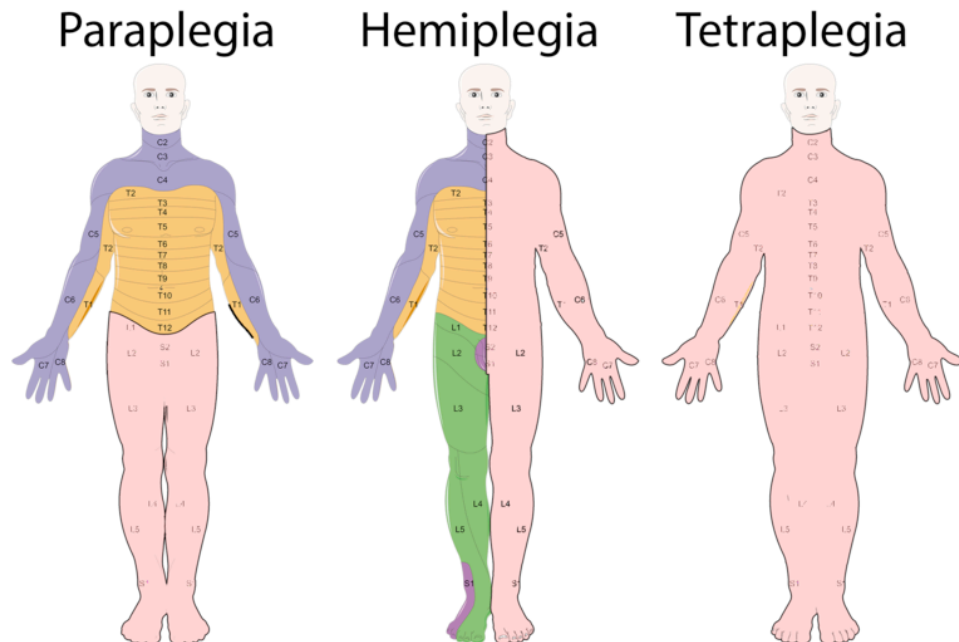


Figure 14.10 Paraplegia, Hemiplegia, and Tetraplegia (Quadriplegia)

Paralysis is also classified by its effect on muscles in terms of being flaccid or spastic¹⁹:

- **Flaccid** (FLĂS-ĭd): The muscles **atrophy** (ĂT-rŏ-fē) (i.e., shrink) due to loss of function.

18. “[Neurological Levels %26 Types of Paralysis.png](#)” by Servier Medical Art is licensed under [CC BY 2.0](#)

19. Cleveland Clinic. (2021, June 10). *Paralysis*. <https://my.clevelandclinic.org/health/diseases/15345-paralysis>

- **Spastic** (spās-TĪK): The muscles tighten, causing uncontrollable jerks and spasms.

There is no cure for permanent paralysis caused by spinal nerve damage because the spinal cord can't heal itself. However, rehabilitative services like physical and occupational therapy can help people with paralysis live independently and enjoy quality of life. Equipment used for rehabilitative/restorative care may include the following²⁰:

- **Adaptive equipment** (ă-DĂP-tiv ĭ-KWĪP-měnt): Equipment that allows people to feed themselves or drive.
- **Assistive equipment** (ă-SĪS-tiv ĭ-KWĪP-měnt): Equipment that enhances mobility, such as wheelchairs, scooters, crutches, and canes.
- **Orthotic/prosthetic devices** (ör-THÖT-ĭk/prös-THĚT-ĭk dĭ-VĪS-ěz): Devices that support the limbs and prevent contractures, such as braces.
- **Voice-activated technology** (vois-ăk-TĪV-ā-těd tĕk-NÖL-ö-jē): Technology that doesn't require the need for touch or movement, such as computers, lighting systems, and phones.

See Figure 14.11²¹ for an image of Mark Manion, founder of “Mark Speaks Out.” Mark was permanently disabled during a cross-country biking trip when he was struck by a drunk driver. He travels the country educating and inspiring audiences on how he has effectively coped with his life circumstances.

20. Cleveland Clinic. (2021, June 10). *Paralysis*. <https://my.clevelandclinic.org/health/diseases/15345-paralysis>

21. “[USMC-100519-M-3215R-002.jpg](#)” by unknown author for [United States Marine Corps](#) is licensed in the [Public Domain](#)



Figure 14.11 Mark Manion

RHABDOMYOLYSIS

Rhabdomyolysis (rab-dō-mī-OL-ĭ-sĭs) refers to the breakdown of muscles that causes damage to the kidney. When muscle is damaged, a protein called **myoglobin** (mī-Ō-glō-bĭn) is released into the bloodstream and is filtered out

of the body by the kidneys. Myoglobin breaks down into substances that damage kidney cells.²² See Figure 14.12²³ for an illustration of rhabdomyolysis.

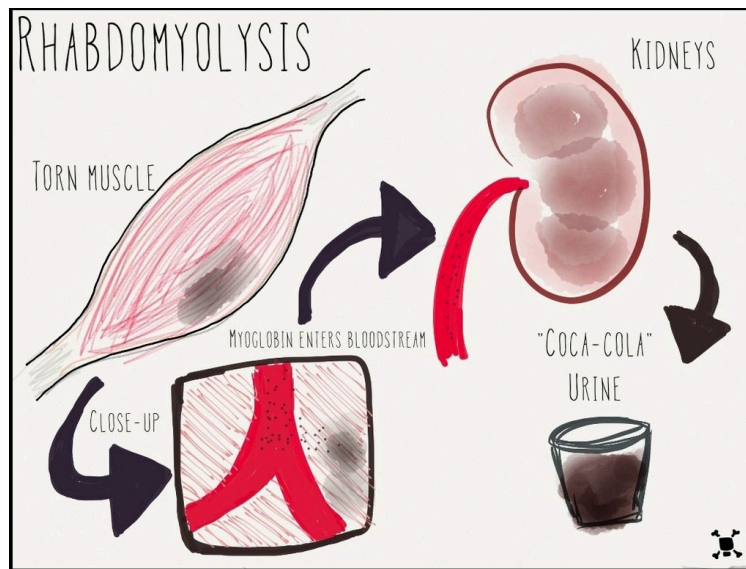


Figure 14.12 Rhabdomyolysis

Rhabdomyolysis may be caused by injury or any other condition that damages skeletal muscle. Potential causes of rhabdomyolysis include the following conditions²⁴:

- Trauma or crush injuries
- Use of drugs such as cocaine, amphetamines, statins, heroin, or

22. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Rhabdomyolysis; [reviewed 2021, Jul 27; cited 2023, Nov 28]. <https://medlineplus.gov/ency/article/000473.htm>

23. "Rhabdo.jpg" by AquapatMedia is licensed under [CC BY-SA 3.0](#)

24. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Rhabdomyolysis; [reviewed 2021, Jul 27; cited 2023, Nov 28]. <https://medlineplus.gov/ency/article/000473.htm>

phencyclidine (PCP)

- Genetic muscle diseases
- Extremes of body temperature
- Ischemia or death of muscle tissue
- Low phosphate levels
- Seizures or muscle tremors
- Severe exertion, such as marathon running or calisthenics
- Lengthy surgical procedures
- Severe dehydration

Symptoms of rhabdomyolysis include dark, red, or cola-colored urine; decreased urine output; weakness; and **myalgia** (mī-AL-jē-ă) (i.e., muscle pain). Rhabdomyolysis is diagnosed with blood tests, including creatine kinase (CK), myoglobin, and creatinine, as well as urine tests such as urinalysis and urine myoglobin. Rhabdomyolysis is treated with intravenous fluids that contain bicarbonate. In cases causing severe kidney damage, dialysis may be required.²⁵

STRAIN

A **strain** (strān) is an injury to a muscle or tendon from being overstretched or torn, causing pain. Strains can be caused by an injury, overusing a muscle, or using a muscle in the wrong way (such as twisting the back while lifting a heavy object). A strain is different from a **sprain** (sprān), which is an injury to a

25. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Rhabdomyolysis; [reviewed 2021, Jul 27; cited 2023, Nov 28]. <https://medlineplus.gov/ency/article/000473.htm>

joint when a ligament is stretched or torn. See Figure 14.13²⁶ for an illustration of a muscle strain and tear. Initial treatments for strains and sprains are similar and can be easily recalled by the mnemonic called RICE, which stands for the following²⁷:

- **Rest:** Rest the strain or sprain for at least 24 hours. The health care provider may recommend not putting any weight on the injured area for 48 to 72 hours, so crutches may be needed for lower extremity injuries.
- **Ice:** Apply ice as soon as possible after the injury to reduce swelling. The ice should not be applied directly to the skin but should be wrapped in a cloth to avoid tissue injury. Ice should be applied for 5 to 20 minutes, four to eight times a day, for the first 48 hours or until swelling improves.
- **Compression:** Compress the area with an elastic wrap or bandage to reduce swelling.
- **Elevate:** Elevate the injured limb above your heart whenever possible to help prevent or limit swelling.
-

26. "[Calf_muscle_strain_and_tear.svg](#)" by InjuryMap is licensed under [CC BY-SA 4.0](#)

27. Mayo Clinic. (2022, March 22). *Sprain: First aid*. <https://www.mayoclinic.org/first-aid/first-aid-sprain/basics/art-20056622>

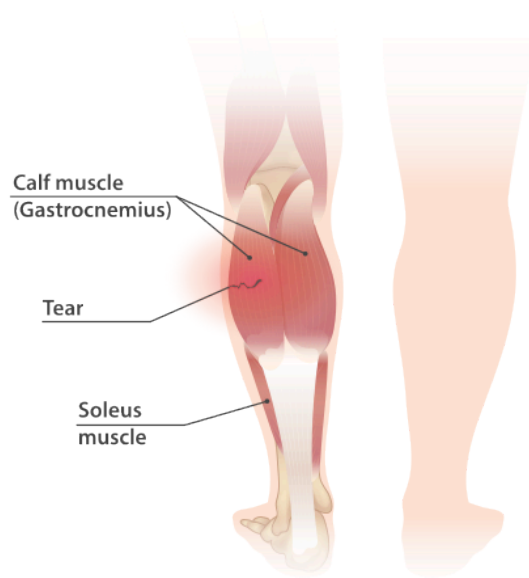


Figure 14.13 Strain

TENDONITIS

Tendonitis (ten-dŏ-NĪT-ĭs) refers to inflammation of a tendon, causing pain around a joint. Tendonitis usually happens after repeated injury to an area such as the wrist or ankle. Common forms of tendonitis are named after the sports that increase their risk, such as tennis elbow, golfer's elbow, pitcher's shoulder, swimmer's shoulder, and jumper's knee. Health care providers diagnose tendonitis based on medical history, a physical exam, and possible imaging tests. Initial treatment is focused on reducing pain and swelling with RICE (rest, ice, compression, and elevation). Other treatments may include ultrasound, physical therapy, steroid injections, and surgery in severe cases.²⁸

28. MedlinePlus [Internet]. Bethesda (MD): National Library of Medicine (US); [updated 2022, Apr. 4]. Tendinitis; [cited 2017, Mar. 16]. <https://medlineplus.gov/tendinitis.html>

14.7 Medical Specialists, Diagnostic Testing, and Procedures Related to Muscular System

MEDICAL SPECIALISTS

There are several types of health care professionals who help treat muscular disorders and diseases and help patients achieve optimal independence and quality of life.

Orthopedists and Orthopedic Surgeons

Orthopedists (ôr-THĒ-pě-dĭsts) are medical doctors who complete specialized training in the prevention, diagnosis, treatment, and surgery of disorders and diseases related to the musculoskeletal system. Some orthopedists are generalists, while others specialize in certain areas of the body, such as the hip and knee, foot and ankle, shoulder and elbow, hand, or spine. Orthopedic surgeons explore nonsurgical options first, such as pain medication or rehabilitation, but also have the expertise to perform surgery to repair an injury or correct a condition, if necessary. They treat patients of all ages, from newborns to the elderly, and treat conditions such as fractures, sports injuries, joint replacements, and spinal deformity.¹

1. American Academy of Orthopaedic Surgeons. (n.d.). *Orthopaedic surgeons:*

- ▶ For more details about orthopedists, see the [American Academy of Orthopaedic Surgeons' web page](#).

Neurologist

Neurologists (nū-rŎL-ŏ-jĭsts) are physicians who specialize in the diagnosis and treatment of disorders and conditions related to the brain, spinal cord, nerves, and muscles. They perform diagnostic testing related to the muscular system, such as electromyograms and muscle biopsies.²

- ▶ For additional information about neurologists, visit the [American Academy of Neurology's web page](#).

Kinesiologist

Kinesiology (kī-nē-sē-ŎL-ŏ-jē) is an academic discipline that studies physical activity and its impact on health and quality of life. It includes areas of study such as exercise science, sports management, athletic training, sports medicine, exercise psychology, fitness leadership, physical education, and pre-professional training for physical therapy, occupational therapy, medicine, and other health-related fields. **Kinesiologists** (kī-nē-sē-ŎL-ŏ-jĭsts) are health

Restoring mobility and keeping our nation in motion. <https://www.aaos.org/about/what-is-an-orthopaedic-surgeon>

2. American Academy of Neurology. (n.d.). *What is a neurologist?* <https://www.aan.com/tools-and-resources/medical-students/careers-in-neurology/what-is-a-neurologist>

care professionals with a degree in kinesiology or related discipline. Kinesiologists work in a variety of settings that assist people with pain management, injury prevention, and health promotion through biomechanics.³

- ▶ To read more information about kinesiologists, visit the [American Kinesiology Association's website](#). To learn more about careers in kinesiology, visit the [Zippia Kinesiologist Overview web page](#).

Occupational Therapists and Occupational Therapy Assistants

Occupational therapists (ŏk-yŭ-pā-shŏn-ăl THĚR-ă-pĭsts) (**OT**) and **occupational therapy assistants** (ŏk-yŭ-pā-shŏn-ăl THĚR-ă-pē ă-SĪS-tănts) (**OTA**) use everyday life activities (i.e., occupations) to promote health and well-being for people who have experienced an injury, disease, or condition that makes it difficult to participate in daily activities. This includes any meaningful activity that a person wants to accomplish, such as taking care of themselves and their family members, working, volunteering, or going to school. Occupational therapists work in a variety of settings, including hospitals, schools, clinics, skilled nursing facilities, community centers, health care facilities, and patient's homes.⁴

3. American Kinesiology Association. (n.d.) *About AKA*.
<https://americankinesiology.org>

4. American Occupational Therapy Association. (n.d.). *What is occupational therapy?* <https://www.aota.org/about/what-is-ot>

Occupational therapy can help people participate in life activities and provide recommendations for the following⁵:

- Activities of daily living (such as bathing, dressing, and eating)
- Adaptive equipment (such as shower chairs or equipment to make daily tasks easier)
- Caregiver and family training
- Planning and making the most of daily routines
- Returning to work, school, and leisure activities
- Techniques to aid in memory, concentration, and executive functioning
- Fall prevention, home safety, and accessibility

To become an occupational therapist (OT), a master's degree in occupational therapy is required. To become an OTA, an associate's degree from an accredited OTA program is required and a state-administered national exam must be passed to obtain licensure or certification. OTs evaluate a patient, create an intervention plan to improve their ability to perform daily activities and reach their goals, and determine if outcomes are being met.

Occupational therapy assistants (OTAs) implement the intervention plan and help patients recover, improve, and maintain skills needed for daily living and working. To become an OTA, an associate's degree from an accredited OTA program is required.

- ▶ Read additional information about occupational therapy on the [American Occupational Therapy Association web page](https://www.aota.org/about/what-is-ot). Read more information about occupational therapy jobs on the Bureau of Labor Statistic's web pages on [Occupational Therapists](#) and [Occupational Therapy Assistants and Aides](#).

5. American Occupational Therapy Association. (n.d.). *What is occupational therapy?* <https://www.aota.org/about/what-is-ot>

Physical Therapists and Physical Therapist Assistants

Physical therapists (FĪZ-ĭ-căl THĚR-ă-pĭsts) (**PT**) are movement experts who improve a person's quality of life through prescribed exercise, hands-on care, and patient education. PTs examine a person and develop a treatment plan to improve their ability to move, reduce or manage pain, restore function, and prevent disability. They work with people of all ages and abilities and in a variety of settings. They help people rehabilitate from injuries, manage chronic conditions, avoid surgery and prescription drugs, and create healthy habits. To become a licensed PT in the United States, a Doctor of Physical Therapy degree must be earned from an accredited physical therapy education program and a state licensure exam must be passed.⁶

Physical therapist assistants (FĪZ-ĭ-căl THĚR-ă-pĭst ă-SĪS-tănts) (**PTA**) provide physical therapy services under the direction and supervision of a physical therapist. PTAs implement components of patient care, obtain data related to the treatments provided, and collaborate with the PT to modify care as necessary. To become an PTA, an associate degree from an accredited PTA program is required and a state-administered national exam must be passed to obtain licensure or certification.⁷

- ▶ To learn more about careers in physical therapy, visit the [American Physical Therapy Association](https://www.apta.org/your-career/careers-in-physical-therapy). Read more information about physical therapy jobs on the Bureau of Labor Statistic's web pages on [Physical Therapists](https://www.bls.gov/ooh/healthcare/physical-therapists.htm) and [Physical Therapist Assistants and Aides](https://www.bls.gov/ooh/healthcare/physical-therapist-assistants-aides.htm).

6. American Physical Therapy Association. (n.d.). *Careers in physical therapy*. <https://www.apta.org/your-career/careers-in-physical-therapy>

7. American Physical Therapy Association. (n.d.). *Careers in physical therapy*. <https://www.apta.org/your-career/careers-in-physical-therapy>

Chiropractors

Chiropractors (kī-RŎP-răk-tŏrs) evaluate and treat musculoskeletal and neurological systems, including muscles, ligaments, tendons, bones, and nerves. Chiropractors use spinal manipulations to relieve pain in joints and muscles. Modern chiropractors have also developed a variety of different therapies to address patients' needs and use a holistic approach that generally excludes drugs or surgery.⁸ Chiropractors must complete a Doctor of Chiropractic (DC) degree to obtain a license to practice. They mostly work in solo or group chiropractic offices.

- ▶ Read more information about the chiropractic profession at the [American Chiropractic Association](#). Additional information about chiropractor jobs is available on the Bureau of Labor Statistic's web page on [chiropractors](#).

Massage Therapists

Massage therapists (MĂ-sāj THĚR-ă-pĭsts) treat patients by applying pressure to manipulate the body's soft tissues and joints. Licensed and/or certified massage therapists typically complete a postsecondary education that combines study and experience, although standards and requirements vary by state regulations.

- ▶ Read more information about massage therapy jobs on the Bureau of Labor Statistic's web page on [Massage Therapists](#).

8. American Chiropractic Association. (n.d.). *Origins and history of chiropractic*. <https://www.acatoday.org/about/history-of-chiropractic>

DIAGNOSTIC TESTING

Common diagnostic tests for muscular disorders include electromyograms, magnetic resonance imaging (MRI), and range-of-motion testing.

Electromyogram

An **electromyogram** (ē-lĕk-trō-mī-Ō-grām) (**EMG**) is a diagnostic procedure that assesses the function of nerve cells that control muscles. Electrodes, either attached to the skin or inserted into the muscle, record electrical impulses. An EMG can identify functional problems with the peripheral nerves, muscles, or with the signals between the nerves and the muscles. During a needle EMG, a needle electrode inserted directly into a muscle records the electrical activity in that muscle. A nerve conduction study, another part of an EMG, uses surface electrodes applied to the skin to measure the speed and strength of signals traveling between two or more points. EMG results are used to diagnose muscle and nerve disorders.⁹ See Figure 14.14¹⁰ for an image demonstrating the basics of an EMG.

9. Mayo Clinic. (2019, May 21). *Electromyography (EMG)*.

<https://www.mayoclinic.org/tests-procedures/emg/about/pac-20393913>

10. “Electromyography.png” by PRATYUSH AGRAWAL is licensed under [CC BY-SA 4.0](#)

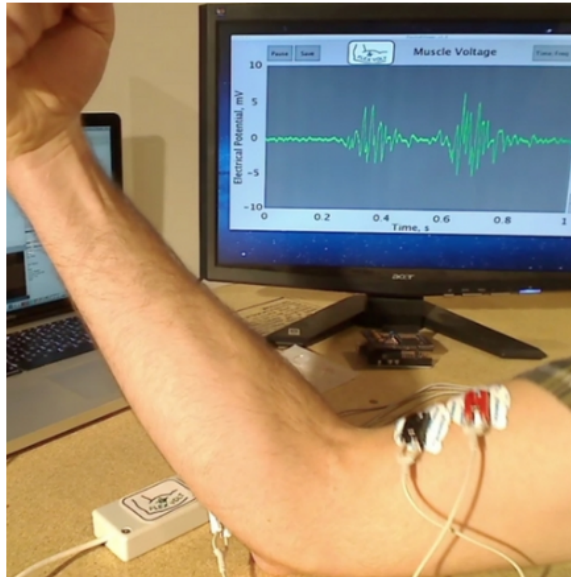


Figure 14.14 Electromyography

Magnetic Resonance Imaging

Magnetic resonance imaging (măg-NĚT-ĭk rĕz-ŏ-năns ĬM-ă-jĭng) (**MRI**) uses radio frequency waves and a strong magnetic field to produce three-dimensional, detailed anatomical images. MRIs are often used for diagnosis and monitoring of muscular and neurological disorders. To obtain an MRI image, a patient is placed inside a large magnet and must remain very still during the imaging process in order not to blur the image. Contrast agents may be intravenously administered to a patient before or during the MRI to enhance the image. MRIs differ from computed tomography (CT) in that they do not use the ionizing radiation of X-rays. The brain, spinal cord and nerves, muscles, ligaments, and tendons are seen much more clearly with MRI than with regular X-rays and CT. For this reason, an MRI is often used to image knee and shoulder injuries. However, people with metal implants, such as pacemakers, vagus nerve stimulators, implantable cardioverter-defibrillators, loop recorders, insulin pumps, cochlear implants, deep brain stimulators, and

capsules from capsule endoscopy, should not enter an MRI machine.¹¹ See Figure 14.15¹² for an image of an MRI machine.



Figure 14.15 Magnetic Resonance Imaging (MRI) Machine

Range of Motion

Range-of-motion testing (rānj ōv mō-shōn tēs-tīng) (**ROM**) is a diagnostic procedure performed by a trained health care professional that is used to determine the amount of movement around a patient's specific joint. See

11. National Institute of Biomedical Imaging and Bioengineering. (n.d.). *Magnetic resonance imaging (MRI)*. National Institutes of Health.
<https://www.nibib.nih.gov/science-education/science-topics/magnetic-resonance-imaging-mri>

12. "Scan_MRI.jpg" by [liz west](#) from Boxborough, MA is licensed under [CC BY 2.0](#)

Figure 14.16¹³ for an image of a child undergoing range-of-motion testing of the shoulder.



Figure 14.16 Range-of-Motion Testing of the Shoulder

ROM exercises are used to treat musculoskeletal disorders and prevent contractures. **Active range of motion** (ăk-tīv rānj ōv mō-shŏn) (**AROM**) refers to joint movements the person can independently achieve when their

13. "[New Horizons 2012 in Peru 120621-F-HI762-602.jpg](#)" by Master Sgt. Kelly Ogden, United States Air Force is licensed in the [Public Domain](#)

opposing muscles contract and relax. **Passive range of motion** (pās-iv rānj ōv mō-shŏn) (**PROM**) refers to joint movements that occur when an outside force, such as a therapist, causes movement of a patient's joint.

PROCEDURES

Surgical procedures related to the muscular system include tenomyoplasty, tenorrhaphy, and myorrhaphy. **Tenomyoplasty** (tĕn-ō-Mĭ-ō-plās-tē) refers to surgical repair of a tendon and muscle. **Tenorrhaphy** (tĕn-OR-ă-fē) refers to suturing of a tendon. **Myorrhaphy** (mĭ-OR-ă-fē) refers to suturing of a muscle.

14.8 Muscular Learning Activities

Interactive Learning Activity: Study muscular system medical terms discussed in this chapter using these flashcards.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=429#h5p-188>

Interactive Learning Activity: Test yourself on these terms related to the muscular system.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=429#h5p-82>

14.9 Glossary

Abduction (ăb-DŮK-shŏn): The movement of a limb or other part away from the midline of the body or from another part. ([Chapter 14.5](#))

Achilles tendon (ə-KĪL-ēz TĚN-dŏn): A tendon of the back of the leg, and the thickest in the human body, attaching the calf muscles to the heel bone. ([Chapter 14.4](#))

Actin (ĂK-tin): A protein that forms (along with myosin) the contractile filaments of muscle cells and is involved in motion in other types of cells. ([Chapter 14.4](#))

Active range of motion (ăk-tĭv rānj ōv mō-shŏn) (AROM): The degree of movement a joint can be moved by a muscle contraction. ([Chapter 14.7](#))

Adaptive equipment (ă-DĂP-tĭv ĭ-KWĪP-mĕnt): Devices or tools used to assist individuals with disabilities in performing tasks and activities, aiming to enhance independence and functionality. ([Chapter 14.6](#))

Adduction (ă-DŮK-shŏn): The movement of a body part toward the body's midline. ([Chapter 14.5](#))

Assistive equipment (ă-SĪS-tĭv ĭ-KWĪP-mĕnt): Tools or devices that aid in performing daily tasks and activities, especially designed for people with disabilities, similar to adaptive equipment but may include a broader range of tools. ([Chapter 14.6](#))

Ataxia (ă-TĂK-sē-ă): The lack of muscle control or coordination of voluntary movements, such as walking or picking up objects. ([Chapter 14.6](#))

Atrophy (ĂT-rŏ-fē): The gradual wasting away, decrease in size, or degeneration of muscle or tissue. ([Chapter 14.6](#))

Biceps brachialis (BĪ-sĕps brā-kē-ĂL-ĭs): A muscle in the upper arm that acts to flex the elbow, situated underneath the biceps brachii. ([Chapter 14.4](#))

Biceps brachii (BĪ-sĕps BRĀ-kē-ĭ): A muscle of the upper arm that flexes the elbow and rotates the forearm. ([Chapter 14.4](#))

Bradykinesia (brād-ē-kĭ-NĒ-zē-ă): Slowness of movement, a common symptom of Parkinson's disease. ([Chapter 14.5](#))

Cardiac muscle (KĂR-dē-ăk MŪS-ăl): Specialized, involuntary muscle tissue

found only in the heart, responsible for pumping blood throughout the body. ([Chapter 14.4](#))

Cerebral palsy (sěr-Ē-brāl pôl-zē) (CP): A group of disorders affecting movement and muscle tone or posture caused by damage that occurs to the immature, developing brain, most often before birth. ([Chapter 14.6](#))

Chiropractors (kī-RŎP-rāk-tōrs): Health care professionals focused on the diagnosis and treatment of neuromuscular disorders, with an emphasis on treatment through manual adjustment and/or manipulation of the spine. ([Chapter 14.7](#))

Contracture (kŏn-TRĀK-chŭr): The permanent tightening of muscles, tendons, skin, and other tissues, leading to a decrease in flexibility and mobility. ([Chapter 14.6](#))

Deltoid (DĚL-toid): A large, triangular muscle covering the shoulder joint and responsible for lifting the arm away from the body. ([Chapter 14.4](#))

Diplopia (dī-PLŎ-pē-ă): Double vision. ([Chapter 14.6](#))

Dorsiflexion (dôr-sĩ-FLĚK-shŏn): The backward flexion or bending of a hand or foot. ([Chapter 14.5](#))

Dysarthria (dīs-ĀR-thrē-ă): Slurred or slow speech that can be difficult to understand. ([Chapter 14.6](#))

Dyskinesia (dīs-kĩ-NĚ-zē-ă): Abnormality or impairment of voluntary movement. ([Chapter 14.5](#), [Chapter 14.6](#))

Dysphagia (dīs-FĀ-jē-ă): Difficulty or discomfort in swallowing. ([Chapter 14.6](#))

Dyspnea (dīsp-NĚ-ă): Difficult or labored breathing. ([Chapter 14.6](#))

Dystrophy (DĪS-trŏ-fē): A disorder in which an organ or tissue of the body wastes away. ([Chapter 14.5](#))

Electromyogram (ĩ-lĚk-trŏ-mĩ-Ŏ-grām) (EMG): A diagnostic test that measures the electrical activity of muscles. ([Chapter 14.7](#))

Eversion (ē-VĚR-zhŭn): The action of turning outward the sole of the foot away from the body's midline. ([Chapter 14.5](#))

Extension (Ěk-STĚN-shŏn): A straightening movement that increases the angle between body parts. ([Chapter 14.5](#))

Fibromyalgia (fĩ-brŏ-mĩ-ĀL-jē-ă): A disorder characterized by widespread

musculoskeletal pain accompanied by fatigue, sleep, memory, and mood issues. ([Chapter 14.6](#))

Flaccid (FLĀS-ĭd): Lacking firmness, resilience, or muscle tone. ([Chapter 14.6](#))

Flexion (FLĚK-shŏn): The action of bending or the condition of being bent, especially the bending of a limb or joint. ([Chapter 14.5](#))

Gastrocnemius (găs-trŏk-NĒ-mē-ŭs): The major calf muscle, responsible for plantar flexing the foot at the ankle joint and flexing the leg at the knee joint. ([Chapter 14.4](#))

Gluteus maximus (glū-TĒ-ŭs MĀK-sĭ-mŭs): The largest and most superficial of the three gluteal muscles, responsible for movement of the hip and thigh. ([Chapter 14.4](#))

Hamstring (HĀM-strĭng): Any of the five tendons at the back of a person's knee. ([Chapter 14.4](#))

Hemiplegia (hĕm-ē-PLĒ-jē-ă): Paralysis of one side of the body. ([Chapter 14.6](#))

Hyperkinesia (hī-pĕr-kĭ-NĒ-zē-ă): Excessive movement; an abnormally high level of activity. ([Chapter 14.5](#))

Hypertrophy (hī-PĚR-trŏ-fĕ): The enlargement of an organ or tissue from the increase in size of its cells. ([Chapter 14.5](#))

Inversion (in-VĚR-zhŭn): The process of turning inward the sole of the foot towards the body's midline. ([Chapter 14.5](#))

Kinesiologists (kī-nē-sē-ŌL-ŏ-jĭsts): Specialists in the study of human movement. ([Chapter 14.7](#))

Kinesiology (kī-nē-sē-ŌL-ŏ-jĕ): The study of the mechanics of body movements. ([Chapter 14.7](#))

Latissimus dorsi (lă-tĭs'ĭ-mŭs DŌR-sĭ): A broad, flat muscle on the back that helps control movement of the shoulder. ([Chapter 14.4](#))

Magnetic resonance imaging (măg-NĚT-ĭk rĕz-ŏ-năns ĪM-ă-jĭng) (MRI): A medical imaging technique used to form pictures of the anatomy and the physiological processes of the body. ([Chapter 14.7](#))

Massage therapists (MĀ-sāj THĚR-ă-pĭsts): Professionals who practice manual manipulation of soft body tissues (muscle, connective tissue, tendons, and ligaments) to enhance a person's health and well-being. ([Chapter 14.7](#))

Muscular dystrophy (mŭs'kyŭ-lăř DĪS-trŏ-fē) (MD): A group of diseases that cause progressive weakness and loss of muscle mass. ([Chapter 14.6](#))

Myalgia (mī-ĀL-jē-ă): Pain in a muscle or group of muscles. ([Chapter 14.5](#), [Chapter 14.6](#))

Myasthenia (mī-ăs-THĒ-nē-ă): Muscle weakness. ([Chapter 14.5](#), [Chapter 14.6](#))

Myasthenia gravis (mī-ăs-THĒ-nē-ă GRĀ-vīs) (MG): A chronic autoimmune neuromuscular disease that causes weakness in the skeletal muscles, which are responsible for breathing and moving parts of the body, including the arms and legs. ([Chapter 14.6](#))

Myoglobin (mī-Ō-glŏ-bĭn): A red protein containing heme that carries and stores oxygen in muscle cells. ([Chapter 14.6](#))

Myorrhaphy (mī-ŌR-ă-fē): The surgical suturing of a muscle. ([Chapter 14.7](#))

Myosin (MĪ-ŏ-sin): A type of protein filament that interacts with actin in muscle contraction and is also involved in cellular transport. ([Chapter 14.4](#))

Neurologists (nŭ-rŌL-ŏ-jĭsts): Physicians who specialize in the treatment of diseases and disorders of the nervous system. ([Chapter 14.7](#))

Occupational therapists (ŏk-yŭ-pā-shŏn-ăl THĒR-ă-pĭsts) (OT): Health professionals who help people recover, develop, and maintain daily living and work skills. ([Chapter 14.7](#))

Occupational therapy assistants (ŏk-yŭ-pā-shŏn-ăl THĒR-ă-pē ă-SĪS-tănts) (OTA): Professionals who work under the direction of occupational therapists to assist patients in developing, recovering, and improving the skills needed for daily living and working. ([Chapter 14.7](#))

Ocular myasthenia (Ō-kyŭ-lăř mī-ăs-THĒ-nē-ă): A form of myasthenia gravis that primarily affects the muscles that control eye and eyelid movement. ([Chapter 14.6](#))

Orthopedists (ŏr-THĒ-pě-dĭsts): Medical doctors who specialize in the diagnosis, correction, prevention, and treatment of patients with skeletal deformities. ([Chapter 14.7](#))

Orthotic/prosthetic devices (ŏr-THŌT-ĭk/prŏs-THĒT-ĭk dĭ-VĪS-ĕz): Apparatuses used to support, align, prevent, or correct deformities, or to improve the function of movable parts of the body. Orthotic devices are

typically used to support weak or ineffective joints or muscles, whereas prosthetic devices replace missing body parts. ([Chapter 14.6](#))

Paralysis (pǎr-ă-LĪ-sīs): The loss of the ability to move (and sometimes to feel anything) in part or most of the body, typically as a result of illness, poison, or injury. ([Chapter 14.6](#))

Paraplegia (pǎr-ă-PLĒ-jē-ă): Paralysis of the legs and lower body, typically caused by spinal injury or disease. ([Chapter 14.6](#))

Passive range of motion (pās-iv rānj ōv mō-shǒn) (PROM): The extent of movement a joint can be moved by an external force without muscle contraction. ([Chapter 14.7](#))

Pectoralis major (pěk'tō-rĂ-līs MĀ-jör): A thick, fan-shaped muscle situated at the chest of the body, making up the bulk of the male chest. ([Chapter 14.4](#))

Physical therapists (FĪZ-ĭ-căl THĒR-ă-pĭsts) (PT): Healthcare professionals who provide services to individuals to develop, maintain, and restore maximum movement and functional ability throughout life. ([Chapter 14.7](#))

Physical therapist assistants (FĪZ-ĭ-căl THĒR-ă-pĭst ă-SĪS-tǎnts) (PTA): Skilled health care workers who work under the supervision of a physical therapist to provide therapy services. ([Chapter 14.7](#))

Plantar flexion (PLĂN-tǎr FLĒK-shǒn): The movement of the foot in which the foot or toes flex downward toward the sole. ([Chapter 14.5](#))

Polymyositis (pöl-ē-mī-ō-SĪ-tīs): Inflammation of many muscles. ([Chapter 14.5](#))

Pronation (prō-NĀ-shǔn): The act of turning the palm downward or when applied to the foot, the inward roll of the foot/ankle. ([Chapter 14.5](#))

Ptosis (TŌ-sīs): Drooping of the upper eyelid due to paralysis or disease, or as a congenital condition. ([Chapter 14.6](#))

Quadriceps (KWŎD-rĭ-sěps): A large muscle group that includes the four prevailing muscles on the front of the thigh. ([Chapter 14.4](#))

Quadriplegia or tetraplegia (kwöd-rĭ-PLĒ-jē-ă or tět-ră-PLĒ-jē-ă): Paralysis of all four limbs; tetraplegia is another term for the same condition. ([Chapter 14.6](#))

Range-of-motion testing (rānj ōv mō-shǒn tēs-tĭng) (ROM): A procedure that measures the extent of movement in a particular joint. ([Chapter 14.7](#))

Rectus abdominis (RĚK-tūs ăb-DŌM-ĭ-nīs): A paired muscle running

vertically on each side of the anterior wall of the human abdomen. ([Chapter 14.4](#))

Rhabdomyolysis (răb-dō-mī-ŎL-ĭ-sĭs): A serious syndrome due to a direct or indirect muscle injury, resulting from the death of muscle fibers and release of their contents into the bloodstream. ([Chapter 14.6](#))

Rotation (rō-TĀ-shŏn): Circular movement around a central point. Internal rotation is toward the center of the body, and external rotation is away from the center of the body. ([Chapter 14.5](#))

Rotator cuff (RŌ-tā-tŏr kŭf): A group of muscles and tendons surrounding the shoulder joint, keeping the head of the humerus firmly within the shallow socket of the shoulder. ([Chapter 14.4](#))

Skeletal muscles (SKĚL-ĕ-tăl MŬS-ălz): Voluntary muscles attached to the skeleton, responsible for movement, posture, and balance. ([Chapter 14.4](#))

Smooth muscle (SMŎŎTH MŬS-ăl): Involuntary, non-striated muscle that is found in the walls of internal organs such as the stomach, intestine, and blood vessels, controlling their movements. ([Chapter 14.4](#))

Spastic (spăs-TĪK): Relating to or affected by muscle spasm or increased reflexes. ([Chapter 14.6](#))

Spasticity (spăs-TĪS-ĭ-tē): A feature of altered skeletal muscle performance with a combination of paralysis, increased tendon reflex activity, and hypertonia. ([Chapter 14.6](#))

Sprain (sprān): An injury to ligaments caused by a wrench or twist, typically resulting in pain, swelling, and difficulty in movement. ([Chapter 14.6](#))

Strain (strān): An injury to a muscle or tendon in which the muscle fibers tear as a result of overstretching, often causing pain and inflammation. ([Chapter 14.6](#))

Striated (STRĪ-ā-tĕd): Muscle tissue characterized by the presence of striations, or alternating light and dark bands, typically found in skeletal and cardiac muscles. ([Chapter 14.4](#))

Supination (sū-pi-NĀ-shŭn): The act of turning the palm upwards or when applied to the foot, the outward roll of the foot/ankle. ([Chapter 14.5](#))

Tendonitis (tĕn-dŏ-NĪ-tĭs): Inflammation of a tendon, often causing pain and swelling. ([Chapter 14.6](#))

Tendons (TĔN-dŏns): Tough bands of fibrous connective tissue that usually

connect muscle to bone and are capable of withstanding tension. ([Chapter 14.4](#))

Tenomyoplasty (těn-ō-Mī-ō-plās-tē): A surgical procedure involving the repair of both muscle and tendon. ([Chapter 14.7](#))

Tenorrhaphy (těn-ŎR-ă-fē): The surgical suturing of a tendon. ([Chapter 14.7](#))

Triceps brachii (TRĪ-sěps BRĀ-kē-ī): A major muscle of the upper arm that extends the elbow. ([Chapter 14.4](#))

Voice-activated technology (vois-ăk-TĪV-ā-těd těk-NŎL-ŏ-jē): Technology that is controlled through voice commands rather than manual operation, often used to assist individuals with mobility or dexterity issues. ([Chapter 14.6](#))

PART XV

CHAPTER 15 SENSORY SYSTEM TERMINOLOGY

15.1 Sensory System Introduction

Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the sensory system
- Identify meanings of key word components of the sensory system
- Categorize diagnostic, therapeutic, procedural, or anatomic terms related to the sensory system
- Use terms related to the sensory system
- Use terms related to the diseases and disorders of the sensory system

Introduction to the Sensory Systems

Most people consider the five major senses to be taste, smell, touch, hearing, and sight. These are referred to as the “special senses” because they have organs devoted to the senses, such as the eye, ear, tongue, and nose.

This chapter will review common word components related to the systems of special senses to assist learners in analyzing, building, and defining medical terms. Other terms, whose definitions cannot be easily built from word components, will be described in context based on the anatomy and physiology of sensory systems and common diseases and disorders. Medical

specialists, diagnostic tests, and procedures related to sensory systems will also be discussed.

15.2 Word Components Related to the Sensory Systems

This section will describe common word components related to the sensory systems. These word components help build definitions for many medical terms. Other common prefixes are described in [Chapter 1.3](#), and common suffixes are described in [Chapter 1.5](#).

PREFIXES RELATED TO THE SENSORY SYSTEMS

- **a-** or **an-**: Absence of, without, no, or not (negates meaning)
- **bi-**: Two
- **bin-**: Two
- **endo-**: Within, in

WORD ROOTS WITH A COMBINING VOWEL RELATED TO THE SENSORY SYSTEMS

- **acous/o**: Hearing

- **audi/o**: Hearing
- **audit/o**: Hearing
- **aur/i** or **aur/o**: Ear
- **blephar/o**: Eyelid
- **cochle/o**: Cochlea
- **conjunctiv/o**: Conjunctiva
- **cor/o**: Pupil
- **core/o**: Pupil
- **corne/o**: Cornea
- **cry/o**: Cold
- **cyst/o**: Bladder, sac, or cyst
- **dacry/o**: Tear, tear duct
- **dipl/o**: Two, double
- **ir/o**: Iris
- **irid/o**: Iris
- **is/o**: Equal
- **kerat/o**: Cornea
- **labyrinth/o**: Labyrinth, inner ear
- **lacrim/o**: Tear, tear duct
- **mastoid/o**: Mastoid bone
- **myring/o**: Tympanic membrane
- **ocul/o**: Eye
- **ophthalm/o**: Eye
- **opt/o**: Vision
- **ossicul/o**: Ossicle
- **ot/o**: Ear
- **phac/o**: Lens
- **phak/o**: Lens
- **phot/o**: Light
- **pupill/o**: Pupil
- **retin/o**: Retina
- **salping/o**: Tube
- **scler/o**: Sclera
- **staped/o**: Stapes, middle ear

- **ton/o**: Tension, pressure
- **tympan/o**: Middle ear, tympanic membrane
- **vestibul/o**: Vestibule
- **xer/o**: Dry

SUFFIXES RELATED TO THE SENSORY SYSTEMS

- **-al**: Pertaining to
- **-algia**: Pain
- **-ar**: Pertaining to
- **-ary**: Pertaining to
- **-eal**: Pertaining to
- **-ectomy**: Excision or surgical removal
- **-gram**: Record, radiographic image
- **-graphy**: Process of recording
- **-ia**: Condition of, diseased or abnormal state
- **-ic**: Pertaining to
- **-itis**: Inflammation
- **-logist**: Specialist who studies and treats
- **-logy**: Study of
- **-malacia**: Softening
- **-meter**: Instrument used to measure
- **-metry**: Process of measuring
- **-oma**: Tumor, swelling
- **-opia**: Vision as it relates to condition
- **-osis**: Abnormal condition
- **-pathy**: Disease
- **-pexy**: Surgical fixation
- **-phobia**: Abnormal fear, aversion to specific things
- **-plasty**: Surgical repair

- **-plegia**: Paralysis
- **-ptosis**: Prolapse, drooping, sagging
- **-rrhea**: Flow, discharge
- **-sclerosis**: Hardening
- **-scope**: Instrument used to view
- **-scopy**: Process of viewing
- **-stomy**: Creation of artificial opening
- **-tomy**: Incision, cut into

15.3 Examples of Sensory Terms Easily Defined By Their Word Components

Here are examples of common medical terms related to the sensory systems that can be easily defined by breaking the terms into their word components.

Audiologist

1. Break down the medical term into word components:
Audi/o/logist
2. Label the word components: **Audi** = WR; **o** = CV; **logist** = S
3. Define the word components: **Audi** = hearing; **logist** = physician who specializes in diagnosing and treating
4. Create a final definition of the medical term: **Specialist who diagnoses and treats hearing**

Ophthalmoscopy

1. Break down the medical term into word components:
Ophthalm/o/scopy
2. Label the word components: **Ophthalm** = WR; **o** = CV; **scopy** = S
3. Define the word components: **Ophthalm** = eye; **scopy**

= process of viewing

4. Create a final definition of the medical term: **Process of viewing the eye**

Tympanoplasty

1. Break down the medical term into word components:
Tympan/o/plasty
2. Label the word components: **Tympan** = WR; **o** = CV; **plasty** = S
3. Define the word components: **Tympan** = tympanic membrane; **plasty** = surgical repair
4. Create a final definition of the medical term: **Surgical repair of the tympanic membrane**



Interactive Learning Activity: Practice defining and pronouncing sensory system medical terms by breaking them into word parts.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=6081#h5p-62>

- ▶ You can also print these flashcard activities as a [Chapter 15](#)

▶ [Student Companion Worksheet](#) and check your answers with this [Answer Key](#).

15.4 Anatomy and Physiology of the Sensory Systems

VISION

Vision is the special sense of sight based on the transduction of light stimuli received through the eyes. See Figure 15.1¹ for an illustration of the eye. The bony orbits surround the eyeballs, protecting them and anchoring the soft tissues of the eye. The eyelashes and eyelids help protect the eye by blocking particles from landing on the surface of the eye.²

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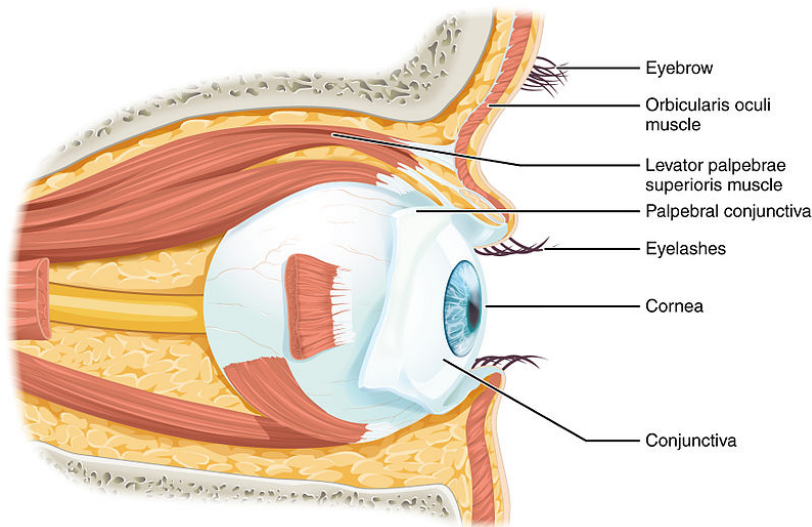


Figure 15.1 The Eye

The inner surface of each lid is a thin membrane known as the **conjunctiva** (kŏn-jŭnk-tī-va). The conjunctiva extends over the white areas of the eye called the **sclera** (sklĕr-ă), connecting the eyelids to the eyeball. The **iris** (ir-ĭs) is the colored part of the eye. The iris is a smooth muscle that opens and closes the **pupil** (pŭ-pĭl), the hole at the center of the eye that allows light to enter. The iris constricts the pupil in response to bright light and dilates the pupil in response to dim light. The **cornea** (KOR-nĕ-ă) is the transparent front part of the eye that covers the iris, pupil, and anterior chamber. The cornea, with the anterior chamber and lens, refracts light and contributes to vision. The innermost layer of the eye is the **retina** (RĕT-ĭ-nă). The retina contains the nervous tissue and specialized cells called photoreceptors for the initial processing of visual stimuli. These nerve cells of the retina leave the eye and enter the brain via the **optic nerve** (OP-tik nerve). See Figure 15.2³ for an illustration of these structures of the eye.⁴

3. "[1413_Structure_of_the_Eye.jpg]" by OpenStax College is licensed under [CC BY 3.0](#)

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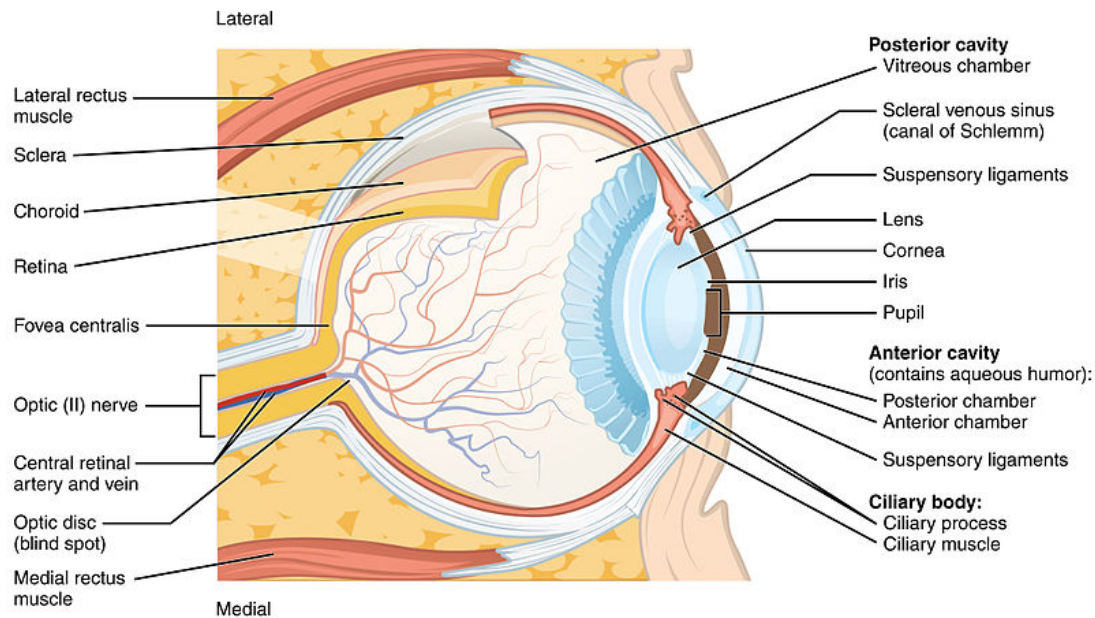


Figure 15.2 Structures of the Eye

Tears are produced by the **lacrimal gland** (LAK-rĭ-măl gland) that is located beneath the lateral edges of the nose. Tears are continuously produced by the lacrimal duct and secreted through a duct onto the surface of the eye to wash away foreign particles. Movement of the eye occurs by the contraction of six voluntary extraocular extrinsic muscles that originate from the bones of the orbit and insert into the surface of the eyeball.⁵

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View a supplementary YouTube video⁶ from Crash
Course on vision: [Vision: Crash Course Anatomy & Physiology #18](#)

AUDITORY

Hearing is a special sense based on the transduction of sound waves into a neural signal that is made possible by the structures of the ear. See Figure 15.3⁷ for an illustration of the ear structures.⁸

6. CrashCourse. (2015, May 11). *Vision: Crash Course Anatomy & Physiology #18* [Video]. YouTube. All rights reserved.
<https://www.youtube.com/watch?v=o0DYP-u1rNM>

7. "5dfc7e834c03e3e7dbbf82de10413b92379a1a57.png" by Clark, et al., is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/biology-2e/pages/1-introduction>.

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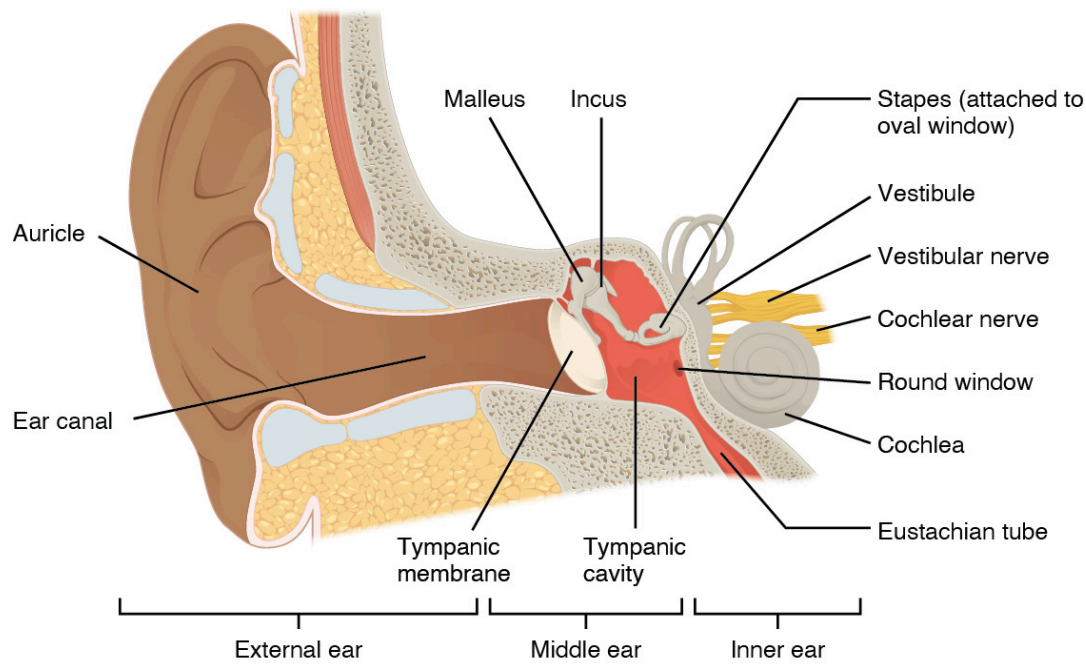


Figure 15.3 Structures of the Ear

The large, fleshy structure on the lateral aspect of the head is the **auricle** (AW-rĭ-kl), also known as the **pinna** (PĪN-ă). The C-shaped curves of the auricle direct sound waves toward the ear canal. At the end of the ear canal is the **tympanic membrane** (tĭm-păn-ik mem-brăn), commonly referred to as the eardrum, that vibrates from sound waves. The auricle, ear canal, and tympanic membrane are referred to as the external ear.⁹

The middle ear consists of a space with three small bones called the malleus, incus, and stapes, the Latin names that roughly translate to “hammer,” “anvil,” and “stirrup.” The **malleus** (MĂL-ē-ŭs) is attached to the tympanic membrane and articulates with the incus. The **incus** (ĪN-kŭs), in turn, articulates with the stapes. The **stapes** (stā-pēz) is attached to the inner ear, where the sound waves are converted into a neural signal. The middle ear

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is also connected to the pharynx through the **Eustachian tube** (yōō-STĀ-shēn tūb) that helps equalize air pressure across the tympanic membrane. The Eustachian tube is normally closed but will pop open when the muscles of the pharynx contract during swallowing or yawning.¹⁰

The **inner ear** (IN-er ĒR) is often described as a bony labyrinth because it is composed of a series of semicircular canals. The semicircular canals have two separate regions called the **cochlea** (KŎK-lē-ă) and the **vestibule** (ves-tĭ-bŭl) that are responsible for hearing and balance. The neural signals from these two regions travel together from the inner ear to the brain via the **vestibulocochlear nerve** (ves-tĭ-bŭl-ō-KŎ-klē-ar nerve). See Figure 15.4¹¹ for an illustration of the transmission of sound from the outer ear to the middle ear and to the inner ear.¹²

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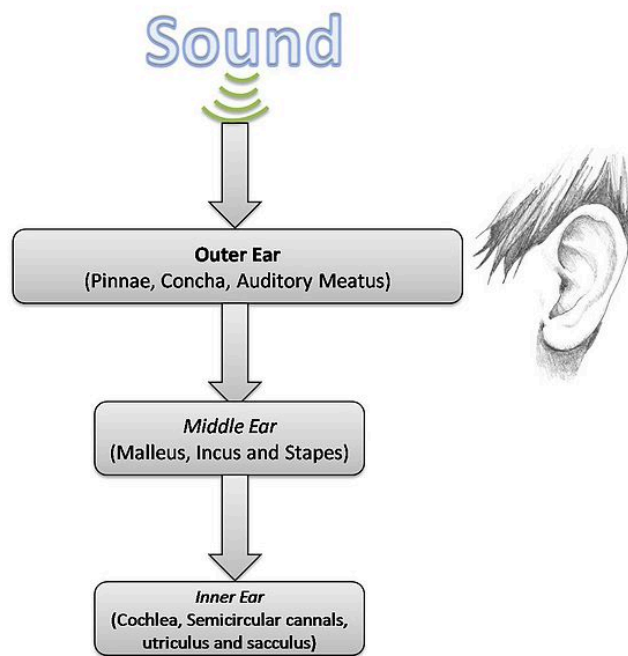


Figure 15.4 Pathway of Sound Vibrations

Hearing

The cochlea encodes auditory stimuli for frequencies between 20 and 20,000 Hz, which is the range of sound that human ears can detect. The hair cells along the length of the cochlear duct, which are each sensitive to a particular frequency, allow the cochlea to separate auditory stimuli by frequency, just as a prism separates visible light into its component colors. See Figure 15.5¹³ for an illustration of the cochlea.¹⁴

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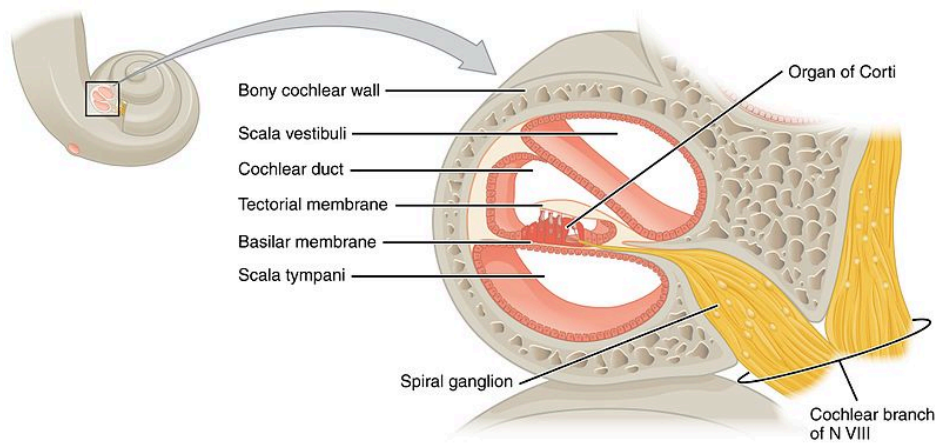


Figure 15.5 Cochlea

Balance

Along with hearing, the inner ear is also responsible for the sense of balance. There are three semicircular canals (superior, posterior, and lateral) extending from the vestibule filled with fluid that work to maintain balance. Hair cells within the vestibule sense head position, head movement, and body motion. Medical conditions affecting the semicircular canals cause incorrect balance signals to be sent to the brain, resulting in a spinning type of dizziness called **vertigo** (VUR-tĭ-gō).¹⁵



View a supplementary YouTube video¹⁶ from Crash

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16. CrashCourse. (2015, May 4). *Hearing & balance: Crash Course*



Course on hearing and balance: [Hearing & Balance: Crash Course Anatomy & Physiology #17](#)

TASTE

Taste is the special sense associated with the tongue. The surface of the tongue contains raised bumps called papillae that contain the structures for taste transmission. Within the structure of the papillae are taste buds that contain specialized receptor cells for the transduction of taste stimuli. These receptor cells are sensitive to the chemicals contained within foods that are ingested, and they release neurotransmitters based on the amount of the chemical in the food. Until recently, only four tastes were recognized: sweet, salty, sour, and bitter. Recent research has suggested that there may also be additional tastes for fats and glutamates (tomatoes, cheese, and mushrooms).¹⁷

Anatomy & Physiology #17 [Video]. YouTube. All rights reserved.

<https://www.youtube.com/watch?v=le2j7GpC4JU>

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SMELL

Olfaction (smell) is a special sense based on receptors in a small region of the nasal cavity that are responsive to chemical stimuli. Scent receptor messages travel to the brain, where smells are interpreted and can even become associated with long-term memories and emotional responses.¹⁸ See Figure 15.6¹⁹ for an illustration of olfaction. In this illustration, the olfactory bulb (1) contains mitral cells (2) that receive information from the olfactory cells (3). The olfactory cells are found within the nasal epithelium (4) and pass their information through the cribriform plate (5) of the ethmoid bone.

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19. “[Cenveo – Drawing Anatomy of the Structures Involved in Smell \(Olfaction\) – Numbered labels](#)” by Cenveo is licensed under [CC BY 4.0](#)

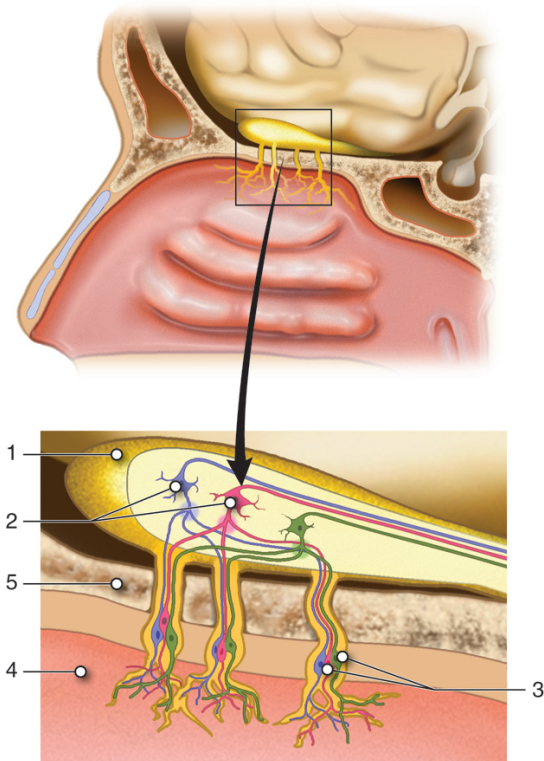


Figure 15.6 Olfaction

View a supplementary YouTube video²⁰ from Crash
 Course on taste and smell: [Taste & Smell: Crash Course
 Anatomy & Physiology #16](https://www.youtube.com/watch?v=mFm3yA1nsIE)

20. CrashCourse. (2015, April 27). *Taste & smell: Crash Course Anatomy & Physiology #16* [Video]. YouTube. All rights reserved.
<https://www.youtube.com/watch?v=mFm3yA1nsIE>

TOUCH

Touch is considered a general sense, as opposed to the special senses that were previously discussed in this section. Many of the receptors for touch are located in the skin, but receptors are also found in muscles, tendons, joint capsules, ligaments, and in the walls of visceral organs. These receptors detect sensations such as pressure, vibration, light touch, tickle, itch, temperature, pain, and proprioception (i.e., the sense of location, movement, and action of our body parts).²¹

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15.5 Diseases and Disorders Related to the Sensory Systems

EYE DISEASES AND DISORDERS

Astigmatism

Astigmatism (ă-STIG-mă-tizm) refers to blurry vision due to the irregular curvature of the cornea or lens. It is treated with corrective glasses or contact lenses.

Blindness

The term “blindness” covers a broad spectrum of visual impairments due to injury, disease, or a congenital condition. **Total blindness** (TŌ-tăl BLĪND-něss) is a term used to describe those who have complete lack of light perception.

Low vision (LŌ VIZH-ŭn) is a term used to describe those individuals whose vision cannot be fully corrected by conventional methods such as glasses, contact lenses, medicine, surgery, magnification aids, or assistive technology.

Visual impairment (VIZH-ŭ-al Im-PĀR-měnt) is a term used to describe decreased visual function that interferes with an individual’s ability to perform activities of daily living, such as reading, driving, and watching TV. **Legal blindness** (LĒ-găl BLĪND-něss), a term used for establishing disability benefits

and rehabilitation training, refers to **visual acuity** (VIZH-u-ăl ă-KŪ-īt-ē) (**VA**) of 20/200 or less in the best-seeing eye after correction.¹

Cataract

A **cataract** (KAT-ă-rakt) is a progressive disease of the lens that causes cloudiness and a lack of transparency. Cataracts are very common in older adults. Over half of all Americans aged 80 or older either have cataracts or have had surgery to remove cataracts. See Figure 15.7² for an image of a cataract. Cataracts develop slowly, and symptoms include faded colors, blurred or double vision, halos around light, and trouble seeing at night. See Figure 15.8³ for a simulated image of a person's vision who has cataracts. Decreased vision due to cataracts may result in trouble reading and driving and increases the risk of falling. Patients often undergo surgery for cataracts. During cataract surgery, the doctor removes the clouded lens and replaces it with a new, artificial lens.⁴

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2. “[Cataract in human eye.png](#)” by Rakesh Ajuja, MD is licensed under [CC BY-SA 3.0](#)
3. “[Eye disease simulation, cataract.jpg](#)” by [National Eye Institute, National Institutes of Health](#) is in the [Public Domain](#).
4. National Eye Institute. (2023, November 15). *Cataracts*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/cataracts>

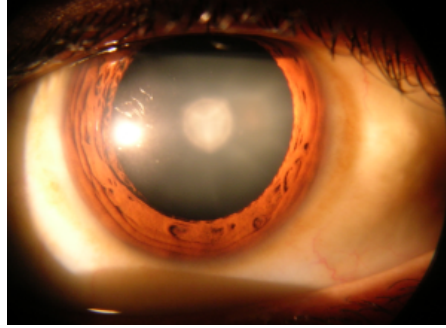


Figure 15.7 Cataract



*Figure 15.8 Simulated
Vision With Cataracts*

Color Blindness

Color blindness, also called color vision deficiency, makes it difficult to differentiate between certain colors. Color blindness tends to run in families as a genetic condition, but it can also occur due to damage to the eye or to the brain. There's no cure for color blindness, but special glasses and contact lenses can help people differentiate between colors. Most people who have

color blindness are able to use visual strategies related to color selection and don't have problems participating in everyday activities.⁵

Conjunctivitis

Conjunctivitis (kŏn-jŭnk-tĭ-VĪT-ĭs) is a viral or bacterial infection that causes swelling and redness in the conjunctiva and sclera. See Figure 15.9⁶ for an image of conjunctivitis. The eye may feel itchy and painful with crusty yellow drainage present. Bacterial conjunctivitis is treated with antibiotic eye drops. Viral conjunctivitis is typically mild and resolves on its own.⁷



Figure 15.9 Conjunctivitis

Diabetic Retinopathy

Diabetic retinopathy (ret-ĭn-ŌP-ă-thē) is a complication caused by diabetes

5. National Eye Institute. (2023, November 15). *Color blindness*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/color-blindness>
6. “Swollen eye with conjunctivitis.jpg” by Tanalai at English Wikipedia is licensed under [CC BY 3.0](https://creativecommons.org/licenses/by/3.0/)
7. National Eye Institute. (2019, July 8). *Causes of pink eye*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/pink-eye/causes-pink-eye>

mellitus. Fluid leakage from blood vessels causes the retinal tissue to swell, resulting in cloudy or blurred vision. If left untreated, diabetic retinopathy can cause blindness. There are various treatments for diabetic retinopathy, such as laser surgery to seal leaking blood vessels or the injection of medications into the eye to decrease inflammation. People with advanced cases of diabetic retinopathy may require surgery to remove and replace the gel-like fluid in the back of the eye, called the vitreous humor. Surgery may also be needed to repair a retinal detachment, a separation of the light-receiving lining in the back of the eye.⁸

Glaucoma

Glaucoma (glaw-KŌ-mă) is a disease that causes vision loss due to increased pressure inside the eye damaging the optic nerve. Treatment includes prescription eye drops to lower the pressure inside the eye and slow the progression of the disease. If not treated appropriately, glaucoma can cause blindness. Symptoms of glaucoma include gradual loss of peripheral vision. See Figure 15.10⁹ for a simulated image of a person's vision with glaucoma.¹⁰

8. American Optometric Association. (n.d.). *Diabetic retinopathy*. <https://www.aoa.org/healthy-eyes/eye-and-vision-conditions/diabetic-retinopathy?sso=y>
9. “Eye disease simulation, glaucoma.jpg” by National Eye Institute, National Institutes of Health is in the Public Domain.
10. National Eye Institute. (2023, November 15). *Glaucoma*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/glaucoma>



Figure 15.10 Simulated Vision With Glaucoma

Macular Degeneration

Age-related **macular degeneration** (MĂK-yŭ-lăR Dĕ-gĕn-ĕ-RĀ-shŭn) is a common condition that causes blurred central vision. It is the leading cause of vision loss for people 50 and older. See Figure 15.11¹¹ for a simulated image of a person's vision who has macular degeneration. There are two types of macular degeneration: dry (nonexudative) and wet (exudative). During dry macular degeneration, cellular debris called drusen accumulates and scars the retina. In the wet (exudative) form, which is more severe, blood vessels grow behind the retina and leak exudate fluid, causing hemorrhaging and scarring. There is no treatment for dry macular degeneration, but laser therapy can be used to help treat wet (exudative) macular degeneration.¹²

11. [“Eye disease simulation, age-related macular degeneration.jpg”](#) by [National Eye Institute, National Institutes of Health](#) is in the [Public Domain](#).

12. National Eye Institute. (2021, June 22). *Age-related macular degeneration*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/age-related-macular-degeneration>



Figure 15.11 Simulated Vision With Macular Degeneration

Myopia

Myopia (mī-Ō-pē-ă), also known as nearsightedness, means normal near vision but far-away objects appear blurry. Myopia occurs when the eyeball grows too long from front to back or when there are problems with the shape of the cornea or the lens. These problems make light focus in front of the retina, instead of on it, causing blurriness. See Figure 15.12¹³ for a simulated image of a person's vision who has myopia. Nearsightedness usually becomes apparent between ages 6 and 14. It is corrected with glasses, contacts, or LASIK surgery.¹⁴

13. “[Eye disease simulation, myopia.jpg](#)” by [National Eye Institute, National Institutes of Health](#) is in the [Public Domain](#).

14. National Eye Institute. (2020, August 28). *Types of refractive errors*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/refractive-errors/types-refractive-errors#section-id-6802>



Figure 15.12 Simulated Vision With Myopia

Night Blindness (Nyctalopia)

Nyctalopia (nik-ta-LŌ-pē-ă) refers to poor vision at night or in dim light. It is also associated with an inability to quickly adapt from a well-illuminated to a poorly illuminated environment. Nyctalopia is not a disease in itself, but rather a symptom of an underlying eye problem, usually a retinal problem.¹⁵

Nystagmus

Nystagmus (nīs-TĂG-mūs) is a disorder that causes involuntary, rhythmic eye movements. Most nystagmus disorders are caused by an underlying medical condition. The repetitive movements can make it impossible for someone to keep their eyes fixed and focused on any given object. Individuals can be born with congenital nystagmus, or it can occur as a result of another condition or a side effect of medication.¹⁶

15. Cleveland Clinic. (2020, December 1). *Night blindness (nyctalopia)*. <https://my.clevelandclinic.org/health/symptoms/10118-night-blindness-nyctalopia>

16. All About Vision. (2019, March 4). *Nystagmus*. <https://www.allaboutvision.com/conditions/nystagmus.htm>

Hyperopia and Presbyopia

Hyperopia (hī-pĕr-Ō-pē-ă) refers to impaired near vision, commonly referred to as “farsightedness” because distance vision is normal but near vision is impaired. When it occurs in middle-aged and older adults, it is referred to as **presbyopia** (prez-bī-Ō-pē-ă). As people age, the lens in the eye gets harder and less flexible and stops focusing light correctly on the retina. Presbyopia can be corrected with glasses and/or contacts.¹⁷ See Figure 15.13¹⁸ for a simulated image of a person’s vision who has presbyopia.



Figure 15.13 Presbyopia

Retinal Detachment

Retinal detachment occurs when the retina is pulled away or separated from its normal position. Sudden flashing lights, floaters, and the appearance of a dark shadow in the center of one’s vision are symptoms of a retinal tear. A retinal tear is a medical emergency because it can lead to a retinal detachment. If left untreated, retinal detachment can lead to blindness.

17. National Eye Institute. (2020, August 28). *Types of refractive errors*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/refractive-errors/types-refractive-errors#section-id-6802>

18. “Pesto ingredients – blurred.jpg” by Colin is licensed under [CC BY-SA 4.0](#)

Ophthalmologists repair the retinal detachment using laser surgery, freezing treatment, and/or other types of surgery to fix the retinal tear and reattach the retina to the back of the eye.¹⁹

Strabismus

Usually, the eyes move together as a pair, but with **strabismus** (stră-BĪZ-mŭs), the eyes don't move together in coordination. One eye might drift in, out, up, or down. If not managed, amblyopia can develop. **Amblyopia** (am-blē-Ō-pē-ă), commonly known as lazy eye, develops when there is a breakdown in how the brain and the eye work together. Over time, the brain relies more and more on the other, stronger eye, while vision in the weaker eye gets worse.²⁰

Stye

A **stye** (stī) is a bacterial infection of an oil gland of the eyelid, causing a red, tender bump. See Figure 15.14²¹ for an image of a stye. Treatment includes applying warm compresses to the eyelid and prescription eyedrops.²²

19. National Eye Institute. (2023, November 15). *Retinal detachment*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/retinal-detachment>
20. National Eye Institute. (2022, September 22). *Amblyopia (lazy eye)*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/amblyopia-lazy-eye>
21. "[External hordeolum.jpg](#)" by [Inrankabirhossain](#) is licensed under [CC BY-SA 4.0](#)
22. National Eye Institute. (2023, November 15). *Blepharitis*. National Institutes of Health. <https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/blepharitis>



Figure 15.14 Stye

EAR DISEASES AND DISORDERS

Hearing Loss

Hearing loss is classified as conductive hearing loss or sensorineural hearing loss. **Conductive hearing loss** (kŏn-DUC-tĭv HĒR-ing LŎS) occurs when something in the external or middle ear is obstructing the transmission of sound. For example, cerumen impaction or a perforated tympanic membrane can cause conductive hearing loss. **Sensorineural hearing loss** (sĕn-sŏ-rĕ-NOOR-ăĭ HĒR-ing LŎS) is caused by pathology of the inner ear, nerve damage, or damage to the auditory areas of the brain. **Presbycusis** (prĕz-bĭ-KŪ-sĭs) is sensorineural hearing loss that occurs with aging due to gradual nerve degeneration.²³

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Cerumen Impaction

Cerumen impaction (sě-ROO-měň Im-PĀK-shŭn) is earwax buildup that blocks the ear canal and can cause symptoms of hearing loss. See Figure 15.15 for an image of cerumen impaction.²⁴ Cerumen can be removed via irrigation of the ear canal, ear drops to dissolve the wax, or manual removal.²⁵ See Figure 15.15 for an image of an ear irrigation procedure, commonly performed by nurses in a clinic setting.²⁶



Figure 15.15 Cerumen Impaction

24. “[Ear Wax.JPG](#)” by [Anand2202](#) is licensed under [CC BY-SA 4.0](#)

25. This work is a derivative of [StatPearls](#) by Mankowski & Raggio and is licensed under [CC BY 4.0](#)

26. “150915-F-GO352-025.jpg” by Staff Sgt. Jason Huddleston for U.S. Air Force is licensed under [CC0](#). Access for free at <https://www.59mdw.af.mil/News/Article-Display/Article/647342/photo-essay-559th-medical-group-at-a-glance/>



Figure 15.16 Ear Irrigation Procedure

Otitis Externa

Otitis externa (ō-TĪ-tīs eks-TUR-nă) is an external ear inflammation and/or infection. See Figure 15.17²⁷ for an image of otitis externa. It is also known as “swimmer’s ear” because it commonly occurs in swimmers due to the continuous exposure to water that washes away the protective wax in their ear canals. Otitis externa causes a reddened and swollen ear canal with associated yellow, white, or grey debris. Patients often report itching in the ear canal with pain that is worsened by pulling upwards and outwards on the auricle. Otitis externa is treated with antibiotic drops placed in the affected ear canal.²⁸

27. “Otitis externa.gif” by S. Bhjimji MD is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/). Access for free at <https://www.ncbi.nlm.nih.gov/books/NBK556055/>

28. This work is a derivative of [StatPearls](https://www.statpearls.com/) by Medina-Blasini & Sharman and is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)



Figure 15.17 Otitis Externa

Otitis Media

Otitis media (ō-Tĭ-tīs MĒ-dē-ă) refers to a middle ear infection. Ear infections are common in children between the ages of 6 months and 2 years because of the size and shape of their Eustachian tubes. Acute otitis media typically occurs after an upper respiratory infection when the Eustachian tube becomes inflamed and the middle ear fills with fluid, causing ear pain and irritability. This fluid can become infected, causing purulent fluid and low-grade fever. Otitis media is diagnosed by a health care provider using an **otoscope** (Ō-tō-skōp) to examine the tympanic membrane for bulging and purulent fluid. If not treated, acute otitis media can potentially cause perforation of the tympanic membrane. Treating early acute otitis media with antibiotics is controversial in the United States due to the effort to prevent antibiotic resistance. However, the treatment goals are to control pain and treat infection with antibiotics if a bacterial infection is present.²⁹

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Some children develop recurrent ear infections that cause intermittent hearing loss affecting their language development. For children experiencing recurring infections, a surgery called **myringotomy** (mĭr-ĭn-GŎT-ō-mē) is performed by an otolaryngologist. During myringotomy surgery, a tympanostomy tube is placed in the tympanic membrane to drain fluid from the middle ear and prevent infection from developing.³⁰ See Figure 15.18³¹ for an image of a tympanostomy tube in the ear.

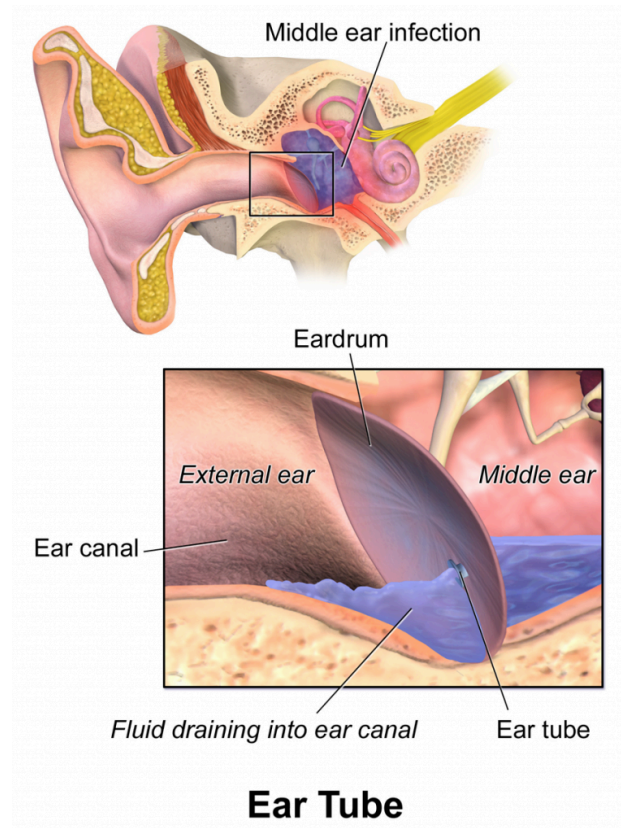


Figure 15.18 Tympanostomy Tube

30. This work is a derivative of [StatPearls](#) by Danishyar & Ashurst and is licensed under [CC BY 4.0](#)

31. "[Ear Tube.png](#)" by [BruceBlaus](#) is licensed under [CC BY-SA 4.0](#)

Otosclerosis

Otosclerosis (ō-tō-sklĕ-RŌ-sĭs) is abnormal bone formation of the middle ear that can cause hearing loss. Treatment for mild otosclerosis is use of a hearing aid, while more severe otosclerosis is treated with surgery called **stapedectomy** (stā-pĕ-DEK-tŏ-mē).³²

Presbycusis

Presbycusis (prez-bĭ-KŪ-sĭs) refers to hearing impairment that occurs with aging. One in three people in the U.S. between the ages of 65 and 74 has hearing loss, and nearly half of those older than 75 have difficulty hearing. Having trouble hearing can make it hard to understand and follow a doctor's advice; respond to warnings; and hear phones, doorbells, and smoke alarms. As we age, changes in the inner ear, middle ear, and nerve pathways from the ear to the brain are common. Long-term exposure to noise and some medical conditions can also play a role in hearing loss. Recent research suggests that certain genes make some people more susceptible to hearing loss as they age. Hearing loss may be treated with hearing aids or cochlear implants.³³

Tinnitus

Tinnitus (tĭ-NĪ-tŭs) is a ringing, buzzing, roaring, hissing, or whistling sound in the ears. The noise may be intermittent or continuous. Tinnitus can be caused by cerumen impaction, noise trauma, or ototoxic medications, such as diuretics or high doses of aspirin. Military personnel have a high incidence of tinnitus due to noise trauma from loud explosions and gunfire. There are no

32. National Institute on Deafness and Other Communication Disorders. (2022, March 16). *Otosclerosis*. National Institutes of Health.
<https://www.nidcd.nih.gov/health/otosclerosis>

33. National Institute on Deafness and Other Disorders. (2023, March 17). *Age-related hearing loss (presbycusis)*. National Institutes of Health.
<https://www.nidcd.nih.gov/health/age-related-hearing-loss>

medications to treat tinnitus, but patients can be referred to an otolaryngologist for treatment such as cognitive therapy or noise masking.³⁴

Vertigo

Vertigo (VUR-tĩ-gō) is a type of dizziness that is often described by patients as, “the room feels as if it is spinning.” Benign positional vertigo (BPV) is a common condition caused by crystals becoming lodged in the semicircular canals in the vestibule of the inner ear that send false signals of movement to the brain. BPV can be treated by trained professionals using a specific set of maneuvers that guide the crystals back to the chamber where they are supposed to be in the inner ear.³⁵

OLFACTORY DISORDERS

Anosmia

Trauma to the face and certain medications can damage the olfactory nerve and cause the loss of smell, known as **anosmia** (a-NOZ-mē-ă). There are also temporary causes of anosmia, such as the inflammatory response related to upper respiratory infections or allergies. The sense of smell is important because it is often the first warning signal alerting us to the smoke of a fire, spoiled food, or the odor of a natural gas leak or dangerous fumes. Anosmia can also result in the loss of taste. A person with an impaired sense of taste

34. This work is a derivative of [StatPearls](#) by Grossan & Peterson and is licensed under [CC BY 4.0](#)

35. Woodhouse, S., & Doriangricchia, J. P. (2022, November). *Benign paroxysmal positional vertigo (BPPV)*. Vestibular Disorders Association. <https://vestibular.org/article/diagnosis-treatment/types-of-vestibular-disorders/benign-paroxysmal-positional-vertigo-bppv/>

may require additional spice and seasonings on their food, and in severe cases, cause the loss of their desire to eat.³⁶

³⁶. National Institute on Deafness and Other Communication Disorders. (2023, July 31). *Smell disorders*. National Institutes of Health.
<https://www.nidcd.nih.gov/health/smell-disorders>

15.6 Medical Specialties, Diagnostic Testing, and Procedures Related to the Sensory System

MEDICAL SPECIALISTS

Several medical specialists help diagnose and treat conditions related to the eye. An **ophthalmologist** (öp-thäl-MÖL-ō-jĭst) is a physician who specializes in treating eye diseases and performs eye surgery. An **optometrist** (öp-TÖM-ě-trĭst) is a doctor who has received a Doctor of Optometry (op-TOM-ě-trē) degree. Optometrists perform eye exams and vision tests and prescribe corrective lenses. **Opticians** (öp-TĭSH-ănz) are technicians trained to design, verify, and fit eyeglass lenses and frames, contact lenses, and other devices to correct eyesight. They use prescriptions supplied by ophthalmologists or optometrists, but do not test vision or write prescriptions for visual correction.¹

1. American Association for Pediatric Ophthalmology and Strabismus (2019, February 26). *Difference between an ophthalmologist, optometrist, and optician*. <https://aapos.org/glossary/difference-between-an-ophthalmologist-optometrist-and-optician>

- ▶ Read additional information on the American Association for Pediatric Ophthalmology and Strabismus: [Difference Between An Ophthalmologist, Optometrist, and Optician web page](#).

Audiology (od-ē-OL-ō-jē) is the study of hearing. **Audiologists** (od-ē-OL-ō-jīstz) are specialists who study and treat hearing. They perform diagnostic testing like audiometry and provide hearing loss interventions, such as hearing aids. **Otology** (ō-TŌL-ō-jē) refers to the study of the ear. An **otolaryngologist** (ō-tō-RĪ-nō-lār-ĭn-GŎL-ō-jīst) is a physician who specializes in ear, nose, and throat (ENT) treatments and conditions.²

- ▶ Read additional information about audiologists on the American Academy of Audiology's [What is An Audiologist?](#) web page.

Ophthalmic Medical Assistant

Ophthalmic medical assistants work in ophthalmology and optometry practices and in retail optical settings. Ophthalmic assistants perform prescreening and specialty testing, assist with dispensing glasses and contact lenses, and perform office management duties, including maintaining patient information and billing and insurance processes.

2. Johns Hopkins Medicine. (n.d.). *Hearing loss*.

<https://www.hopkinsmedicine.org/health/conditions-and-diseases/hearing-loss>

Optometric Technician

Optometric technicians work under the supervision of an optometrist or ophthalmologist. Optometric technicians assist an optometrist during eye exams and other optometric procedures.

DIAGNOSTIC TESTING

Eye Exams

Common tools used to screen individuals for vision problems are the Snellen chart, a near vision chart, and Ishihara plates. If a vision problem is identified, the patient is referred to an optometrist for further vision testing. An **ophthalmoscope** (op-THAL-mŏ-skōp) is an instrument used to view the eye, and **ophthalmoscopy** (op-thal-MOS-kŏ-pē) is the process of viewing the eye.

Snellen Chart

Distant vision is tested by using the Snellen chart. See Figure 15.19³ for an image of the Snellen chart. The patient is placed 20 feet away from the chart and asked to cover one eye and read the letters from the lowest line they can see clearly. This is repeated with the other eye. A person with normal **visual acuity** (VIZH-u-ăl ă-KŪ-īt-ē) or sharpness or clearness of vision is documented as having 20/20 vision. A person with impaired vision has a different lower denominator of this fraction. For example, a vision measurement of 20/30 indicates that the patient has decreased distant vision and can see letters clearly at 20 feet that a person with normal vision can see clearly at 30 feet.⁴

3. "[Snellen chart.jpg](#)" by [Jeff Dahl](#) is licensed under [CC BY-SA 3.0](#)

4. Sue, S. (2007). Test distance vision by using a Snellen chart. *Community Eye Health*, 20(63), 52. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2040251/>

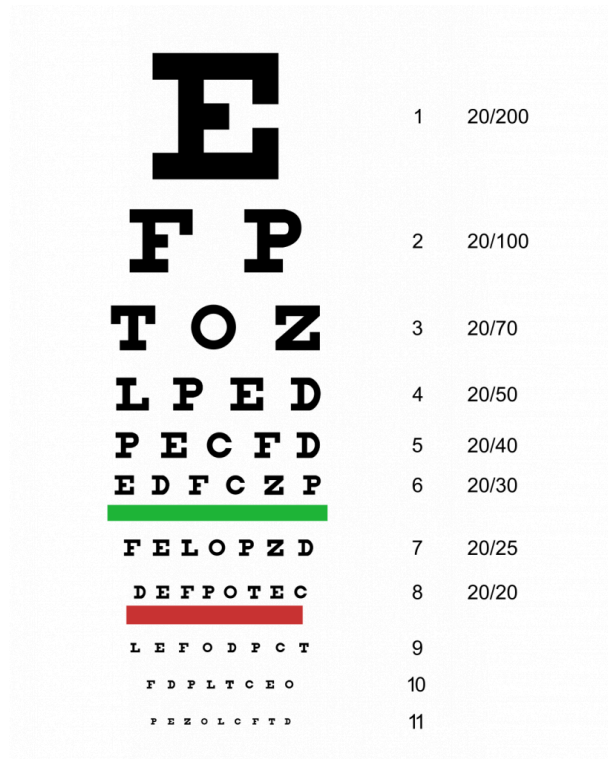


Figure 15.19 Snellen Chart

Near Vision Chart

Near vision is assessed by having a patient read from a prepared card that is held 14 inches away from the eyes. See Figure 15.20⁵ for an image of a prepared card used to assess near vision.

5. "111012-F-ZT401-067.JPG" by Airman 1st Class Brooke P. Beers for U.S. Air Force is in the [Public Domain](https://www.pacaf.af.mil/News/Article-Display/Article/593609/keeping-sight-all-right/). Access for free at <https://www.pacaf.af.mil/News/Article-Display/Article/593609/keeping-sight-all-right/>

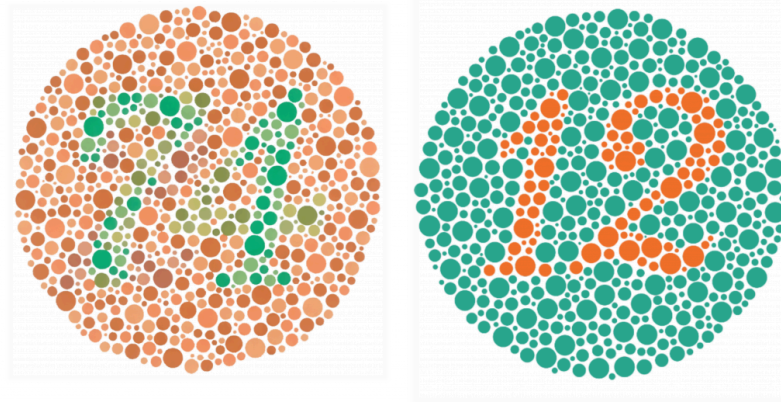


Figure 15.21 Ishihara Plates

Ear Exams

An **otoscope** (Ō-tō-skōp) is an instrument used to view the ear, and **otoscopy** (ō-TŌS-kō-pē) is the process of viewing the ear.

Audiometry

Audiometry (od-ē-OM-ě-trē) refers to diagnostic testing that measures hearing. This includes tests of mechanical sound transmission (middle ear function), neural sound transmission (cochlear function), and speech discrimination ability (central integration). A complete evaluation of a patient's hearing is done by trained personnel using instruments designed specifically for this purpose. For example, an **audiometer** (od-ē-OM-ět-ěr) is an electric instrument consisting of a tone generator, a bone conduction oscillator for measuring cochlear function, and earphones for air conduction testing. Sounds are played through headphones to one ear at a time, and the patient is asked to respond if they hear each sound. An **audiogram** (OD-ē-ō-gram) is a chart that shows the results of a hearing test. It shows how well sounds are heard in terms of frequency (high-pitched sounds versus low-pitched sounds) and intensity (loudness).⁷

⁷ Johns Hopkins Medicine. (n.d.). *Hearing loss*.

<https://www.hopkinsmedicine.org/health/conditions-and-diseases/hearing-loss>

15.7 Sensory System Learning Activities

Interactive Learning Activity: Practice labeling the parts of the eye, Activity 1.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=401#h5p-66>

Interactive Learning Activity: Practice labeling the parts of the eye, Activity 2.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=401#h5p-69>

Interactive Learning Activity: Practice labeling the parts of the ear.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=401#h5p-64>

Interactive Learning Activity: Study sensory system medical terms discussed in this chapter using these

flashcards.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=401#h5p-191>

Interactive Learning Activity: Check your knowledge of sensory system terminology.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=401#h5p-74>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=401#h5p-71>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it

online here:

<https://wtcs.pressbooks.pub/medterm/?p=401#h5p-72>



Interactive Learning Activity: Practice identifying and defining word parts for terms discussed in this chapter.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=401#h5p-210>

- ▶ You can also print this as a [Chapter 15 Practice Worksheet](#) and check your answers with this [Answer Key PDF](#).

15.8 Glossary

Amblyopia (am-blē-Ō-pē-ă): Often called “lazy eye,” a vision development disorder where an eye fails to achieve normal visual acuity. ([Chapter 15.5](#))

Anosmia (a-NŌZ-mē-ă): Loss or impairment of the sense of smell, which can be temporary or permanent. ([Chapter 15.5](#))

Astigmatism (ă-STIG-mă-tizm): A vision condition that causes blurred vision due to the irregular curvature of the cornea or lens. ([Chapter 15.5](#))

Audiogram (AW-dē-ō-gram): A graphic record of the results of a hearing test, typically showing hearing sensitivity at different frequencies. ([Chapter 15.6](#))

Audiologists (aw-dē-OL-ŏ-jĭsts): Health care professionals specializing in diagnosing, managing, and treating hearing or balance problems. ([Chapter 15.6](#))

Audiology (aw-dē-OL-ŏ-jē): The study of hearing. ([Chapter 15.6](#))

Audiometer (aw-dē-OM-ĕt-ĕr): An electronic device used in audiometry to generate pure tones of controlled intensity for hearing testing. ([Chapter 15.6](#))

Audiometry (aw-dē-OM-ĕ-trē): The testing of a person’s hearing ability, usually by producing sounds of different frequencies and intensities. ([Chapter 15.6](#))

Auricle (AW-rĭ-kl): The large fleshy structure on the lateral aspect of the head, directing sound waves into the ear canal. ([Chapter 15.4](#))

Cataract (KAT-ă-rakt): A progressive disease of the lens causing cloudiness and lack of transparency, leading to vision impairment. ([Chapter 15.5](#))

Cerumen impaction (sĕ-ROO-mĕn Im-PĂK-shŭn): The buildup of earwax (cerumen) in the ear canal, which can lead to symptoms such as hearing loss, tinnitus, or discomfort. ([Chapter 15.5](#))

Cochlea (KŎK-lē-ă): A part of the inner ear involved in hearing; it converts sound waves into neural signals. ([Chapter 15.4](#))

Conductive hearing loss (kŏn-DUC-tĭv HĒR-ing LŎS): Hearing loss caused by problems with the ear canal, eardrum, or middle ear and its little bones (the malleus, incus, and stapes). ([Chapter 15.5](#))

Conjunctiva (kǒn-jǔnk-TI-va): The inner surface of each lid, a thin membrane that extends over the white areas of the eye called the sclera, connecting the eyelids to the eyeball. ([Chapter 15.4](#))

Conjunctivitis (kǒn-jǔnk-tǐ-VĪT-ĭs): An infection or inflammation of the conjunctiva, causing redness, swelling, and often discharge in the eye. ([Chapter 15.5](#))

Cornea (KOR-nē-ă): The transparent front part of the eye covering the iris, pupil, and anterior chamber, playing a key role in focusing vision. ([Chapter 15.4](#))

Diabetic retinopathy (ret-ĭn-OP-ă-thē): A complication of diabetes mellitus causing fluid leakage from blood vessels in the retina, leading to vision impairment. ([Chapter 15.5](#))

Eustachian tube (yōō-STĀ-shən tūb): A tube connecting the middle ear to the pharynx, helping equalize air pressure across the tympanic membrane. ([Chapter 15.4](#))

Glaucoma (glăw-KŌ-mă): A group of eye conditions that damage the optic nerve, often caused by abnormally high pressure in the eye. ([Chapter 15.5](#))

Hyperopia (hī-pěr-Ō-pē-ă): Also known as farsightedness, a condition where distant objects can be seen more clearly than close ones. ([Chapter 15.5](#))

Incus (ĪN-kŭs): A small anvil-shaped bone in the middle ear, connecting the malleus to the stapes. ([Chapter 15.4](#))

Inner ear (IN-er ĒR): The part of the ear that includes the cochlea, vestibule, and semicircular canals, responsible for processing sound and maintaining balance. ([Chapter 15.4](#))

Iris (IR-ĭs): The colored part of the eye, a smooth muscle that controls the diameter and size of the pupil. ([Chapter 15.4](#))

Lacrimal gland (LAK-rĭ-măl glănd): A gland located beneath the lateral edges of the nose that produces tears. ([Chapter 15.4](#))

Legal blindness (LĒ-găl BLĪND-něss): A defined level of visual impairment that has been established as a threshold for eligibility for governmental disability benefits; typically, visual acuity of 20/200 or less in the best-corrected eye. ([Chapter 15.5](#))

Low vision (LŌ VIZH-ŭn): A condition where an individual has significant visual impairment that cannot be fully corrected with standard glasses,

contact lenses, medicine, or surgery, and which interferes with daily activities. ([Chapter 15.5](#))

Macular degeneration (MĀK-yŭ-lǎr Dě-gĕn-ě-RĀ-shŭn): A common eye condition among older adults that leads to loss of vision in the center of the visual field (the macula) due to damage to the retina. ([Chapter 15.5](#))

Malleus (MĀL-ē-ŭs): A small bone in the middle ear attached to the tympanic membrane, resembling a hammer. ([Chapter 15.4](#))

Myopia (mī-Ō-pē-ă): Also known as nearsightedness, a common vision condition where distant objects appear blurry. ([Chapter 15.5](#))

Myringotomy (mŭr-ĭn-GŎT-ō-mē): A surgical procedure where a small incision is made in the eardrum to relieve pressure or drain fluid. ([Chapter 15.5](#))

Nyctalopia (nik-ta-LŌ-pē-ă): Poor vision at night or in dimly lit environments, commonly known as night blindness. ([Chapter 15.5](#))

Nystagmus (nŭs-TĀG-mŭs): Involuntary rhythmic movement of the eyes, which can impair vision and affect balance. ([Chapter 15.5](#))

Ophthalmologist (ŏp-thăl-MŎL-ō-jŭst): A physician who specializes in diagnosing and treating eye disorders and performing eye surgery. ([Chapter 15.6](#))

Ophthalmoscope (op-THAL-mŏ-skŏp): An instrument used to examine the interior structures of the eye. ([Chapter 15.6](#))

Ophthalmoscopy (op-thal-MOS-kŏ-pē): The examination of the interior of the eye, particularly the retina, using an ophthalmoscope. ([Chapter 15.6](#))

Optic nerve (OP-tik nerv): The nerve that transmits visual information from the retina to the brain. ([Chapter 15.4](#))

Opticians (ŏp-TĪSH-ăns): Technicians who design, verify, and fit eyeglass lenses and frames, contact lenses, and other devices to correct eyesight. ([Chapter 15.6](#))

Optometrist (ŏp-TŎM-ě-trĭst): A health care professional who examines eyes for vision and health problems and prescribes corrective lenses. ([Chapter 15.6](#))

Otitis externa (ō-TĪ-tĭs eks-TUR-nă): Inflammation or infection of the outer ear canal, often referred to as “swimmer’s ear.” ([Chapter 15.5](#))

Otitis media (ō-TĪ-tĭs MĒ-dē-ă): Inflammation or infection of the middle ear,

common in children and often associated with upper respiratory infections. ([Chapter 15.5](#))

Otolaryngologist (ō-tō-lăr-ĭn-GŎL-ō-jĭst): A physician who specializing in ear, nose, and throat disorders, also known as an ENT doctor. ([Chapter 15.6](#))

Otology (ō-TŎL-ō-jē): The study of the ear and its diseases. ([Chapter 15.6](#))

Otosclerosis (ō-tō-sklĕ-RŌ-sĭs): A hearing loss condition caused by abnormal bone growth in the middle ear. ([Chapter 15.5](#))

Otoscope (Ō-tō-skōp): An instrument used for visual examination of the ear canal and tympanic membrane. ([Chapter 15.5](#), [Chapter 15.6](#))

Otoscopy (ō-TŎS-kō-pē): The examination of the ear canal and eardrum with an otoscope. ([Chapter 15.6](#))

Pinna (PĪN-ă): Another term for the auricle, the visible part of the ear that resides outside of the head. ([Chapter 15.4](#))

Presbycusis (prez-bĭ-KŪ-sĭs): Age-related hearing loss, often due to gradual nerve degeneration and other changes in the inner ear. ([Chapter 15.5](#))

Presbyopia (prez-bĭ-Ō-pē-ă): An age-related condition in which the ability to focus on close objects decreases over time. ([Chapter 15.5](#))

Pupil (PŪ-pĭl): The hole at the center of the eye that allows light to enter, its size is controlled by the iris. ([Chapter 15.4](#))

Retina (RĚT-ĭ-nă): The innermost layer of the eye, containing photoreceptors and nerve cells for initial processing of visual stimuli. ([Chapter 15.4](#))

Sclera (sklĕr-ă): The white, outer layer of the eyeball that extends from the cornea to the optic nerve at the back of the eye. ([Chapter 15.4](#))

Sensorineural hearing loss (sĕn-sō-rĕ-NOOR-ăĭ HĒR-ing LŎS): A type of hearing loss resulting from damage to the inner ear (cochlea) or to the nerve pathways from the inner ear to the brain. ([Chapter 15.5](#))

Stapedectomy (stā-pĕ-DEK-tŏ-mē): A surgical procedure to remove part or all of the stapes bone and replace it with a prosthesis to improve hearing. ([Chapter 15.5](#))

Stapes (STĀ-pĕz): A stirrup-shaped bone in the middle ear, attached to the inner ear where sound waves are converted into neural signals. ([Chapter 15.4](#))

Strabismus (stră-BĪZ-mŭs): A condition where the eyes do not properly align with each other when looking at an object. ([Chapter 15.5](#))

Stye (STĭ): An infection of an oil gland in the eyelid, leading to a painful, red swelling on the eyelid. ([Chapter 15.5](#))

Tinnitus (tĭ-Nĭ-tŭs): A condition characterized by hearing ringing, buzzing, or other noises in the ear in the absence of external sound. ([Chapter 15.5](#))

Total blindness (TŌ-tăl BLĪND-nĕss): The complete absence of visual perception, characterized by the inability to perceive light or discern any visual images. ([Chapter 15.5](#))

Tympanic membrane (tĭm-PĀN-ik MEM-brān): Also known as the eardrum, it vibrates in response to sound waves. ([Chapter 15.4](#))

Vertigo (VUR-tĭ-gō): A sensation of spinning or dizziness, often caused by issues with the inner ear or vestibular system. ([Chapter 15.4](#), [Chapter 15.5](#))

Vestibule (ves-tĭ-bŭl): A part of the inner ear that contributes to balance and spatial orientation. ([Chapter 15.4](#))

Vestibulocochlear nerve (vēs-tĭ-bŭl-ō-KŌ-klē-ār nerv): The nerve that carries auditory and balance information from the inner ear to the brain. ([Chapter 15.4](#))

Visual acuity (VIZH-u-ăl ā-KŪ-ĭt-ē): The sharpness or clearness of vision, typically measured with a Snellen chart. ([Chapter 15.5](#), [Chapter 15.6](#))

Visual impairment (VIZH-ŭ-al Im-PĀR-mĕnt): A decrease in the ability to see to a significant degree, which may cause problems not fixable by usual means, such as glasses or medication. ([Chapter 15.5](#))

PART XVI

CHAPTER 16 NERVOUS SYSTEM TERMINOLOGY

16.1 Nervous System Introduction

Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the nervous system
- Identify meanings of key word components of the nervous system
- Categorize diagnostic, therapeutic, procedural, or anatomic terms related to the nervous system
- Use terms related to the nervous system
- Use terms related to the diseases and disorders of the nervous system

Introduction to the Nervous System

The nervous system includes the brain, the spinal cord, and a complex system of nerves. It uses electrical signals and chemical substances called neurotransmitters for communication across body parts.

This chapter will review common word components related to the nervous system to assist learners in analyzing, building, and defining medical terms. Other terms, whose definitions cannot be easily built from word components, will be described in context based on the anatomy and physiology of the nervous system and common diseases and disorders. Medical specialists,

diagnostic tests, and procedures related to the nervous system will also be discussed.

View a supplementary YouTube video¹ on the nervous
 system by Crash Course: [The Nervous System, Part 1: Crash Course Anatomy & Physiology #8](https://www.youtube.com/watch?v=qPix_X-9t7E)

1. CrashCourse. (2015, February 23). *The nervous system, Part 1: Crash Course Anatomy & Physiology #8* [Video]. YouTube. All rights reserved. https://www.youtube.com/watch?v=qPix_X-9t7E

16.2 Word Components Related to the Nervous System

This section will describe common word components related to the nervous system. These word components help build definitions for many medical terms. Other common prefixes are described in [Chapter 1.3](#), and common suffixes are described in [Chapter 1.5](#).

PREFIXES RELATED TO THE NERVOUS SYSTEM

- **a-**: Absence of, without, no, not
- **an-**: Absence of, without, no, not
- **dys-**: Abnormal, difficult, labored
- **hemi-**: Half
- **hyper-**: Above, excessive
- **inter-**: Between
- **intra-**: Within
- **pan-**: All, total
- **para-**: Beside, beyond, around, abnormal
- **poly-**: Many, much
- **post-**: After
- **pre-**: Before
- **sub-**: Below, under

WORD ROOTS WITH COMBINING VOWELS RELATED TO THE NERVOUS SYSTEM

- **alges/o**: Sensitivity to pain
- **cephal/o**: Head
- **cerebell/o**: Cerebellum
- **cerebr/o**: Cerebrum
- **dur/o**: Dura mater, hard
- **encephal/o**: Brain
- **esthesi/o**: Sensation, sensitivity
- **gangli/o**: Ganglion
- **ganglion/o**: Ganglion
- **gli/o**: Glia, gluey substance
- **mening/o**: Meninges
- **meningi/o**: Meninges
- **ment/o**: Mind
- **mon/o**: One, single
- **myel/o**: Spinal cord
- **neur/o**: Nerve
- **phas/o**: Speech
- **poli/o**: Gray matter
- **pont/o**: Pons (structure in the brain)
- **psych/o**: Mind
- **quadr/i**: Four
- **radic/o**: Nerve root
- **radicul/o**: Nerve root
- **rhiz/o**: Nerve root
- **thalam/o**: Thalamus
- **thec/o**: Sheath
- **vag/o**: Vagus nerve

SUFFIXES RELATED TO THE NERVOUS SYSTEM

- **-al**: Pertaining to
- **-algia**: Pain
- **-algesia**: Sensitivity to pain
- **-cele**: Hernia, protrusion
- **-cyte**: Cell
- **-ectomy**: Excision, surgical removal, cutting out
- **-genic**: Producing, originating, causing
- **-gram**: The record, radiographic image
- **-graph**: Instrument used to record
- **-graphy**: Process of recording, radiographic imaging
- **-ia**: Condition of, diseased state or abnormal state
- **-ic**: Pertaining to
- **-iatrist**: Specialist, physician
- **-iatry**: Specialty, treatment
- **-ictal**: Seizure, attack
- **-itis**: Inflammation
- **-lepsy**: Seizure
- **-logist**: Specialist who studies and treats
- **-logy**: Study of
- **-lysis**: Loosening, dissolution, separating
- **-malacia**: Softening
- **-oid**: Resembling
- **-oma**: Tumor
- **-osis**: Abnormal condition
- **-paresis**: Slight paralysis
- **-pathy**: Disease
- **-phasia**: Speech
- **-plasty**: Surgical repair
- **-plegia**: Paralysis
- **-praxia**: To perform, action

- **-sclerosis:** Hardening
- **-rrhaphy:** Suturing, repairing
- **-tomy:** Incision, cut into

16.3 Examples of Nervous System Terms Easily Defined By Their Word Components

Here are examples of common medical terms related to the nervous system that can be easily defined by breaking the terms into their word components.

Encephalitis

1. Break down the medical term into word components:
Encephal/itis
2. Label the word components: **Encephal** = WR; **itis** = S
3. Define the word components: **Encephal** = brain; **itis** = inflammation
4. Create a final definition of the medical term:
Inflammation of the brain

Neuralgia

1. Break down the medical term into word components:
Neur/algia
2. Label the word components: **Neur** = WR; **algia** = S

3. Define the word components: **Neur** = nerves; **algia** = pain
4. Create a final definition of the medical term: **Nerve pain**

Psychosis

1. Break down the medical term into word components:
Psych/osis
2. Label the word components: **Psych** = WR; **osis** = S
3. Define the word components: **Psych** = mind; **osis** = abnormal condition
4. Create a final definition of the medical term: **Abnormal condition of the mind**



Interactive Learning Activity: Practice defining and pronouncing medical terms related to the nervous system by breaking them down into word parts.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=6373#h5p-117>

- ▶ You can also print these flashcard activities as a [Chapter 16 Student Companion Worksheet](#) and check your answers with this [Answer Key](#).

16.4 Anatomy of the Nervous System

The nervous system is divided into two main parts called the central nervous system and the peripheral nervous system. See Figure 16.1¹ for an illustration of the nervous system.

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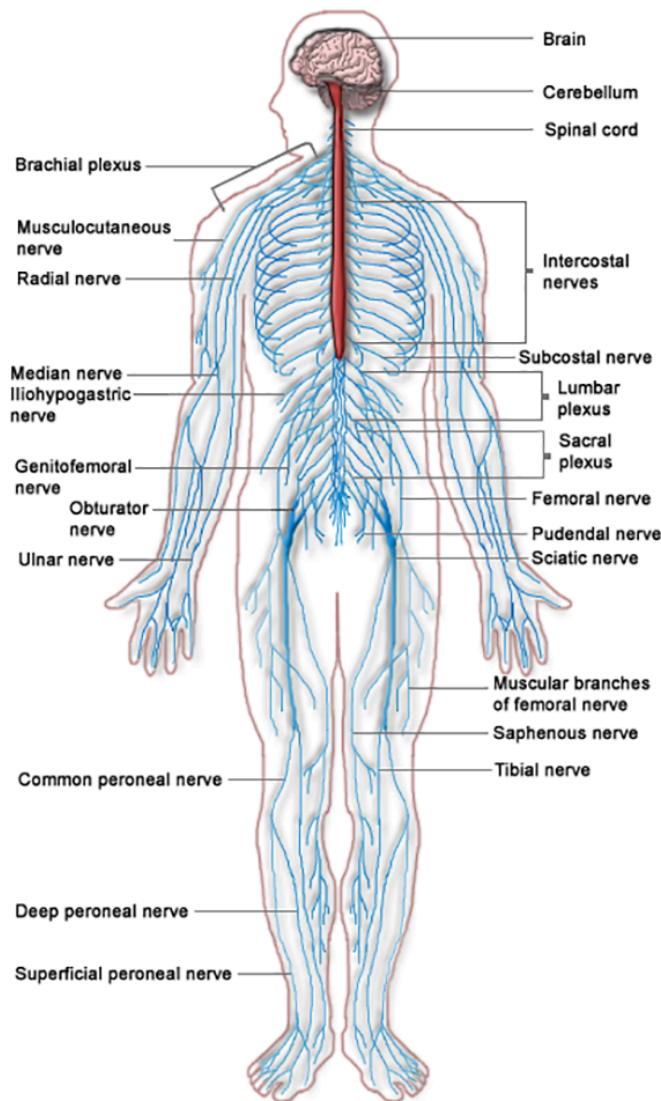


Figure 16.1 Nervous System

The Central Nervous System

The **central nervous system** (SEN-träl NŮR-vŭs SĪS-tēm) (**CNS**) includes the brain and the spinal cord. The brain can be described as the interpretation center, and the spinal cord can be described as the transmission pathway.²

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Brain

The major regions of the brain are the cerebrum, cerebral cortex, hypothalamus, thalamus, brain stem, and the cerebellum.

The largest portion of our brain is called the **cerebrum** (sě-rē-brŭm). The cerebrum is covered by a wrinkled outer layer of gray matter called the **cerebral cortex** (sě-rē-brăl kôr-těks). The cerebral cortex is involved in complex brain functions including memory, attention, perceptual awareness, thought, language, and consciousness. The cerebral cortex is divided into four lobes named the frontal, parietal, occipital, and temporal lobes. Each lobe has the following specific functions³:

- **Frontal Lobe** (FRŎN-tăl lōb): The frontal lobe is associated with movement. It contains neurons that instruct cells in the spinal cord to move skeletal muscles. The anterior portion of the frontal lobe is called the **prefrontal cortex** (prē-FRŎN-tăl KÔR-těks). The prefrontal cortex provides cognitive functions such as planning and problem-solving that are the basis of our personality, short-term memory, and consciousness. **Broca's area** (brō-kăz ăr-ē-ă) is located in the frontal lobe of the dominant hemisphere and is responsible for the production of language and controlling movements responsible for speech.
- **Parietal Lobe** (pă-rī-ě-tăl lōb): The parietal lobe processes general sensations, including touch, pressure, tickle, pain, itch, and vibration.
- **Temporal Lobe** (tēm-pŏ-răl lōb): The temporal lobe processes auditory information. **Wernicke's area** (wěr-nĭk-kēz ăr-ē-ă) is located in the temporal lobe of the dominant hemisphere and is responsible for the comprehension of written and spoken language. Because regions of the temporal lobe are part of the limbic system, memory is also an important function associated with the temporal lobe. The limbic system is involved

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with our behavioral and emotional responses needed for survival, such as feeding, reproduction, and the fight-or-flight responses.

- **Occipital Lobe** (ŏk-SĭP-ĭ-tăĭ lōb): The occipital lobe primarily processes visual information.

The **cerebellum** (sĕr-ĕ-bĕl-ŭm) is the posterior part of the brain that controls fine motor skills. See Figure 16.2⁴ for an illustration of the cerebellum and the lobes of the cerebral cortex.

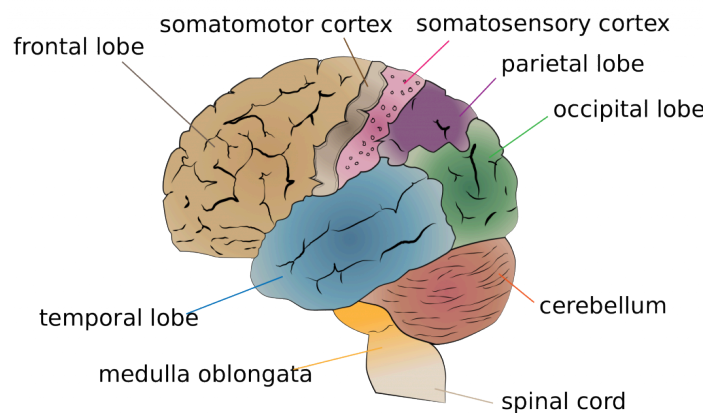


Figure 16.2 Cerebellum and Lobes of the Cerebrum

Deep within the cerebrum are the **hypothalamus** (hĭ-pō-THAL-ă-mŭs) and the **thalamus** (thăĭ-ă-mŭs). The hypothalamus coordinates the autonomic nervous system and the activity of the pituitary, controlling body temperature, thirst, hunger, and other homeostatic systems. The thalamus is

4. "[Cerebrum lobes.svg](#)" by [Jkwchui](#) is licensed under [CC BY-SA 3.0](#)

the relay center for sensory and motor signals to the cerebral cortex.⁵ See Figure 16.3⁶ for an illustration of the hypothalamus and the thalamus.

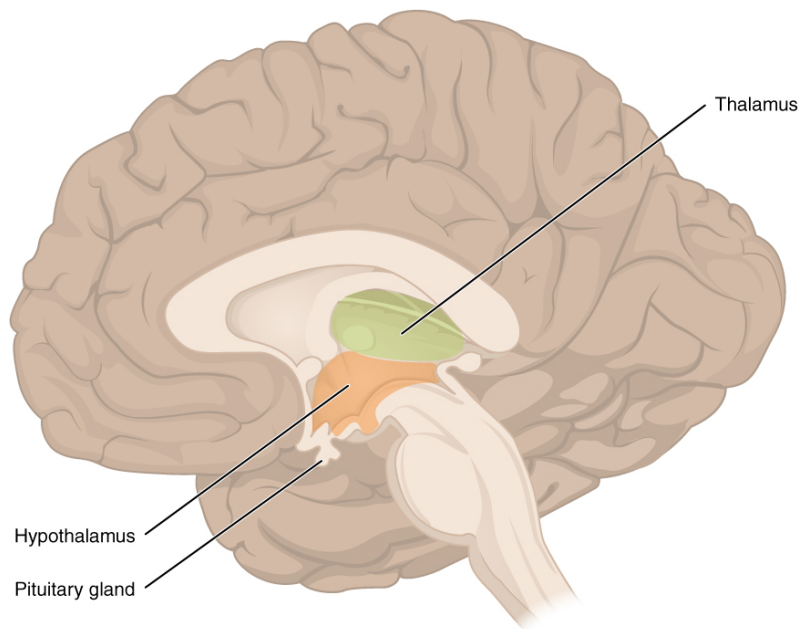


Figure 16.3 Hypothalamus and Thalamus

The **ventricles** (vĕn-trĭ-kŭls) are a group of interconnected, fluid-filled cavities within the brain. The **meninges** (mĕn-ĭn-jĕz) are three layered membranes that cover the brain and spinal cord. The **dura mater** (dŏŏ-ră mă-tĕr) is the tough outermost membrane enveloping the brain and spinal cord. The arachnoid layer is the web-like middle layer, and the pia mater is the delicate innermost layer of the meninges. The **brain stem** (brān stĕm) connects the spinal cord with the brain. It is composed of three parts, the midbrain, pons, and medulla oblongata. The brain stem regulates several crucial autonomic

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functions in the body, including involuntary functions in the cardiovascular and respiratory systems and reflexes like vomiting, coughing, sneezing, and swallowing.⁷

Spinal Cord

The **spinal cord** (spī-nāl kôrd) is a bundle of nerve fibers enclosed in the spine that connects nearly all parts of the body to the brain. It is a continuation of the brain stem that transmits sensory information to the brain and motor impulses to the muscles.⁸

Peripheral Nervous System

The **peripheral nervous system** (pě-rĭF-ěr-ăl NŮR-vŭs SĪS-těm) (**PNS**) consists of the remaining parts of the nervous system outside of the brain and spinal cord, including the cranial nerves that branch out from the brain and the spinal nerves that branch out from the spinal cord. The peripheral nervous system is the communication network between the brain and the body's parts.⁹

Cranial nerves (krā-nē-ăl nĕrvz) are directly connected from the brain to the periphery. They are primarily responsible for the sensory and motor functions of the head and neck. The **vagus nerve** (vā-gŭs nĕrv) is a cranial nerve that

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innervates the heart and digestive system and is involved in regulating many critical bodily functions.¹⁰

Spinal nerves (spī-nāl nĕrvz) are named based on the level of the spinal cord where they emerge. See Figure 16.4¹¹ for an illustration of spinal nerves. There are eight pairs of cervical nerves designated C1 to C8, twelve thoracic nerves designated T1 to T12, five pairs of lumbar nerves designated L1 to L5, five pairs of sacral nerves designated S1 to S5, and one pair of coccygeal nerves. All spinal nerves are mixed nerves, meaning they can carry both sensory and motor information. Spinal nerves extend outward from the vertebral column to innervate the periphery while also transmitting sensory information back to the brain.¹²

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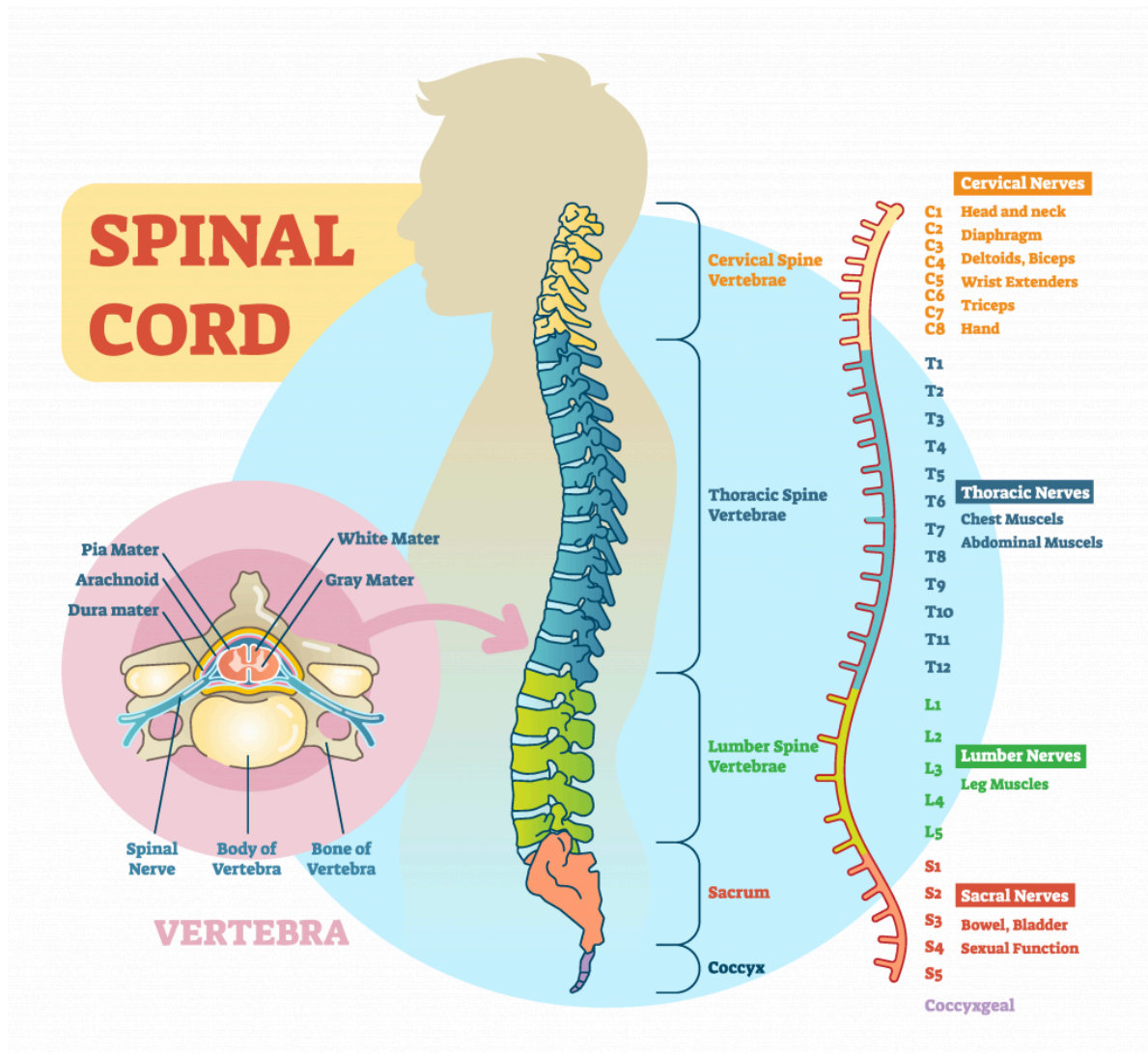


Figure 16.4 Spinal Nerves

Each spinal nerve innervates a specific region of the body¹³:

- C1 provides motor innervation to muscles at the base of the skull.
- C2 and C3 provide both sensory and motor control to the back of the head and behind the ears.
- The phrenic nerve from C3, C4, and C5 innervates the diaphragm to

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enable breathing. This is vital because if a patient has an injury where the spinal cord is cut above C3, then spontaneous breathing is not possible.

- C5 through C8 and T1 combine to form the brachial plexus, a tangled array of nerves that serve the upper limbs and upper back.
- The lumbar plexus arises from L1-L5 and innervates the pelvic region and the anterior legs.
- The sacral plexus comes from the lower lumbar nerves L4 and L5 and the sacral nerves S1 to S4. The sciatic nerve is a part of the sacral plexus. If the sciatic nerve becomes compressed due to degeneration of an intervertebral disc, a medical condition called **sciatica** (sī-ăt-ĭ-kă) occurs that causes pain in the back, hip, and outer side of the leg.

If a patient experiences a spinal cord injury, the degree of paralysis can be predicted by the location of the spinal cord injury. The higher up on the spinal cord an injury occurs, the greater loss of function. For example, a spinal cord injury higher on the spinal cord can cause paralysis in most of the body and affect all limbs (tetraplegia or quadriplegia). An injury that occurs lower on the spinal cord may only affect a person's lower body and legs (paraplegia).

Review information about paralysis in "[Diseases and Disorders of the Musculoskeletal System](#)" section of the Musculoskeletal System chapter.

It is also important to remember when a patient has a spinal cord injury and motor nerves are damaged, their sensory nerves may still be intact. If this occurs, the patient can still feel sensation even if they can't move the extremity.

NEURONS

Nervous tissues present in both the CNS and PNS contain two basic types of cells: neurons and neuroglia (glial cells). **Neurons** (nŭr-ŏns) are responsible for the communication that the nervous system provides. They are electrically

active and release chemical signals called neurotransmitters. Neuroglia plays a supporting role for nervous tissue.¹⁴

Neurons provide electrical signals that communicate information about sensations and, in response, stimulate movements. The three-dimensional shape of neurons makes massive numbers of connections within the nervous system. The main part of a neuron is the **cell body** (sěl bōd-ē). A fiber that emerges from the cell body and projects to target cells is called the **axon** (āk-sōn). A single axon can branch repeatedly to communicate with many target cells by sending nerve impulses. **Dendrites** (dĕn-drīt-z) conduct information received from other neurons at contact areas called a **synapse** (sĭn-ăps). A synapse is a junction between two nerve cells, consisting of a tiny gap through which neurotransmitters pass.¹⁵ See Figure 16.5¹⁶ for an illustration of a neuron.

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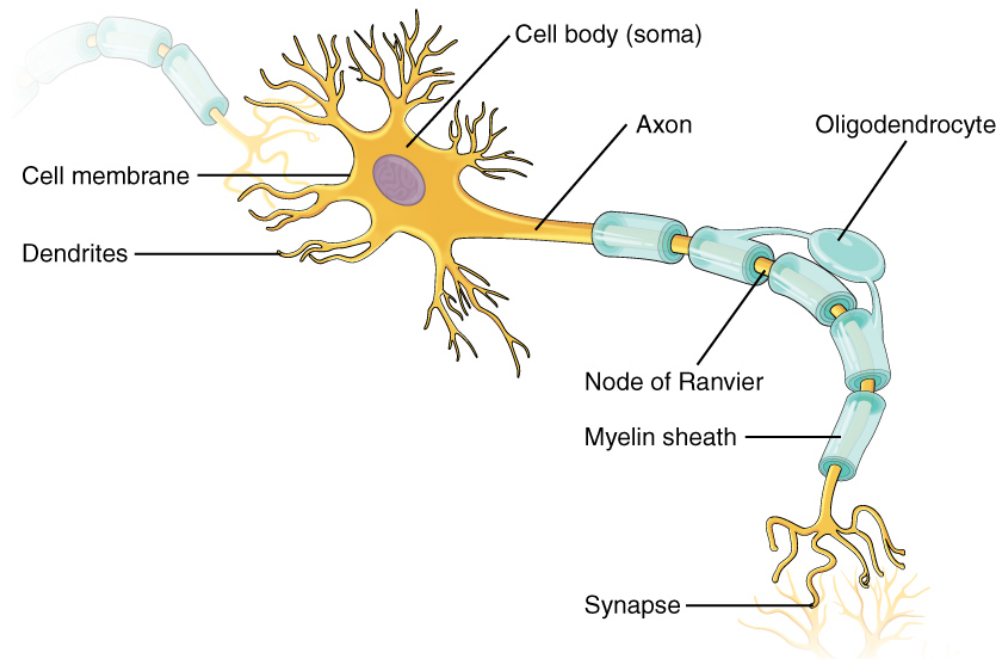


Figure 16.5 Neuron

Many axons are wrapped by an insulating substance called **myelin** (mī-ě-līn), which is made from neuroglia. Myelin acts as insulation much like the plastic or rubber that is used to insulate electrical wires.¹⁷

NEUROTRANSMITTERS

Electrical impulses from neurons signal the release of a **neurotransmitter** (nŭr-ō-trăns-mīt-ěr) into a synapse. Neurotransmitters allow the impulse to be transferred to a neuroreceptor on another neuron, muscle fiber, or other structure. Neuroreceptors are specific for certain neurotransmitters, and the

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two fit together like a key and lock.¹⁸ See Figure 16.6¹⁹ for an illustration of neuron communication.

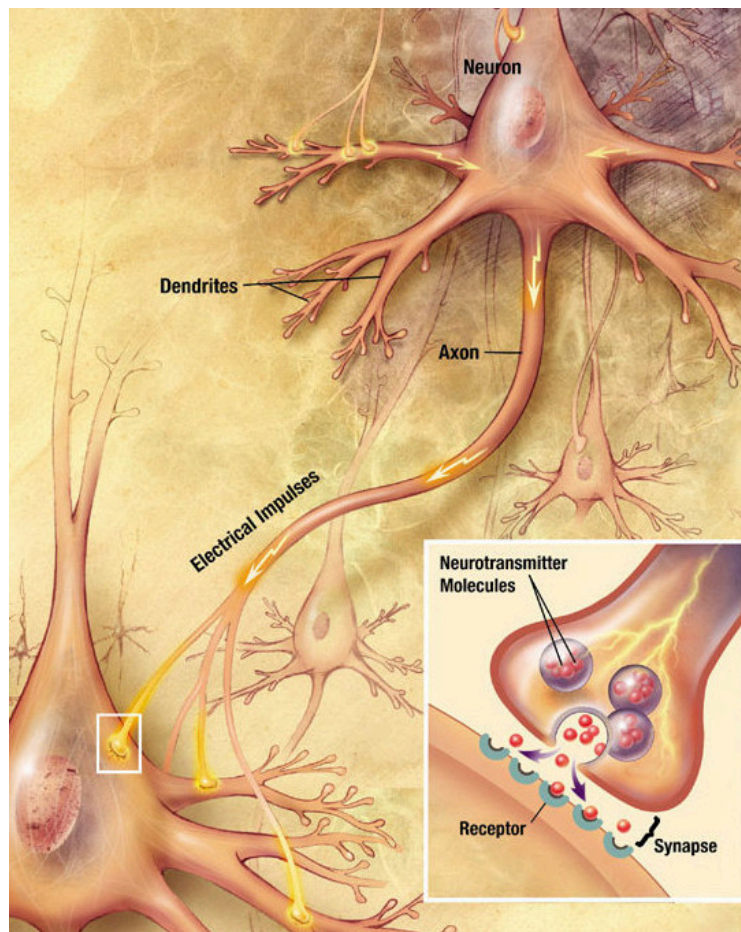


Figure 16.6 Neuron Communication

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- ¹⁹. “Chemical synapse schema cropped.jpg” by Looie496 is licensed under Public Domain. Access for free at [https://med.libretexts.org/Bookshelves/Anatomy_and_Physiology/Book%3A_Anatomy_and_Physiology_\(Boundless\)/10%3A_Overview_of_the_Nervous_System/10.1%3A_Introduction_to_the_Nervous_System/10.1A%3A_Organization_of_the_Nervous_System](https://med.libretexts.org/Bookshelves/Anatomy_and_Physiology/Book%3A_Anatomy_and_Physiology_(Boundless)/10%3A_Overview_of_the_Nervous_System/10.1%3A_Introduction_to_the_Nervous_System/10.1A%3A_Organization_of_the_Nervous_System)

Many nervous system diseases and mental health disorders are related to abnormal impulse transmission and/or imbalanced levels of neurotransmitters. For example, dopamine is a neurotransmitter that influences movement and cognition. Dopamine imbalances are associated with Parkinson's disease, schizophrenia, and substance use disorders. Serotonin is another type of neurotransmitter whose imbalance affects moods and feelings of depression. Medications used to treat many mental health disorders help balance neurotransmitter levels.²⁰

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16.5 Physiology of the Nervous System

MAJOR FUNCTIONS OF THE NERVOUS SYSTEM

Three main functions of the nervous system are sensation, response, and integration.¹

Sensation

The first major function of the nervous system is sensation (i.e., receiving information about what is happening within or outside the body). Our five senses receive sensations from the outside world, and various receptors within the body receive internal sensations.²

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Read more information about the five senses in the “[Sensory System Terminology](#)” chapter.

Paresthesia (par-es-THĒ-zh(ē-)ă) refers to an abnormal sensation in the extremities (i.e., numbness, tingling, and pain), and **anesthesia** (an-ēs-THĒ-zhă) refers to a lack of feeling or sensation.

Response

The nervous system produces a response based on sensations received. For example, if our hand accidentally touches a hot stove, the nervous system automatically and quickly moves the hand away. Responses can be classified as voluntary (such as contraction of skeletal muscle) and involuntary (such as contraction of smooth muscles, regulation of cardiac muscle, and activation of endocrine glands).³

Voluntary responses are governed by the somatic nervous system, and involuntary responses are governed by the autonomic nervous system. The somatic nervous system is responsible for conscious perception, senses, and voluntary motor responses. An example of the somatic nervous system is when a person purposefully takes deep breaths to quell feelings of anxiety.⁴

The autonomic nervous system (ANS) is responsible for involuntary regulation of body processes to maintain homeostasis. For example, sweat

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glands are controlled by the autonomic nervous system. When a person receives the sensation of feeling hot, the ANS system processes this information and automatically creates a response of sweating to help cool down the body.⁵

The autonomic nervous system is further divided into the sympathetic nervous system and the parasympathetic nervous system. The sympathetic nervous system is responsible for “fight or flight” responses, and the parasympathetic nervous system controls rest and digestive functions.⁶

Integration

Stimuli are interpreted and acted upon by the brain during a process referred to as integration. The brain analyzes stimuli with other perceived stimuli, memories of previous stimuli, or the person’s emotional state and generates a specific response. For example, a person may receive an internal sensation from the bladder for the need to urinate. However, the brain analyzes that stimulus and integrates it with the awareness of being in a public area and postpones the response to urinate until there is time to locate a nearby restroom.⁷

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HIGHER MENTAL FUNCTIONS

The cerebral cortex performs higher mental functions referred to as cognitive abilities. The responsibilities for these cognitive abilities are distributed across regions of the cortex, and specific locations can be said to be responsible for particular functions. For this reason, if a particular area of the brain becomes injured or diseased, specific cognitive abilities are affected.⁸

Cognitive abilities can be classified by four areas: orientation and memory, language and speech, sensorium, and judgment and abstract reasoning⁹:

- **Orientation and Memory:** **Orientation** (or-ē-ĕn-TĀ-shŏn) is the patient's awareness of their immediate circumstances. In the medical field, this is typically referred to as "being oriented to person, place, and time." An adult with normal cognitive functioning is aware of their name, where they are and why, and the date. This function occurs in the prefrontal cortex, and it can be temporarily or permanently affected by many medical conditions. **Memory** (MĚM-ŏ-rē) refers to how the brain stores and remembers information. It is a function of the temporal lobe.
- **Language** (LĀNG-gwij) **and Speech** (spēch): Wernicke's area and Broca's area are involved in speech and language. See Figure 16.7¹⁰ for an illustration of the location of Wernicke's area and Broca's area in the brain. Both areas are found in a person's dominant hemisphere, which for most

8. This work is a derivative of [Anatomy and Physiology](#) by [OpenStax](#) licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

9. This work is a derivative of [Anatomy and Physiology](#) by [OpenStax](#) licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

10. "[1605_Brocas_and_Wernickes_Areas-02.jpg](#)" by OpenStax College is licensed under [CC BY 3.0](#)

people is the left side of the brain. **Aphasia** (ă-FĀ-zh-ē-ă) is the inability to speak. Aphasia associated with Broca's area is known as an **expressive aphasia** (eks-PRĒS-ivă-ă-FĀ-zh-ē-ă), which means that speech production is compromised, leading to broken, slow, or hesitant speech. **Receptive aphasia** (rĭ-SEP-tivă-ă-FĀ-zh-ē-ă) is associated with Wernicke's area, which is a loss of understanding of speech content.

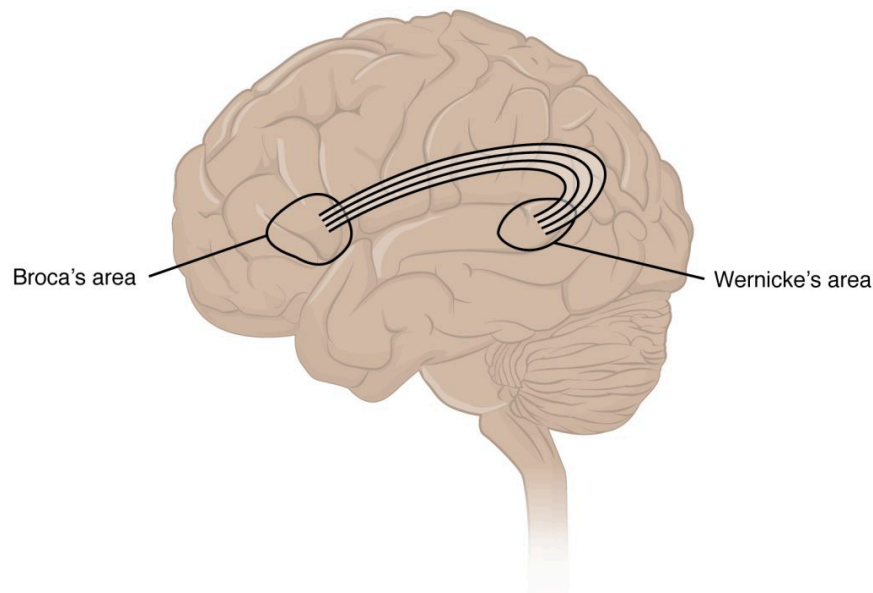


Figure 16.7 Broca's Area and Wernicke's Area

- **Sensorium** (sĕn-SAWR-ē-ŭm): Sensorium refers to interpretation of sensory stimuli, as previously discussed in this section. The cerebral cortex has several regions responsible for sensory perception.
- **Abstract reasoning** (ăb-străkt RĒ-zŏn-ĭng) **and judgment** (JŭJ-mĕnt): Abstract reasoning and judgment refer to making sense of concepts and making appropriate decisions. For example, when your alarm goes off in the morning, you must decide whether to hit the snooze button or jump out of bed. You use judgement and abstract reasoning to decide if the ten extra minutes of sleep is worth rushing through your morning routine or risking being late. The decision you make can potentially impact the rest of your day. The prefrontal cortex is responsible for these functions of planning and making decisions.¹¹

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16.6 Diseases and Disorders of the Nervous System

AMYOTROPHIC LATERAL SCLEROSIS

Amyotrophic lateral sclerosis (ā-mī-ō-TRŎF-ik LĀT-ěr-ăl sklě-RŌ-sīs) (**ALS**), also known as Lou Gehrig's disease, is a neurological disorder that affects motor neurons and the control of voluntary muscle movement and breathing. As motor neurons degenerate and die, they stop sending messages to the muscles, causing them to weaken, twitch, and shrink. Eventually, the brain loses its ability to control voluntary movements, such as walking, talking, chewing, and breathing. However, cognitive abilities are not affected. Medications are available that may prolong survival, reduce the rate of decline, or help manage symptoms, but there is no known treatment to cure ALS.¹

ALZHEIMER'S DISEASE

Alzheimer's disease (ălts-hī-měrz dĩ-zēz) (**AD**) is a common neurological disorder that causes worsening cognitive abilities and the inability to

1. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Amyotrophic lateral sclerosis*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/amyotrophic-lateral-sclerosis-als>

remember and make decisions. An estimated 6.7 million Americans aged 65 and older are living with Alzheimer's disease, and over 33% of people aged 85 or older have Alzheimer's disease. AD is caused by a type of protein that abnormally clumps together and damages healthy neurons. As the neurons die, the brain irreversibly shrinks and progressively loses more function.² See Figure 16.8³ for an illustration comparing a healthy brain to one that has shrunk due to severe Alzheimer's disease.

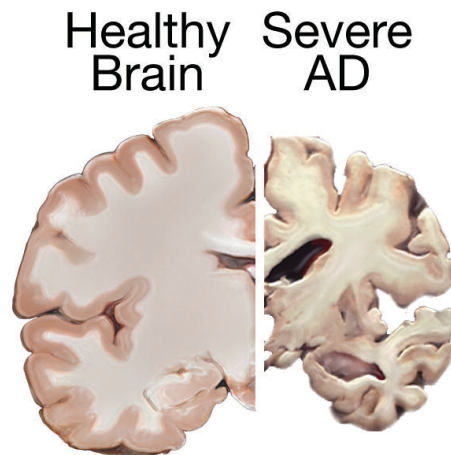


Figure 16.8 Comparison of Healthy Brain Tissue to Severe Alzheimer's Disease

AD develops over many years before memory problems occur. AD gradually causes behavior and personality changes, difficulty recognizing family and friends, and a severe loss of mental function. People with severe AD cannot communicate and are completely dependent on others for their care. There

2. Alzheimer's Association. (2023). *Alzheimer's disease: Facts and figures*. <https://www.alz.org/alzheimers-dementia/facts-figures>

3. "Broca's Area and Wernicke's Area" by NIH Image Gallery from Bethesda, Maryland, USA is licensed in the [Public Domain](#).

are no treatments that can stop the progression of AD, but medications can temporarily slow its worsening.⁴

ATTENTION DEFICIT HYPERACTIVITY DISORDER

Attention deficit hyperactivity disorder (ă-těn-shŭn dĕf-ĭ-sĭt hĭ-pĕr-ăk-tĭv-ĭ-tē dĭs-ôr-dĕr) (**ADHD**) is a neurodevelopmental disorder that is typically diagnosed in childhood and often lasts into adulthood. Children with ADHD may have trouble paying attention, controlling impulsive behaviors (i.e., act without thinking about what the result will be), or being overly active. ADHD is treated with a combination of behavior therapy and medication.⁵

CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome (KÄR-păl TŬN-ĕl SĬN-drôm) is a common neurological disorder that occurs when the median nerve, which runs from the forearm into the palm of the hand, becomes pressed or squeezed at the wrist. The median nerve passes through the carpal tunnel, a narrow, rigid passageway of ligament and bones at the base of the hand. The median

4. National Institute of Neurological Diseases and Stroke. (2023, November 28). *Alzheimer's disease*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/alzheimers-disease>
5. Centers for Disease Control and Prevention. (2023, October 16). *Attention-deficit/hyperactivity disorder*. <https://www.cdc.gov/ncbddd/adhd/index.html>

nerve provides feeling to the thumb, index, middle finger, and part of the ring finger. Compression of this nerve causes the symptoms of numbness, tingling, weakness, and pain.⁶ See Figure 16.9⁷ for an illustration of carpal tunnel syndrome.

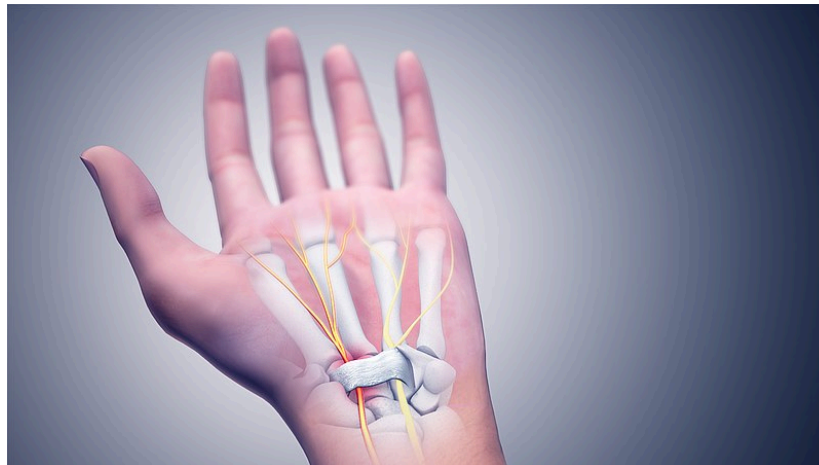


Figure 16.9 Carpal Tunnel Syndrome

Carpal tunnel syndrome may be diagnosed with a nerve conduction study that measures how quickly impulses are transmitted along a nerve. An electromyography test may also be used, where a fine needle is inserted into a muscle, and electrical activity is viewed on a screen to determine the severity of damage to the median nerve. Treatment includes wearing a splint at night while sleeping to keep the wrist straight and medications to reduce

6. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Carpal tunnel syndrome*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/carpal-tunnel-syndrome>

7. “Carpal Tunnel Syndrome.jpg” by www.scientificanimations.com is licensed under [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

inflammation in the carpal tunnel. If these treatments are not effective, carpal tunnel release surgery is performed to release pressure on the nerve.⁸

CEREBRAL PALSY

Cerebral palsy is a neurological condition that affects muscles. Read about cerebral palsy in the “[Diseases and Disorders of the Muscular System](#)” section of the “Muscular System Terminology” chapter.

MENTAL HEALTH DISORDERS

Many mental health disorders, such as anxiety, bipolar disorder, obsessive compulsive disorder (OCD), and schizophrenia can be caused by imbalanced levels of neurotransmitters. Mental health disorders are treated with a combination of medications, psychotherapy, and support groups.

- ▶ Read additional information about common mental health disorders in the “[Disorders of the CNS System](#)” in the “Central Nervous System” chapter in *Open RN Nursing Pharmacology*, 2e. For more detailed information, view chapters on these

8. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Carpal tunnel syndrome*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/carpal-tunnel-syndrome>

- ▶ disorders in Open RN *[Nursing: Mental Health and Community Concepts](#)*.

MULTIPLE SCLEROSIS

Multiple sclerosis (MŬL-tŭ-pl sklĕ-RŌ-sĭs) (**MS**) is a neurological disease with symptom onset generally between the ages of 20 to 40 years. MS is an autoimmune disease causing the immune system to mistakenly attack myelin in the brain, optic nerves, and the spinal cord. Myelin is a substance that coats and protects axons of the neurons. See Figure 16.10⁹ for an illustration of MS. MS is a chronic disease that affects people differently. Some people have mild disease with little to no disability, whereas others will have a steadily worsening disease that leads to increased disability.¹⁰

9. “[Multiple_Sclerosis.jpg](#)” by BruceBlaus is licensed under [CC BY-SA 4.0](#)

10. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Multiple sclerosis*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/multiple-sclerosis>

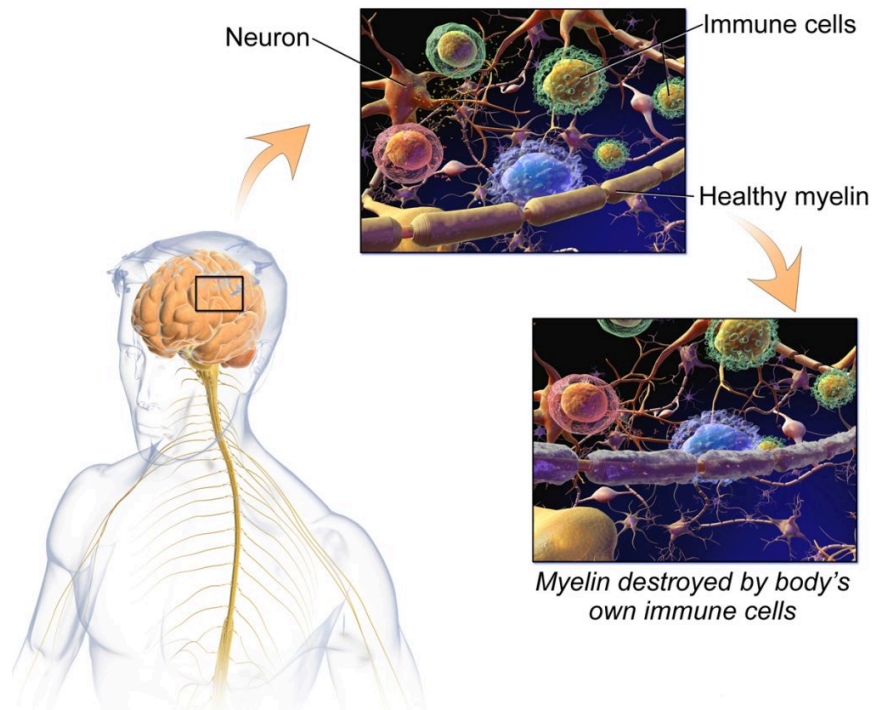


Figure 16.10 Multiple Sclerosis

MS symptoms include muscle weakness; vision loss; dizziness; tingling, numbness, or pain in nerves across the body; bladder control issues; and balance problems. There is no cure for MS, but there are medications and treatments that can reduce the number and severity of relapses and delay the long-term disability progression of the disease.¹¹

PARALYSIS

Paralysis is caused by a neurological condition that affects the muscles. Read

11. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Multiple sclerosis*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/multiple-sclerosis>

about paralysis in the “[Diseases and Disorders of the Muscular System](#)” section of the “Muscular System Terminology” chapter.

PARKINSON’S DISEASE

Parkinson’s disease (pär-kĭn-sŏnz dĭ-zēz) (**PD**) is a nervous system disorder that affects movement and worsens over time. As neurons in parts of the brain are damaged, people with PD have symptoms of tremors, rigidity in the limbs or the trunk of the body, slowed voluntary movements, and impaired balance. See Figure 16.11¹² for an illustration of someone with an appearance of typical PD symptoms. As symptoms progress, people may have difficulty walking, talking, or completing simple tasks. There is no cure for PD, but medications or surgery can help improve motor symptoms.¹³

¹². “[Sir_William_Richard_Gowers_Parkinson_Disease_sketch_1886.jpg](#)” by unknown author is licensed in the [Public Domain](#).

¹³. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Parkinson’s disease*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/parkinsons-disease>



Figure 16.11 Parkinson's Disease

POST-TRAUMATIC STRESS DISORDER

Post-traumatic stress disorder (pōst-TRŌ-măt-ĭk strēs dīs-ôr-děr) (**PTSD**) is diagnosed in individuals who have been exposed to a traumatic event with chronic stress symptoms lasting more than one month that are so severe they interfere with relationships, school, or work. Anyone can develop PTSD at any age, including war veterans; children who have experienced trauma; or adults who have experienced a physical or sexual assault, abuse, accident, disaster, being a refugee, or some other serious event.¹⁴

Symptoms of PTSD include mentally reexperiencing the event; feeling tense, easily startled, or experiencing angry outbursts; avoiding activities that are reminders of the trauma; and loss of interest in activities one typically

14. National Institute of Mental Health. (2023, May). *Post-traumatic stress disorder*. National Institutes of Health. <https://www.nimh.nih.gov/health/topics/post-traumatic-stress-disorder-ptsd>

enjoys. PTSD treatments include medications, psychotherapy, or a combination of both.¹⁵

SEIZURES

A **seizure** (sē-zhŭrz) is a sudden, uncontrolled electrical disturbance in the brain that causes changes in behaviors, movements, or changes in levels of consciousness. During a seizure, large numbers of brain cells are abnormally activated, like an electrical storm in the brain. Seizures may alter consciousness and produce abnormal motor activity. Symptoms may include muscle jerking; becoming limp or rigid; brief muscle twitching; or changes in sensations, emotions, or thinking. Epilepsy is a neurological disease that causes recurrent seizures. Seizures are diagnosed with electroencephalograms (EEGs), CT scans, and MRIs. Epilepsy is treated with medications.¹⁶

STROKE

A stroke is also called a **cerebrovascular accident** (sĕr-ĕ-brō-VĀS-kyŭ-lăr ħk-sĭ-dĕnt) (**CVA**). It is a sudden interruption of blood flow to the brain and requires immediate emergency care. Diagnosing and treating a stroke is often

¹⁵. National Institute of Mental Health. (2023, May). *Post-traumatic stress disorder*. National Institutes of Health. <https://www.nimh.nih.gov/health/topics/post-traumatic-stress-disorder-ptsd>

¹⁶. Epilepsy Foundation. (2019, October 1). *Understanding seizures*. <https://www.epilepsy.com/what-is-epilepsy/understanding-seizures>

referred to as “time is brain.” With timely treatment it is possible to save brain cells and greatly reduce the damage or death that can occur due to stroke. Brain cells die because they stop getting the oxygen and nutrients needed to function or they are damaged by sudden bleeding in or around the brain. Knowing the signs of stroke and calling 911 immediately can help save someone’s life.¹⁷

People who have a stroke may not realize what is happening, ignore the signs, or may not be able to call for emergency help on their own. Call 911 immediately if you notice someone is having one or more of the following symptoms¹⁸ :

- Sudden numbness or weakness of an arm or leg, especially on one side of the body
- Sudden confusion, trouble speaking, or understanding
- Sudden loss of vision or trouble seeing in one or both eyes
- Sudden trouble walking, dizziness, or loss of balance or coordination
- Sudden unusually severe headache with no known cause

There are two types of strokes called ischemic and hemorrhagic. An ischemic stroke is the loss of blood flow to an area because vessels are blocked or narrowed. This can be caused by plaque that has built up and blocked the vessel, or a blood clot that has travelled from another area of the body and lodged in the brain. A hemorrhagic stroke is bleeding into the brain because of a damaged blood vessel. Accumulated blood fills a region of the cranium and presses against the tissue in the brain, referred to as **intracranial**

17. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Stroke*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/stroke>

18. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Stroke*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/stroke>

pressure (în-tră-KRĀ-nē-ăl PRĚSH-ŭr).¹⁹ See Figure 16.12²⁰ for an illustration comparing ischemic and hemorrhagic strokes, and Figure 16.13²¹ for an image containing a radiographic image of a hemorrhagic stroke.

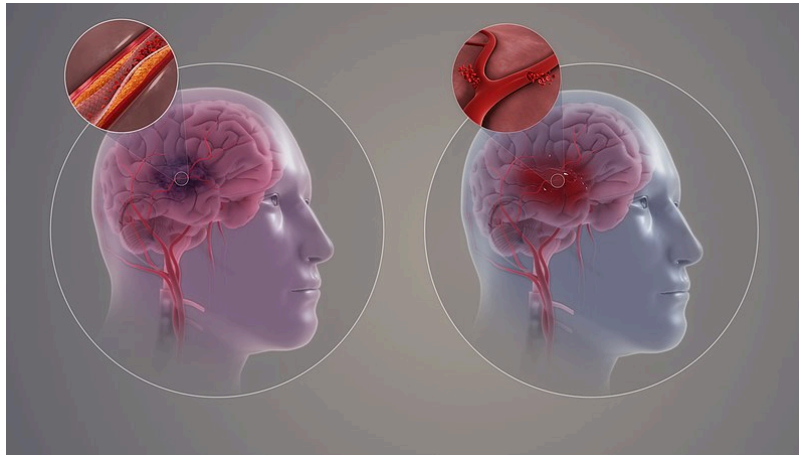


Figure 16.12 Comparison of Ischemia and Hemorrhagic Strokes

19. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Stroke*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/stroke>
20. “Types_of_Stroke.jpg” by <https://www.scientificanimations.com/> is licensed under [CC BY-SA 4.0](#)
21. “1602_The_Hemorrhagic_Stroke-02.jpg” by OpenStax College is licensed under [CC BY 3.0](#)

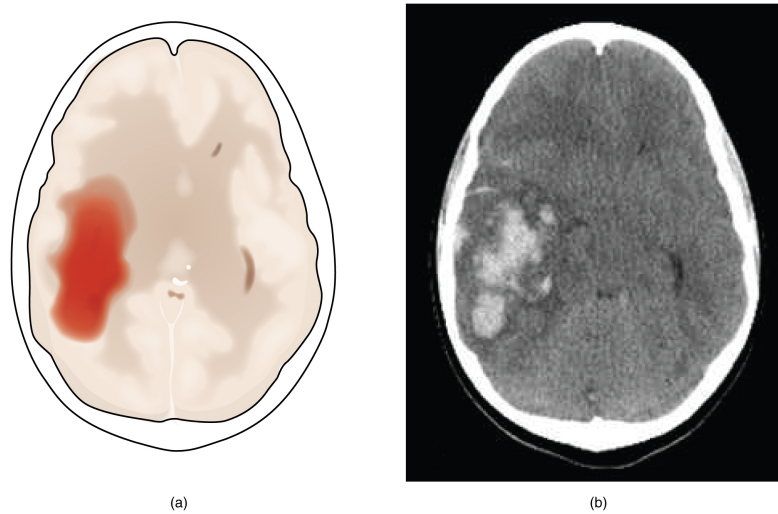


Figure 16.13 Hemorrhagic Stroke

Subarachnoid hemorrhage (sŭb-ă-răk-NOYD HĚM-ŏr-ĭj) refers to bleeding in the space between the brain and the surrounding membrane (subarachnoid space). The primary symptom is a sudden, severe headache, often described by patients as the worst headache they have ever felt.²²

Transient ischemic attacks (trăn-zhěnt ĭs-kē-mĭk ă-tăks) (**TIA**s) are temporary periods of symptoms similar to a stroke, but irreversible damage to the brain cells do not occur. However, TIAs are considered warning signs of an impending stroke and the opportunity to prevent it.²³

Strokes are often diagnosed with diagnostic imaging tests like CT scans or MRIs. A cerebral angiogram may be performed for an ischemic stroke, where a catheter is inserted into the arteries supplying the brain and a dye is

22. Mayo Clinic. (2022, August 31). *Subarachnoid hemorrhage*.
<https://www.mayoclinic.org/diseases-conditions/subarachnoid-hemorrhage/symptoms-causes/syc-20361009>

23. Mayo Clinic. (2022, March 26). *Transient ischemic attack*.
<https://www.mayoclinic.org/diseases-conditions/transient-ischemic-attack/symptoms-causes/syc-20355679>

injected to reveal the blockage site. Treatment of strokes depends on the cause and may include medications or surgery.²⁴

TRAUMATIC BRAIN INJURY

A **traumatic brain injury** (trô-măt-ĭk brān ĨN-jŭ-rē) (**TBI**) can be caused by a forceful bump, blow, or jolt to the head or body or from an object that pierces the skull and enters the brain. Some types of mild TBI, like a concussion, can cause temporary or short-term problems with normal brain function, including problems with how the person thinks, understands, moves, communicates, and acts. A serious TBI can lead to severe, permanent disability or death.²⁵

Symptoms of a TBI may include loss of consciousness; headache; blurred vision; unequal eye pupil size; nausea and vomiting; clear fluids draining from the nose or ears; sensitivity to light, a condition called **photophobia** (fō-tō-FŌ-bē-ă); ringing in the ears; or other neurological symptoms. TBI is diagnosed using standardized concussion tools and diagnostic testing such as CT scans and MRIs, if necessary.²⁶

- 24. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Stroke*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/stroke>
- 25. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Traumatic brain injury (TBI)*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/traumatic-brain-injury-tbi>
- 26. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Traumatic brain injury (TBI)*. National Institutes of Health.

There are many types of TBIs, including concussions, hematomas, skull fractures, and chronic traumatic encephalopathy²⁷ :

- **Concussion** (kŏn-KŬSH-ŭn): A concussion is a temporary, mild TBI that may take several months to heal. A concussion can be caused by a blow to the head, sports injury, fall, motor vehicle accident, weapons blast, or a rapid acceleration/deceleration of the brain within the skull, such as an infant being shaken.
- **Hematoma** (hĕm-ă-TŌ-mă): A hematoma refers to bleeding in and around the brain caused by a ruptured blood vessel. Different types of hematomas form depending on where the blood collects. For example, **subdural hematomas** (sŭb-DŪ-răł hĕm-ă-TŌ-măz) are common in the elderly after experiencing a TBI from a fall. It involves bleeding below the dura mater, the membrane directly under the skull.
- **Skull fracture** (skŭl FRĂK-chŭr): Skull fractures are cracks in one or more of the bones that form the skull. They can cause damage to the membranes, blood vessels, and brain under the fracture. Helmets and seat belts significantly help prevent skull fractures and TBI.
- **Chronic traumatic encephalopathy** (KRŎN-ĭk trô-măt-ĭk ěn-sĕf-ăl-ŌP-ă-thĕ): Chronic traumatic encephalopathy occurs in people with extraordinary exposure to multiple blows to the head, such as boxers and football players. It is a delayed consequence after many years and a progressive neurological disorder associated with symptoms that may include problems with thinking, understanding, and communicating; motor disorders (affecting movement); problems with impulse control

<https://www.ninds.nih.gov/health-information/disorders/traumatic-brain-injury-tbi>

27. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Traumatic brain injury (TBI)*. National Institutes of Health.

<https://www.ninds.nih.gov/health-information/disorders/traumatic-brain-injury-tbi>

and depression; confusion; and irritability.

Treatments are based on the cause and severity of the TBI. For example, mild concussions are commonly treated with rest and pain reliever medications, whereas severe TBIs may require surgery to drill a hole into the skull and drain fluids to relieve pressure inside the skull.²⁸

28. National Institute of Neurological Disorders and Stroke. (2023, November 28). *Traumatic brain injury (TBI)*. National Institutes of Health. <https://www.ninds.nih.gov/health-information/disorders/traumatic-brain-injury-tbi>

16.7 Medical Specialists, Diagnostic Testing, and Procedures Related to the Nervous System

MEDICAL SPECIALISTS

Neurology (noo-ROL-ŏ-jē) is the study of the nervous system. **Psychiatry** (sī-KĪ-ă-trē) is the study of disorders of the mind. **Psychology** (sī-KOL-ŏ-jē) is the study of the mind.

Neurologist

A **neurologist** (nū-RŎL-ŏ-jĭst) is a physician who specializes in the diagnosis and treatment of disorders and conditions related to the brain, spinal cord, nerves, and muscles. **Neurosurgeons** (nū-RŎ-sŭrj- ŭnz) perform surgeries on the nervous system.

► Read additional information about neurologists on the [American Academy of Neurology's web page](#).

Psychiatrist

A **psychiatrist** (sī-KĪ-ă-trĭst) is a medical doctor who specializes in mental

health and substance disorders. Because they are physicians, psychiatrists can order or perform a full range of medical laboratory and psychological tests. Mental health diagnoses are based on criteria established in *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)*, which contains descriptions, symptoms, and other criteria for diagnosing mental disorders. Psychiatrists prescribe a variety of treatments, including talk therapy, medications, psychosocial interventions, and other treatments such as **electroconvulsive therapy** (ē-lek-trō-kŏn-VŬL-sĭv THĔR-ă-pē) (**ECT**), depending on the needs of each patient. ECT is the application of electrical currents to the brain, typically used to treat severe depression that has not responded to other treatments.

- ▶ Read more information about psychiatrists on the [American Psychiatric Association's web page](#).

Psychologist

Psychologists (sĭ-KŎL-ŏ-jĭstz) are professionals with graduate degrees, and many have doctoral degrees (i.e., PhD, PsyD, or EdD). They specialize in helping people learn to cope with stressful situations, overcome substance use disorders, and manage chronic mental health disorders, and they also perform psychological tests.

- ▶ Read more information about psychologists on the [American Psychological Association's web page](#).

Social Workers

Social workers (SŌ-shăl WŬR-kĕrz) help people prevent and cope with

problems in their everyday lives. Social workers typically need a bachelor's or master's degree in social work (BSW or MSW) from an accredited program.

- ▶ Read more about [social workers](#) on the Bureau of Labor Statistics' web page.

Counselors

Substance use and mental health counselors advise people on issues such as those relating to alcoholism, substance use disorders, or depression.

Education and training requirements vary for entering these occupations by state. For example, in Wisconsin there are associate degree programs available in substance use disorder counseling. Mental health counseling typically requires a master's degree.

- ▶ Read more about counselors on the Bureau of Labor Statistics' [web page](#).

DIAGNOSTIC TESTS RELATED TO THE NERVOUS SYSTEM

Cerebral Angiography

Cerebral angiography (SĔR-ă-brīl, an-jē-OG-ră-fē) uses X-rays and special dye to see how blood flows through the brain. Specially trained health care providers perform this procedure in an operating room. During the

procedure, a provider inserts a catheter into an artery in the wrist or groin area, injects contrast material through the catheter, and then takes X-rays of the blood vessels. Cerebral angiograms provide more detailed images of blood vessels than other imaging tests, like CT or MRI scans.¹

Electroencephalogram (EEG)

An **electroencephalogram** (ě-lek-trō-ěň-SEF-ă-lŏ-gram) (**EEG**) is a test to measure the electrical activity of the brain. The test is performed by an electroencephalogram (EEG) technologist in a laboratory, health care provider's office, or hospital. Flat metal disks called electrodes are placed on many spots on the scalp. The electrodes are connected by wires to a recording machine that changes the electrical signals into patterns that can be seen on a monitor or drawn on paper.² See Figure 16.14³ for an image of an EEG.

1. Cleveland Clinic. (2023, August 8). *Cerebral angiogram*.
<https://my.clevelandclinic.org/health/diagnostics/13476-cerebral-angiogram>
2. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. EEG; [reviewed 2023, Jan 1; cited 2023, Dec 7].
<https://medlineplus.gov/ency/article/003931.htm>
3. "Three_quarter_view_of_EEG_subject.jpg" by Chris Hope and shared by Tim Sheerman-Chase is licensed under [CC BY 2.0](https://creativecommons.org/licenses/by/2.0/)

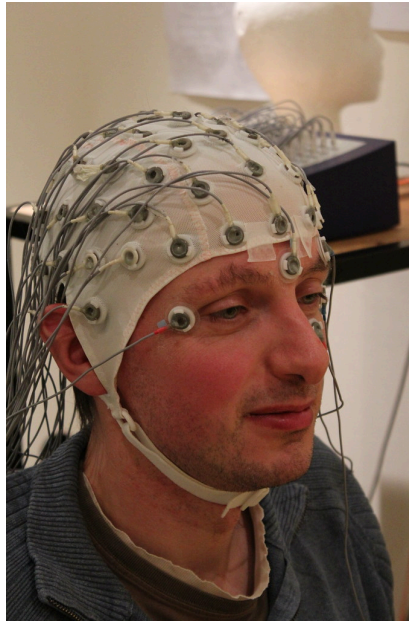


Figure 16.14 EEG

Electromyography (EMG)

An **electromyogram** (ē-lĕk-trō-mī-Ō-grām) (**EMG**) is a diagnostic procedure that assesses the function of nerve cells that control muscles. Electrodes, either attached to the skin or inserted into the muscle, record electrical impulses. An EMG can identify functional problems with the peripheral nerves, muscles, or with the signals between the nerves and the muscles. A nerve conduction study, another part of an EMG, uses surface electrodes applied to the skin to measure the speed and strength of signals traveling between two or more points. EMG results are used to diagnose muscle and nerve disorders.⁴

Lumbar Puncture (Spinal Tap)

A **lumbar puncture** (LŬM-bār PŬNK-chŭr), which is also called a spinal tap, is

4. Mayo Clinic. (2019, May 21). *Electromyography (EMG)*. <https://www.mayoclinic.org/tests-procedures/emg/about/pac-20393913>

a test used to diagnose nervous system infections and other conditions. During a lumbar puncture, a needle is inserted into the space between two vertebrae in the lumbar region to remove a sample of cerebrospinal fluid (CSF). CSF is the fluid that surrounds the brain and spinal cord to protect them from injury.⁵ See Figure 16.15⁶ for an illustration of a lumbar puncture.

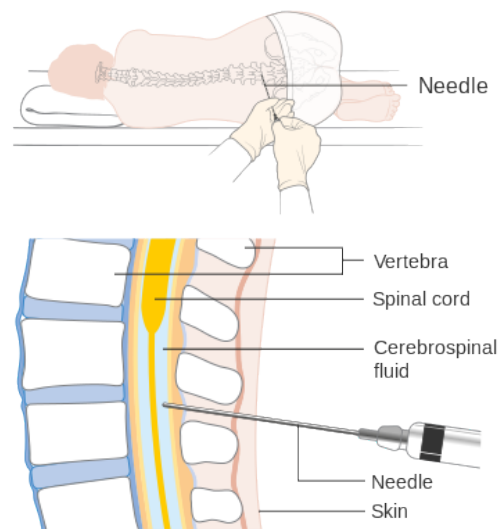


Figure 16.15 Lumbar Puncture

5. Mayo Clinic. (2022, April 30). *Lumbar puncture (spinal tap)*.
<https://www.mayoclinic.org/tests-procedures/lumbar-puncture/about/pac-20394631>
6. “[Diagram showing how you have a lumbar puncture CRUK_157.svg](#)” by Cancer Research UK is licensed under [CC BY-SA 4.0](#)

PROCEDURES RELATED TO THE NERVOUS SYSTEM

Carotid Endarterectomy

A **carotid endarterectomy** (kă-rōt-ĭd ěnd-ă-r-těr-ĔK-tō-mē) is the surgical removal of plaque blocking the carotid arteries in the neck. The carotid arteries are the main blood vessels that carry oxygen and blood to the brain. This procedure is performed to prevent or treat a stroke.⁷

7. Johns Hopkins Medicine. (n.d.). *Carotid endarterectomy*.

<https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/carotid-endarterectomy>

16.8 Nervous System Learning Activities

Interactive Learning Activity: Practice labeling parts of the brain.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=543#h5p-119>

Interactive Learning Activity: Study nervous system medical terms discussed in this chapter using these flashcards.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=543#h5p-192>

Interactive Learning Activity: Test your knowledge of these nervous system terms.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=543#h5p-124>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=543#h5p-121>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=543#h5p-122>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=543#h5p-123>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.





An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=543#h5p-79>



Interactive Learning Activity: Practice identifying and defining word parts for terms discussed in this chapter.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=543#h5p-208>

- ▶ You can also print this as a [Chapter 16 Practice Worksheet](#) and check your answers with this [Answer Key PDF](#).

16.9 Glossary

Abstract reasoning (ăb-străkt RĒ-zōn-īng): The ability to analyze information, detect patterns and relationships, and solve problems on a complex, intangible level. ([Chapter 16.5](#))

Alzheimer's disease (ălts-hī-měrz dī-zēz) (AD): A progressive neurodegenerative disorder characterized by memory loss, language deterioration, and impaired ability to mentally manipulate visual information. ([Chapter 16.6](#))

Amyotrophic lateral sclerosis (ā-mī-ō-TRŌF-ik LĀT-ēr-ăl sklě-RŌ-sīs) (ALS): A progressive neurodegenerative disease that affects nerve cells in the brain and spinal cord, causing muscle weakness and atrophy. ([Chapter 16.6](#))

Anesthesia (an-ēs-THĒ-zhă): The loss of sensation or feeling in a part or all of the body, often induced for medical procedures. ([Chapter 16.5](#))

Aphasia (ă-FĀ-zh-ē-ă): A condition characterized by either partial or total loss of the ability to communicate verbally or using written words. ([Chapter 16.5](#))

Attention deficit hyperactivity disorder (ă-těn-shŭn dėf-ī-sīt hī-pěr-ăk-tīv-ī-tē dīs-ôr-děr) (ADHD): A neurodevelopmental disorder characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development. ([Chapter 16.6](#))

Axon (ăk-sŏn): The long, slender projection of a nerve cell that typically conducts electrical impulses away from the neuron's cell body. ([Chapter 16.4](#))

Brain stem (brān stēm): The central trunk of the brain, consisting of the medulla oblongata, pons, and midbrain, and continuing downward to form the spinal cord. ([Chapter 16.4](#))

Broca's area (brō-kăz ăr-ē-ă): A region in the frontal lobe of the brain with functions linked to speech production. ([Chapter 16.4](#))

Carotid endarterectomy (kă-rŏt-īd ěnd-ăr-těr-ĚK-tŏ-mē): A surgical procedure to remove plaque from the carotid arteries and restore blood flow to the brain, often used to prevent stroke. ([Chapter 16.7](#))

Carpal tunnel syndrome (KĀR-păl TŪN-ěl SĪN-drŏm): A condition caused

by compression of the median nerve within the carpal tunnel of the wrist, leading to pain, numbness, and tingling in the hand. ([Chapter 16.6](#))

Cell body (sěl bōd-ē): The spherical part of the neuron that contains the nucleus and connects to the dendrites and axon. ([Chapter 16.4](#))

Central nervous system (SEN-trāl NŮR-vūs SĪS-tēm) (CNS): The part of the nervous system consisting of the brain and spinal cord, responsible for processing and transmitting information throughout the body. ([Chapter 16.4](#))

Cerebellum (sēr-ě-běl-ŭm): A major structure of the hindbrain that is responsible for fine motor coordination, balance, equilibrium, and muscle tone. ([Chapter 16.4](#))

Cerebral angiography (SĚR-ē-brāl ăn-jē-ŎG-ră-fē): A diagnostic imaging technique that uses X-rays to visualize blood flow in the arteries and veins in the brain. ([Chapter 16.7](#))

Cerebral cortex (sě-RĚ-brāl KÔR-těks): The outer layer of the cerebrum, playing a key role in memory, attention, perception, cognition, awareness, thought, language, and consciousness. ([Chapter 16.4](#))

Cerebrovascular accident (sēr-ě-brō-VĀS-kyŭ-lăr ăk-sĭ-děnt) (CVA): Also known as a stroke, it is the sudden death of brain cells due to lack of oxygen, caused by blockage of blood flow or rupture of an artery in the brain. ([Chapter 16.6](#))

Cerebrum (sě-RĚ-brŭm): The largest part of the brain, responsible for voluntary muscular activity, vision, speech, taste, hearing, thought, and memory. ([Chapter 16.4](#))

Chronic traumatic encephalopathy (KRŎN-ĭk trô-măt-ĭk ěn-sěf-ăl-ŎP-ă-thē) (CTE): A brain condition associated with repeated blows to the head and repeated episodes of concussion. ([Chapter 16.6](#))

Concussion (kŏn-KŮSH-ŭn): A type of traumatic brain injury caused by a blow to the head or body, a fall, or another injury that jars or shakes the brain inside the skull. ([Chapter 16.6](#))

Cranial nerves (krā-nē-ăl nĕrvz): The 12 pairs of nerves that emerge directly from the brain, as opposed to spinal nerves, with functions largely concerning the head and neck. ([Chapter 16.4](#))

Dendrites (děn-drĭts): Extensions of a neuron that receive signals from other neurons and transmit them toward the cell body. ([Chapter 16.4](#))

Dura mater (dǔŏ-rǎ mā-těr): The thick, tough outer layer of the meninges surrounding the brain and spinal cord. ([Chapter 16.4](#))

Electroconvulsive therapy (ē-lek-trō-kǒn-VŮL-sĭv THĚR-ǎ-pē) (ECT): A medical treatment most commonly used for patients with severe major depression or bipolar disorder that has not responded to other treatments, involving brief electrical stimulation of the brain while the patient is under anesthesia. ([Chapter 16.7](#))

Electroencephalogram (ě-lek-trō-ěn-SĚF-ǎ-lǒ-gram) (EEG): A test that detects electrical activity in the brain using small, flat metal discs (electrodes) attached to the scalp. ([Chapter 16.7](#))

Electromyogram (ē-lěk-trō-MĪ-ŏ-gram) (EMG): A diagnostic test that measures the electrical activity of muscles to help diagnose muscle and nerve disorders. ([Chapter 16.7](#))

Expressive aphasia (eks-PRĚS-ĭv ǎ-FĀ-zh-ē-ǎ): A type of aphasia where a person knows what they want to say but has difficulty communicating it to others. ([Chapter 16.5](#))

Frontal lobe (FRŎN-tǎl lōb): A region of the cerebral cortex associated with reasoning, motor skills, higher-level cognition, and expressive language. ([Chapter 16.4](#))

Hematoma (hēm-ǎ-TŌ-mǎ): A solid swelling of clotted blood within the tissues, often caused by an injury. ([Chapter 16.6](#))

Hypothalamus (hĭ-pō-THAL-a-mus): A region of the forebrain below the thalamus that coordinates both the autonomic nervous system and the activity of the pituitary, controlling body temperature, thirst, hunger, and other homeostatic systems. ([Chapter 16.4](#))

Intracranial pressure (ĭn-trǎ-KRĀ-nē-ǎl PRĚSH-ŭr): Pressure inside the skull and thus in the brain tissue and cerebrospinal fluid, usually in the context of illness or injury. ([Chapter 16.6](#))

Judgment (JŮJ-měnt): The ability to make considered decisions or come to sensible conclusions. ([Chapter 16.5](#))

Language (LĀNG-gwĭj): The method of human communication, either spoken or written, consisting of the use of words. ([Chapter 16.5](#))

Lumbar puncture (LŮM-bǎr PŮNK-chŭr): A medical procedure where a needle is inserted into the lower part of the spinal column to collect

cerebrospinal fluid for diagnostic testing or to relieve pressure. ([Chapter 16.7](#))

Memory (MĚM-ō-rē): The faculty by which the mind stores and remembers information. ([Chapter 16.5](#))

Meninges (mĕn-ĭn-jēz): The three membranes that envelop the brain and spinal cord, providing protection for these structures. ([Chapter 16.4](#))

Multiple sclerosis (MŮL-tĭ-pl sklĕ-RŌ-sĭs) (MS): An autoimmune disease that affects the brain and spinal cord, leading to demyelination, inflammation, and scarring, resulting in a range of symptoms including physical, mental, and sometimes psychiatric problems. ([Chapter 16.6](#))

Myelin (mĭ-ĕ-lĭn): The protective fatty layer that wraps around the nerve fibers (axons), facilitating the fast transmission of electrical signals. ([Chapter 16.4](#))

Neurologist (nū-RŌL-ō-jĭst): A physician who specializes in the diagnosis and treatment of disorders of the nervous system, brain, spinal cord, nerves, and muscles. ([Chapter 16.7](#))

Neurology (noo-ROL-ō-jē): The study of the nervous system. ([Chapter 16.7](#))

Neurons (nŭr-ōns): Nerve cells that are the basic building blocks of the nervous system, responsible for transmitting information throughout the body. ([Chapter 16.4](#))

Neurosurgeons (nū-RŌ-sŭrj-ŭnz): Surgeons who specialize in surgery on the nervous system, including the brain and spinal cord. ([Chapter 16.7](#))

Neurotransmitter (nŭr-ō-trāns-mĭt-ēr): Chemical substances that transmit nerve signals across a synapse from one neuron to another. ([Chapter 16.4](#))

Occipital lobe (ōk-SĪP-ĭ-tāl lōb): The rearmost lobe in each cerebral hemisphere of the brain, responsible for processing visual information. ([Chapter 16.4](#))

Orientation (or-ē-ĕn-TĀ-shŏn): The patient's awareness of their immediate circumstances (i.e., being oriented to person, place, and time). ([Chapter 16.5](#))

Paresthesia (par-es-THĒ-zh(ē)-ă): An abnormal sensation, such as tingling, pricking, or numbness, typically with no apparent physical cause. ([Chapter 16.5](#))

Parietal lobe (pă-rĭ-ĕ-tāl lōb): The upper middle lobe of the cerebrum, involved in processing sensory information such as touch, temperature, and pain. ([Chapter 16.4](#))

Parkinson's disease (pär-kĭn-sönz dĭ-zēz) (PD): A progressive nervous system disorder that affects movement, often including tremors, muscle rigidity, and changes in speech and gait. ([Chapter 16.6](#))

Peripheral nervous system (pě-rĭF-ēr-āl NŮR-vŭs SĬS-tēm) (PNS): The part of the nervous system outside the CNS, consisting mainly of the nerves that extend from the brain and spinal cord. ([Chapter 16.4](#))

Photophobia (fō-tō-FŌ-bē-ă): An extreme sensitivity to light, often causing discomfort or pain in the eyes. ([Chapter 16.6](#))

Post-traumatic stress disorder (pōst-TRŌ-măt-ĭk strēs dĭs-ôr-dēr) (PTSD): A mental health condition triggered by experiencing or witnessing a terrifying event, characterized by flashbacks, nightmares, severe anxiety, and uncontrollable thoughts about the event. ([Chapter 16.6](#))

Prefrontal cortex (prē-FRŌN-tăl KŌR-těks): The front part of the frontal lobe, involved in complex behaviors such as planning, and contributing to personality development. ([Chapter 16.4](#))

Psychiatrist (sĭ-KĬ-ă-trĭst): A medical doctor specializing in the diagnosis, prevention, study, and treatment of mental disorders, including prescribing medication. ([Chapter 16.7](#))

Psychiatry (sĭ-KĬ-ă-trē): The medical specialty devoted to diagnosing, preventing, studying, and treating mental disorders. ([Chapter 16.7](#))

Psychologists (sĭ-KŌL-ō-jĭstz): Professionals who study cognitive, emotional, and social processes and behavior by observing, interpreting, and recording how individuals relate to one another and to their environments. ([Chapter 16.7](#))

Psychology (sĭ-KOL-ō-jē): The study of the mind and its functions, especially those affecting behavior. ([Chapter 16.7](#))

Receptive aphasia (rĭ-SEP-tĭv ă-FĀ-zh-ē-ă): A form of aphasia where individuals have trouble understanding spoken or written language. ([Chapter 16.5](#))

Sciatica (sĭ-ăt-ĭ-kă): Pain affecting the back, hip, and outer side of the leg, caused by compression or irritation of the sciatic nerve. ([Chapter 16.4](#))

Seizure (sē-zhŭr): An uncontrolled electrical disturbance in the brain, which can cause changes in behavior, movements, feelings, and levels of consciousness. ([Chapter 16.6](#))

Sensorium (sĕn-SAWR-ĕ-ŭm): The sensory apparatus or faculties considered as a whole. ([Chapter 16.5](#))

Skull fracture (skŭl FRĀK-chŭr): A break in one or more of the bones in the skull, often caused by a blow to the head. ([Chapter 16.6](#))

Social workers (SŌ-shāl WŪR-kĕrz): Professionals who provide a wide range of services to help people cope with and overcome challenges in their everyday lives, including mental health and substance abuse counseling. ([Chapter 16.7](#))

Speech (spĕch): The expression of thoughts and feelings by articulating sounds. ([Chapter 16.5](#))

Spinal cord (spī-nāl kôrd): The cylindrical bundle of nerve fibers and associated tissue enclosed in the spine, connecting nearly all parts of the body to the brain. ([Chapter 16.4](#))

Spinal nerves (spī-nāl nĕrvz): Nerves that originate in the spinal cord and branch out to provide motor and sensory functions to the body. ([Chapter 16.4](#))

Subarachnoid hemorrhage (sŭb-ă-răk-NOYD HĚM-ôr-ĭj): A type of stroke caused by bleeding into the space surrounding the brain, leading to sudden severe headache and other symptoms. ([Chapter 16.6](#))

Subdural hematoma (sŭb-DŪ-rāl hĕm-ă-TŌ-mă): A type of hematoma, usually associated with traumatic brain injury, involving bleeding in the outermost meningeal layer, just under the skull. ([Chapter 16.6](#))

Synapse (sĭn-ăps): The junction between two nerve cells, consisting of a minute gap across which impulses pass by diffusion of a neurotransmitter. ([Chapter 16.4](#))

Temporal lobe (tĕm-pŏ-rāl lōb): A region of the cerebral cortex responsible for processing auditory information and is also involved in memory storage. ([Chapter 16.4](#))

Thalamus (thāl-ă-mŭs): A small structure within the brain located just above the brain stem between the cerebral cortex and the midbrain with multiple functions, including relaying sensory and motor signals to the cerebral cortex. ([Chapter 16.4](#))

Transient ischemic attacks (trăn-zhĕnt ĭs-KĒ-mĭk ă-tăks) (TIAs): Often called a “mini-stroke,” a temporary period of symptoms similar to those of a stroke, indicating a high risk of a full-blown stroke in the future. ([Chapter 16.6](#))

Traumatic brain injury (trô-măt-ĭk brān ĨN-jŭ-rē) (TBI): A form of brain injury caused by a blow, jolt, or other traumatic injury to the head or body, causing temporary or permanent damage. ([Chapter 16.6](#))

Vagus nerve (VĀ-gŭs nĕrv): A cranial nerve that extends from the brain stem to the abdomen, playing critical roles in the heart, lungs, and digestive tract functioning. ([Chapter 16.4](#))

Ventricles (vĕn-trĭ-kŭls): Hollow, fluid-filled cavities within the brain that help to protect the brain and reduce its weight. ([Chapter 16.4](#))

Wernicke's area (wĕr-nĭk-kēz ăr-ē-ă): A region of the brain that is important for language development, located in the temporal lobe. ([Chapter 16.4](#))

PART XVII

CHAPTER 17 ENDOCRINE SYSTEM TERMINOLOGY

17.1 Endocrine System Introduction

Learning Objectives

- Apply the rules of medical language to build, analyze, spell, pronounce, abbreviate, and define terms as they relate to the endocrine system
- Identify meanings of key word components of the endocrine system
- Categorize diagnostic, therapeutic, procedural, or anatomic terms related to the endocrine system
- Use terms related to the endocrine system
- Use terms related to the diseases and disorders of the endocrine system

Introduction to Endocrine System

The endocrine system is the body's "chemical messenger system." The major glands of the endocrine system secrete specialized chemical messengers called hormones into the bloodstream. The hormones travel to target organs and tissues where they initiate specific physiological responses.

This chapter will review common word components related to the endocrine system to assist learners in analyzing, building, and defining medical terms. Other terms, whose definitions cannot be easily built from word components, will be described in context based on the anatomy and

physiology of the endocrine system and common diseases and disorders. Medical specialists, diagnostic tests, and procedures related to the endocrine system will also be discussed.

 View a supplementary YouTube video¹ on the endocrine system from Crash Course: Endocrine System, Part 1 – Glands & Hormones: Crash Course Anatomy & Physiology #23

1. CrashCourse. (2015, June 22). *Endocrine system, Part 1 – Glands & hormones: Crash Course Anatomy & Physiology #23* [Video]. YouTube. All rights reserved. <https://www.youtube.com/watch?v=eWHH9je2zG4>

17.2 Word Components Related to the Endocrine System

This section will describe common word components related to the endocrine system. These word components help build definitions for many medical terms. Other common prefixes are described in [Chapter 1.3](#), and common suffixes are described in [Chapter 1.5](#).

PREFIXES RELATED TO THE ENDOCRINE SYSTEM

- **eu-**: Good, normal
- **hyper-**: Above, excessive
- **hypo-**: Below, under, deficient
- **oxy-**: Rapid, sharp, acid
- **pan-**: All, total
- **para-**: Around, beside, beyond, abnormal
- **poly-**: Many or much
- **syn-**: Joined, together
- **tetr-**: Four
- **tri-**: Three

WORD ROOTS WITH COMBINING

VOWELS RELATED TO THE ENDOCRINE SYSTEM

- **acr/o**: Extremities, height
- **aden/o**: Gland
- **adren/o**: Adrenal glands
- **adrenal/o**: Adrenal glands
- **calc/i**: Calcium
- **cortic/o**: Cortex, outer layer of a body organ
- **dips/o**: Thirst
- **endocrin/o**: Endocrine
- **glyc/o**: Sugar
- **home/o**: Sameness
- **kal/i**: Potassium
- **myx/o**: Mucus
- **natr/o**: Sodium
- **parathyroid/o**: Parathyroid gland
- **phys/o**: Growing
- **pituitar/o**: Pituitary gland
- **somat/o**: Body
- **thyr/o**: Thyroid gland
- **thyroid/o**: Thyroid gland

SUFFIXES RELATED TO THE ENDOCRINE SYSTEM

- **-drome**: Run, running together
- **-ectomy**: Excision, cut out
- **-emia**: In the blood

- **-ia**: Condition of, abnormal state, diseased state
- **-ism**: State of
- **-itis**: Inflammation
- **-logist**: Specialist who studies and treats
- **-logy**: Study of
- **-megaly**: Enlarged, enlargement
- **-oid**: Resembling
- **-oma**: Tumor
- **-pathy**: Disease
- **-plasia**: Condition of, formation, development, growth
- **-tomy**: Incision, cut into

17.3 Examples of Endocrine Terms Easily Defined By Their Word Components

Here are examples of common medical terms related to the endocrine system that can be easily defined by breaking the terms into their word components.

Hyperglycemia

1. Break down the medical term into word components:
Hyper/glyc/emia
2. Label the word components: **Hyper** = P; **glyc** = WR; **emia** = S
3. Define the word components: **Hyper** = excessive; **glyc** = sugar; **emia** = in the blood
4. Create a final definition of the medical term: **Excessive sugar in the blood**

Polydipsia

1. Break down the medical term into word components:
Poly/dips/ia
2. Label the word components: **Poly** = P; **dips** = WR; **ia** = S

3. Define the word components: **Poly** = much; **dips** = thirst; **ia** = condition of
4. Create a final definition of the medical term: **Condition of much thirst**

Adrenalectomy

1. Break down the medical term into word components: **Adrenal/ectomy**
2. Label the word components: **Adrenal** = WR; **ectomy** = S
3. Define the word components: **Adrenal** = adrenal gland; **ectomy** = removal
4. Create a final definition of the medical term: **Excision of the adrenal gland(s)**



Interactive Learning Activity: Practice defining and pronouncing endocrine system medical terms by breaking them down into word parts.



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<https://wtcs.pressbooks.pub/medterm/?p=6397#h5p-127>

- ▶ You can also print these flashcard activities as a [Chapter 17](#)

▶ [Student Companion Worksheet](#) and check your answers with this [Answer Key](#).

17.4 Anatomy of the Endocrine System

The endocrine system includes the pineal, pituitary, thyroid, parathyroid, and adrenal glands, as well as the pancreas, ovaries, and testes. See Figure 17.1¹ for an illustration of the endocrine system.²

1. "e73bab44e2c1a6d18058e8ac13c76807add6c209.jpg" by Betts et al., is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-1-an-overview-of-the-endocrine-system>
2. This work is a derivative of [Anatomy and Physiology](https://openstax.org/books/anatomy-and-physiology) by [OpenStax](https://openstax.org) licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

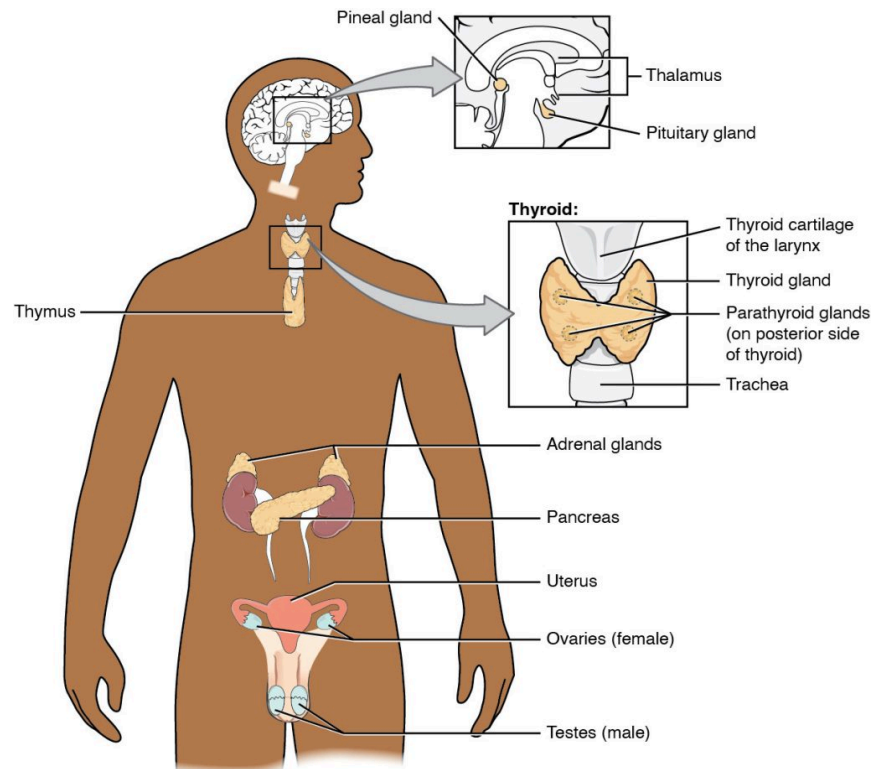


Figure 17.1 Endocrine System

Endocrine glands secrete **hormones** (HÖR-mōnz) as chemical messengers. Hormones are transported via the bloodstream throughout the body, where they bind to receptors on target cells, triggering a characteristic response. This long-distance communication is the fundamental function of the endocrine system.³

Pineal Gland

The **pineal gland** (PĪ-nē-ăl gland) is a small cone-shaped structure that extends from a ventricle of the brain. The pineal gland produces the hormone

3. This work is a derivative of [Anatomy and Physiology](https://openstax.org/books/anatomy-and-physiology/pages/1-introduction) by OpenStax licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

melatonin (MĚL-ă-tō-nĭn). Melatonin affects reproductive development and daily physiological cycles.⁴

Pituitary Gland

The **pituitary gland** (pĭ-TŪ-ĭ-tĕr-ē gland) is about the size of a pea. It is a protrusion off the bottom of the hypothalamus at the base of the brain. There are two parts of the pituitary gland called the anterior and the posterior pituitary.

Anterior Pituitary Gland

The anterior pituitary gland secretes several hormones that stimulate the other endocrine glands. These hormones include **human growth hormone** (HYOO-măŋ GRŌTH HŌR-mŏn) (**HGH**), **thyroid-stimulating hormone** (THĪ-rŏid-STĪM-yŭ-lăt-ing HŌR-mŏn) (**TSH**), **adrenocorticotrophic hormone** (ă-drē-nō-kŏr-tĭ-kŏ-TRŌP-ik HŌR-mŏn) (**ACTH**), **follicle-stimulating hormone** (FŎL-ĭ-kŭl STĪM-yŭ-lăt-ing HŌR-mŏn) (**FSH**), **luteinizing hormone** (LŪ-tē-ĭ-nĭz-ing HŌR-mŏn) (**LH**), **beta endorphin** (BĀ-tă ěn-DŌR-fĭn), and **prolactin** (prŏ-LĀK-tĭn).⁵

Hypopituitarism (hĭ-pŏ-pĭ-TŪ-ĭt-ă-rizm) refers to deficient pituitary gland activity. Human growth hormone (HGH) deficiency, also known as **dwarfism** (DWŌR-fĭz-əm), is a condition caused by insufficient amounts of human growth hormone in the body. In contrast, **gigantism** (jĭ-GĀN-tĭz-əm) is caused by excessive human growth hormone in childhood that causes excessive growth and height.

4. This work is a derivative of [Anatomy and Physiology](#) by [OpenStax](#) licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>
5. National Cancer Institute. (n.d.). *Endocrine glands & their function*. National Institutes of Health. <https://training.seer.cancer.gov/anatomy/endocrine/glands/>

Posterior Pituitary Gland

The posterior pituitary secretes **antidiuretic hormone** (ăn-tī-dī-yū-RĚT-ik HŌR-mōn) (**ADH**) that acts on the kidneys. Its effect is to regulate water reabsorption and control fluid balance. For example, if a person becomes dehydrated, the posterior pituitary releases ADH to stimulate additional water reabsorption by the kidneys and return more water to the bloodstream. In contrast, if a person becomes overhydrated from drinking too much water without other substances, the posterior pituitary decreases ADH release. In response, the kidneys decrease water reabsorption, and the excessive water is eliminated in urine output. The posterior pituitary gland also secretes the hormone oxytocin. **Oxytocin** (ők-sē-TŌ-sĭn) is a hormone that stimulates labor contractions and lactation after delivery.⁶

Thyroid Gland

The **thyroid gland** (THĪ-rōid gland) is a butterfly-shaped endocrine gland located in the neck, just below the larynx. It helps to regulate metabolic processes in the body by producing and releasing thyroid hormones called **thyroxine** (thī-RŌK-sĭn) (**T4**) and **triiodothyronine** (trī-ī-ō-dō-THĪ-rō-nĕn) (**T3**). These hormones are critical for regulating the **basal metabolic rate** (BĀ-săl MĚT-ă-bŏl-ĭk RĀT) (**BMR**), the rate at which the body burns energy while at rest. T3 and T4 control how the body uses energy and oxygen, impacting processes such as digestion, heart rate, and temperature regulation. The thyroid also secretes **calcitonin** (kăl-sĭ-TŌ-nĭn), a hormone that lowers blood calcium levels.⁷

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Euthyroid (yū-THĪ-rōid) refers to normal thyroid gland functioning with the production of the correct amount of thyroid hormones. **Hypothyroidism** (hī-pō-THĪ-rōid-izm) refers to deficient thyroid gland activity. **Hyperthyroidism** (hī-pēr-THĪ-rōid-izm) refers to excessive thyroid gland activity. **Goiter** (GOI-tēr) is the abnormal enlargement of the thyroid gland that is a symptom of either hypothyroidism or hyperthyroidism. Read more information about hypothyroidism and hyperthyroidism in the “[Diseases and Disorders of the Endocrine System](#)” section.

Parathyroid Glands

Four small masses of tissue are embedded on the surface of the thyroid gland called **parathyroid glands** (PĀR-ă-THĪ-rōid glandz). Parathyroid glands secrete **parathyroid hormone** (PĀR-ă-THĪ-rōid HŌR-mōn) (**PTH**) that increases blood calcium levels when necessary to maintain homeostatic balance.⁸

Adrenal Glands

The **adrenal glands** (ă-DRĒ-nal glandz) are small glands located on top of each kidney. There are two parts to each adrenal gland called the adrenal cortex and the adrenal medulla.

The **adrenal cortex** (ă-DRĒ-nal KŌR-těks), the outer part of the adrenal gland, consists of three different regions, with each region producing different types of hormones called mineralocorticoids, glucocorticoids, and androgens. The principal mineralocorticoid is **aldosterone** (ăl-DŌS-tě-rōn), which acts on the kidneys to reabsorb sodium and water and return these substances to the bloodstream. The principal glucocorticoid is **cortisol** (KŌR-tī-sŏl). Cortisol helps control blood glucose, blood pressure, and metabolism. **Androgens** (ĂN-drō-jěnz) contribute to the development and maintenance of male characteristics. Androgens are secreted in minimal amounts in both

8. National Cancer Institute. (n.d.). *Endocrine glands & their function*. National Institutes of Health. <https://training.seer.cancer.gov/anatomy/endocrine/glands/>

sexes by the adrenal cortex, but their effects in females are typically masked by hormones secreted by the ovaries.⁹

The adrenal medulla, the inner part of the adrenal gland, secretes two hormones, **epinephrine** (ěp-ĩ-NĚF-rĩn) and **norepinephrine** (nôr-ěp-ĩ-NĚF-rĩn), also referred to as **catecholamines** (kăt-ě-KŌL-ă-mēns). These hormones are secreted by the nervous system in response to stress.¹⁰

Pancreas

The **pancreas** (PĀN-krē-ăs) is a long, flat gland that lies behind the stomach. The pancreas serves two functions called exocrine and endocrine roles. The **exocrine** (ĚK-sō-krĩn) role refers to the release of digestive enzymes, including amylase and lipase that help to digest food. The **endocrine** (ĚN-dō-krĩn) role refers to the production of hormones called glucagon and insulin that regulate blood glucose levels.¹¹

Glucose (GLŪ-kōs) is the preferred fuel for all body cells. The digestive system breaks down carbohydrate-containing foods and fluids into glucose, where it is absorbed into the bloodstream. Glucose is taken up by cells from the bloodstream for fuel.¹²

9. National Cancer Institute. (n.d.). *Endocrine glands & their function*. National Institutes of Health. <https://training.seer.cancer.gov/anatomy/endocrine/glands/>
10. National Cancer Institute. (n.d.). *Endocrine glands & their function*. National Institutes of Health. <https://training.seer.cancer.gov/anatomy/endocrine/glands/>
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Blood glucose levels are maintained by healthy individuals' bodies between 70 mg/dL and 110 mg/dL. **Hyperglycemia** (hī-pěr-glī-SĒ-mē-ă) refers to excessively high blood glucose. **Hypoglycemia** (hī-pō-glī-SĒ-mē-ă) refers to abnormally low blood glucose. Receptors located in the pancreas sense blood glucose levels. Specialized cells called islet cells secrete glucagon or insulin to maintain normal blood glucose levels. For example, if blood glucose levels rise above normal range, **insulin** (ĪN-sū-lĭn) is released, which facilitates the uptake of glucose into cells. However, if blood glucose levels drop below normal range, **glucagon** (GLŪ-kă-gŏn) is released, which stimulates the liver cells to release more glucose into the bloodstream.¹³

Ovaries and Testes

The ovaries and testes are responsible for producing ova and sperm and also secrete hormones.

In females, ovaries secrete **estrogen** (ēs-trō-jĕn) and **progesterone** (prō-JĔS-tĕ-rŏn). At the onset of puberty, estrogen promotes the development of breasts and the maturation of the uterus. Progesterone causes the uterine lining to thicken in preparation for pregnancy. Together, progesterone and estrogen are responsible for the changes that occur in the uterus during the menstrual cycle.¹⁴

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14. National Cancer Institute. (n.d.). *Gonads*. National Institutes of Health. <https://training.seer.cancer.gov/anatomy/endocrine/glands/gonads.html>

In males, testes secrete **testosterone** (tēs-TŌS-tě-rōn). At the onset of puberty, testosterone is responsible for the following actions¹⁵:

- Growth and development of the male reproductive structures
- Increased skeletal and muscular growth
- Enlargement of the larynx accompanied by a deepening voice
- Growth and distribution of body hair

¹⁵. National Cancer Institute. (n.d.). *Gonads*. National Institutes of Health.
<https://training.seer.cancer.gov/anatomy/endocrine/glands/gonads.html>

17.5 Physiology of the Endocrine System

The endocrine system communicates with other parts of the body by secreting hormones from the endocrine glands. Hormones are transported primarily via the bloodstream throughout the body. Each hormone binds to receptors on specific target cells, creating a desired response.¹

For example, when a person is exposed to a dangerous situation, the “**fight-or-flight response**” (fīt-ŏr-flīt rĭ-spŏns) occurs. The fight-or-flight response is triggered by the release of epinephrine and norepinephrine hormones from the adrenal gland. These hormones act on target organs like the heart (to beat faster), the lungs (to breathe more efficiently), and blood vessels to the skeletal muscles (to provide more oxygenated blood with glucose for energy). These targeted actions are intended to help the individual to fight or run away from the dangerous situation.²

Although hormones travel throughout the body, they only affect cells with receptors for that particular hormone, called target cells. After the hormone binds to the receptor, a chain of events is initiated that leads to the target cell's response. Hormones play a critical role in the regulation of physiological

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2. This work is a derivative of [Anatomy and Physiology](https://openstax.org/books/anatomy-and-physiology/pages/1-introduction) by [OpenStax](https://openstax.org/books/anatomy-and-physiology/pages/1-introduction) licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

processes such as metabolism, growth and development of body tissues, fluid, electrolyte balance, sleep, and reproduction.³

View a supplementary YouTube video⁴ on hormones by
 Crash Course: [Endocrine System, Part 2 – Hormone Cascades: Crash Course Anatomy & Physiology #24](#)

3. This work is a derivative of [Anatomy and Physiology](#) by [OpenStax](#) licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

4. CrashCourse. (2015, June 29). *Endocrine system, Part 2 – Hormone cascades: Crash Course Anatomy & Physiology #24* [Video]. YouTube. All rights reserved. https://www.youtube.com/watch?v=SCV_m9ImN-Q

17.6 Diseases and Disorders of the Endocrine System

ACROMEGALY

Acromegaly (ak-rō-MEG-ă-lē) is an endocrine disorder in adults caused when abnormally high levels of human growth hormone (HGH) trigger additional growth of the bones in the face, hands, and feet. Because the growth plates are closed in adults, the bones grow wider and thicker. In most cases, acromegaly is caused by a benign tumor in the pituitary gland, called a pituitary **adenoma** (ăd-ě-NŌ-mă). Treatment may include surgery, medications, and/or radiation therapy to remove or control tumor size and return HGH levels back to normal.¹ See Figure 17.2² for an image of a man with acromegaly with enlarged bones in the face and hands.

1. National Institute of Diabetes and Digestive and Kidney Disorders. (2020, January). *Acromegaly*. National Institutes of Health.
<https://www.niddk.nih.gov/health-information/endocrine-diseases/acromegaly>
2. “[Man showing the characteristic appearances of acromegaly Wellcome L0062529.jpg](#)” by unknown author via [Wellcome Collection Gallery](#) and is licensed under [CC BY 4.0](#)

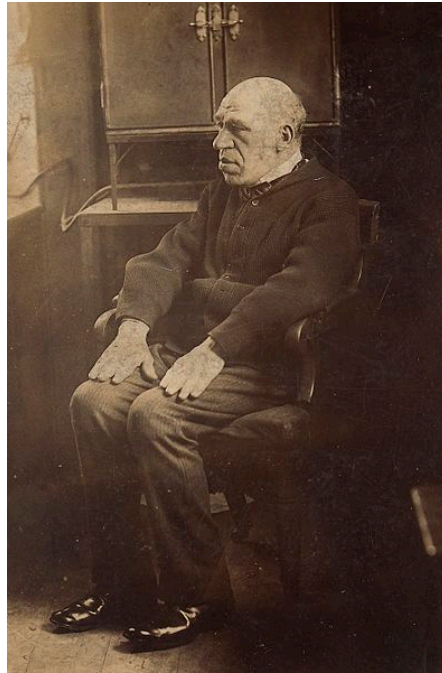


Figure 17.2 Acromegaly

ADDISON'S DISEASE

Addison's disease (ăd-ĭ-Sŏnz dĩ-ZĒZ) is a disorder in which the adrenal glands don't produce enough cortisol and aldosterone hormones, also called **adrenal insufficiency** (ă-drē-năl ĭn-sŭ-fĭsh-ĕn-sē). Decreased cortisol results in **hypoglycemia** (hĭ-pŏ-glĭ-SĒ-mē-ă), which is low blood glucose levels. Because aldosterone helps maintain the balance of sodium and potassium in the blood and regulates blood pressure, low aldosterone levels cause **hypotension** (hĭ-pŏ-TĒN-shŭn), which is low blood pressure. Other symptoms of Addison's disease are fatigue, muscle weakness, loss of appetite, weight loss, and abdominal pain. The most serious complication of adrenal

insufficiency is called adrenal crisis. If not treated right away, adrenal crisis can cause death.^{3,4}

Adrenal insufficiency is commonly diagnosed by an ACTH stimulation test. In this diagnostic test, ACTH is administered intravenously (IV), and then blood samples are taken to measure cortisol levels in the blood. The normal response is a rise in blood cortisol levels, but people with Addison's disease have little or no increase in cortisol levels. Treatment of Addison's disease consists of hormone replacement medication to restore normal levels of cortisol and aldosterone.^{5,6}

3. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Adrenal insufficiency & Addison's disease*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/endocrine-diseases/adrenal-insufficiency-addisons-disease>
4. Mayo Clinic. (2022, December 8). *Addison's disease*. <https://www.mayoclinic.org/diseases-conditions/addisons-disease/symptoms-causes/syc-20350293>
5. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Adrenal insufficiency & Addison's disease*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/endocrine-diseases/adrenal-insufficiency-addisons-disease>
6. Mayo Clinic. (2022, December 8). *Addison's disease*. <https://www.mayoclinic.org/diseases-conditions/addisons-disease/symptoms-causes/syc-20350293>

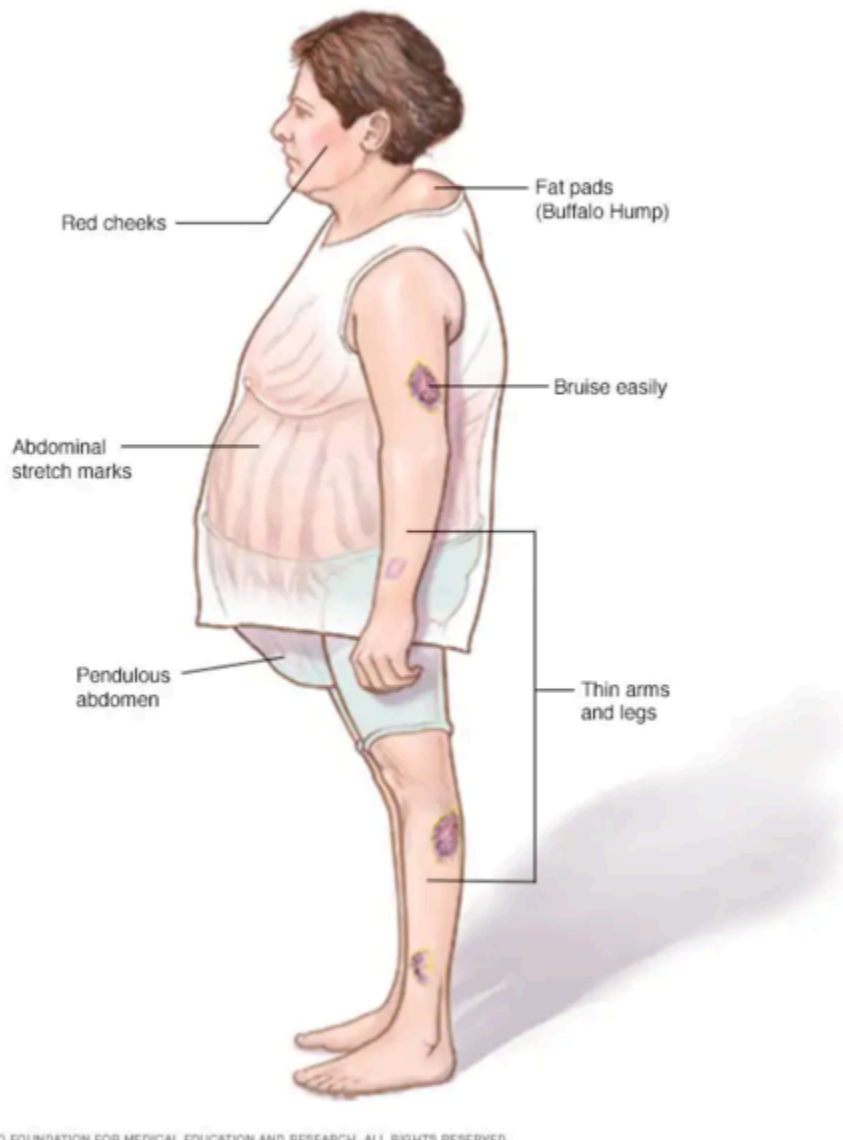
CUSHING'S DISEASE AND CUSHING'S SYNDROME

Cushing's disease (KŪSH-īngz dī-ZĒZ) is a disorder caused by the excessive secretion of cortisol, resulting in **hyperglycemia** (hī-pĕr-glī-SĒ-mĕ-ă), which is elevated blood glucose levels. A common cause of Cushing's disease is a pituitary tumor. **Cushing's syndrome** (KŪSH-īngz SĪN-drōm) happens when the body makes too much cortisol, or the person is taking medications called glucocorticoids that affect the body the same way as cortisol. A **syndrome** (SĪN-drōm) refers to signs and symptoms that occur together that are characteristic of a specific disorder.

Too much cortisol causes symptoms such as a fatty hump between the shoulders, thin legs and arms, a round face, easy bruising, and pink or purple stretch marks on the skin called **striae** (STRĪ-ē). See Figure 17.3⁷ for an illustration of a person with Cushing's syndrome. It can also cause high blood pressure, bone loss, poor wound healing, and type 2 diabetes. Treatment depends on the cause. If glucocorticoid medications are being taken, their use is reduced or eliminated, if possible. If a tumor is the cause, then it is removed by surgery or reduced in size by radiation therapy. Medications may also be prescribed to control the body's production of cortisol.⁸

7. "[Cushing's Syndrome.webp](#)" by [Mayo Clinic](#) is licensed under [CC BY-SA 4.0](#)

8. Mayo Clinic. (2023, June 7). *Cushing's syndrome*. <https://www.mayoclinic.org/diseases-conditions/cushing-syndrome/symptoms-causes/syc-20351310>



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Figure 17.3 Cushing's Syndrome

DIABETES INSIPIDUS

Diabetes insipidus (dī-ă-BĒ-tēz in-SIP-ĭ-dŭs) (**DI**) is condition caused by a lack of antidiuretic hormone (ADH). It is characterized by large amounts of very dilute urine, referred to as **polyuria** (pŏl-ē-YŌŌR-ē-ă). While most people make 1 to 3 quarts of urine a day, people with diabetes insipidus can make up

to 20 quarts of urine a day. See Figure 17.4⁹ for an image of dilute urine seen in polyuria. DI is often treated with medication that mimics the effects of ADH. Note that diabetes insipidus is not the same as diabetes mellitus. Although both conditions can increase thirst and polyuria, they are not related.¹⁰



Figure 17.4 Dilute Urine Seen in Polyuria

DIABETES MELLITUS

Diabetes mellitus (dī-ă-BĒ-tēz MĒL-ĭ-tŭs) (**DM**) refers to disorders that cause hyperglycemia (high levels of glucose in the blood). Over time, hyperglycemia damages the blood vessels in the heart, kidneys, feet, and eyes.

9. “31388976010_b0750ceed4_k.jpg” by [John Campbell](#) is licensed in the [Public Domain](#).
10. National Institute of Diabetes and Digestive and Kidney Disease. (2021, September). *Diabetes insipidus*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/kidney-disease/diabetes-insipidus>

There are different types of diabetes called type 1, type 2, and gestational. **Type 1 diabetes** (tīp wŭn dī-ă-BĒ-tēz) is caused by an autoimmune disease that destroys the cells of the pancreas that create insulin. In **type 2 diabetes** (tīp tōō dī-ă-BĒ-tēz), the cells of the body do not use insulin effectively to facilitate the uptake of glucose for energy. Additionally, the pancreas may not be making enough insulin to maintain blood glucose levels within normal range. **Gestational diabetes** (jēs-TĀ-shŭn-ăl dī-ă-BĒ-tēz) refers to a type of diabetes that develops during pregnancy. Gestational diabetes typically goes away after the baby is born, but it increases the risk of the mother for developing type 2 diabetes later in life.

Common symptoms of untreated diabetes are:

- **Polydipsia** (pŏl-ē-DĪP-sē-ă): Excessive thirst
- **Polyuria** (pŏl-ē-YŌŌR-ē-ă): Excessive urine output
- **Polyphagia** (pŏl-ē-FĀ-jē-ă): Excessive hunger/eating

Diabetes mellitus is diagnosed with blood tests that evaluate blood glucose levels, including the following tests:

- **Fasting blood glucose** (FĀST-ing blŭd GLŪ-kōs) (**FBG**): Assesses an individual's blood glucose level when they have had no caloric intake for at least eight hours. The normal fasting blood glucose range is between 70-100 mg/dL. **Hypoglycemia** (hī-pō-glī-SĒ-mē-ă) refers to an abnormally low blood glucose level below 70 mg/dL.
- **Random blood glucose** (răn-dŏm blŭd GLŪ-kōs): Measures the level of glucose in the blood at any given time, without the requirement for fasting.
- **Hemoglobin A1C** (HĒ-mō-glō-bĭn Ā-wŭn-SĒ) (**HbA1C**): Assesses an individual's average blood glucose levels over the preceding two to three months. HbA1C is a form of hemoglobin. When glucose is in the bloodstream, it attaches to hemoglobin, forming glycated hemoglobin. The normal range for HbA1C is typically less than 5.7%.
- **Oral glucose tolerance test** (ŌR-ăl GLŪ-kōs TŌL-ěr-ăns tĕst) (**OGTT**): Evaluates the body's ability to regulate blood glucose levels, especially after consuming a high dose of glucose. The results are typically reported

as blood glucose levels measured at different time points (such as fasting one hour post-glucose consumption and two hours post-glucose consumption). Elevated blood glucose levels at any of these time points indicate diabetes. This test is often performed during pregnancy to assess for gestational diabetes.

People with diabetes must monitor their blood glucose levels and often adjust their medications based on these levels. See Figure 17.4¹¹ for an image of a blood glucose monitor typically used in hospital and home settings.¹²

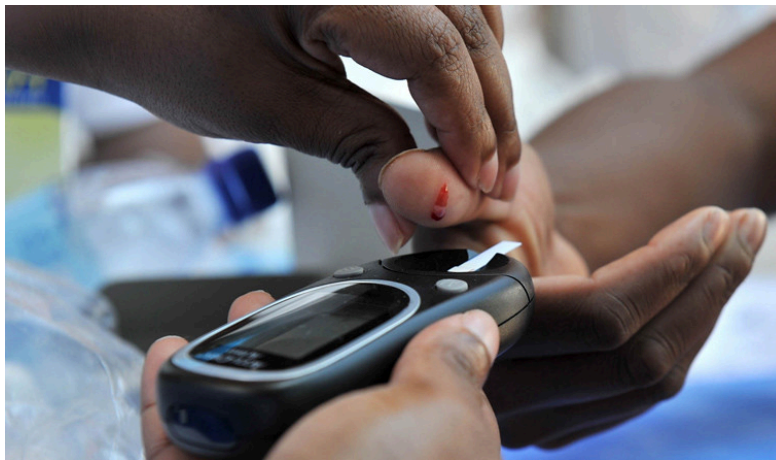


Figure 17.4 Blood Glucose Monitoring Device

Diabetes is treated with insulin injections, oral medications, or inhaler medications. Some people with type 1 diabetes have insulin pumps they wear

11. “8286152103_b624d39f68_c.jpg” by [GovernmentZA](#) is licensed under [CC BY-ND 2.0](#)

12. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Diabetes*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/diabetes>

outside of their body that deliver steady doses of insulin to mimic the function of the pancreas.¹³

A potentially life-threatening complication of type 1 diabetes is **diabetic ketoacidosis** (dī-ă-BĔT-ĭk kē-tō-ăs-ĭ-DŌ-sĭs) (**DKA**). DKA develops when the body breaks down fatty acids for energy when there isn't enough insulin to facilitate the uptake of glucose into cells. As a result, excessive ketones are created, causing the body to become acidic. Treatment includes intravenous administration of insulin, fluids, and electrolytes to restore normal body functioning.

Gigantism

Gigantism (jĭ-GĂN-tĭz-əm) is a rare endocrine condition characterized by excessive growth and height significantly above average. This condition is caused by the overproduction of human growth hormone (HGH) in childhood, often due to an HGH-secreting pituitary tumor. Treatment for gigantism is based on the cause and may include surgery or radiation to remove or shrink the tumor.¹⁴ See Figure 17.5¹⁵ for an image of an individual with gigantism compared to an individual of average height.

13. National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *Diabetes*. National Institutes of Health. <https://www.niddk.nih.gov/health-information/diabetes>

14. Cleveland Clinic. (2022, May 9). *Gigantism*. National Institutes of Health. <https://my.clevelandclinic.org/health/diseases/22954-gigantism>

15. “[Robert Wadlow postcard.jpg](#)” by unknown author is licensed in the [Public Domain](#).



Figure 17.5 Gigantism

Hirsutism

Hirsutism (HĪR-sū-tīz-əm) refers to the overgrowth of hair in women, such as on the chin and face, due excessive production of androgens. See Figure 17.6¹⁶ for an image of hirsutism. Hirsutism is caused by endocrine disorders such as polycystic ovary syndrome (PCOS) and Cushing's syndrome or from side effects of certain medications. Treatment may include medications or hair removal options.¹⁷

¹⁶. "PMC4103002_ircmj-16-9410-g001.png" by Gacaferri Lumezi B. et al., is licensed under [CC BY 3.0](https://creativecommons.org/licenses/by/3.0/)

¹⁷. Cleveland Clinic. (2022, July 8). *Hirsutism*. <https://my.clevelandclinic.org/health/diseases/14523-hirsutism>



Figure 17.6 Hirsutism

HYPERPARATHYROIDISM

Hyperparathyroidism (hī-pěr-PĀR-ă-THĪ-rōid-izm) refers to a condition in which the parathyroid glands produce too much parathyroid hormone (PTH), leading to **hypercalcemia** (hī-pěr-kāl-SĒ-mē-ă), which is excessive calcium in the blood. Treatment is based on the cause. For example, if the condition is caused by a tumor on one or more of the parathyroid gland(s), a **parathyroidectomy** (păr-ă-thī-royd-ĖK-tō-mē) is performed to remove the affected parathyroid gland.¹⁸

HYPERTHYROIDISM

Hyperthyroidism (hī-pěr-THĪ-rōid-izm) refers to abnormally high levels of thyroid hormones (i.e., T3 and T4) that cause increased metabolism and

18. Mayo Clinic. (2022, May 17). *Hyperparathyroidism*. <https://www.mayoclinic.org/diseases-conditions/hyperparathyroidism/diagnosis-treatment/drc-20356199>

symptoms like unintended weight loss, profuse sweating, and increased heart rate. Conditions that can cause hyperthyroidism are as follows:

- **Grave's disease** (GRĀVZ dī-ZĒZ): An autoimmune disorder of the thyroid gland causing the production of excess thyroid hormones
- **Adenomas** (ăd-ě-NŌ-măz): Overactive thyroid nodules that produce thyroid hormones
- **Thyroiditis** (thī-royd-ĪT-īs): Inflammation of the thyroid gland

A classic symptom of Grave's disease is **exophthalmos** (ek-saaf-thal-muhs), which refers to bulging eyes. See Figure 17.7¹⁹ for an image of exophthalmos.



Figure 17.7 Exophthalmos

Several treatments are available for hyperthyroidism, such as antithyroid medications, radioactive iodine therapy, or surgery to remove all or part of the thyroid gland, referred to as a **thyroidectomy** (thī-royd-EK-tō-mē).²⁰

19. “[Proptosis and lid retraction from Graves%27 Disease.jpg](#)” by Jonathan Trobe, M.D. – University of Michigan Kellogg Eye Center is licensed under [CC BY 3.0](#)

20. Mayo Clinic. (2022, November 30). *Hyperthyroidism*.
<https://www.mayoclinic.org/diseases-conditions/hyperthyroidism/symptoms-causes/syc-20373659>

HYPOPARATHYROIDISM

Hypoparathyroidism (hī-pō-pär-ă-THĪ-rōid-izm) is a condition in which the parathyroid glands do not produce enough parathyroid hormone (PTH), leading to **hypocalcemia** (hī-pō-kāl-SĒ-mē-ă), low levels of calcium in the blood. Hypoparathyroidism can be caused by accidental damage to the parathyroid glands during thyroid or neck surgery or due to an autoimmune disease. It is treated with parathyroid hormone replacement and supplements like calcium and vitamin D.²¹

HYPOTHYROIDISM

Hypothyroidism (hī-pō-THĪ-rōid-izm) refers to abnormally low levels of thyroid hormones (T3 and T4) produced by the thyroid gland. Symptoms include unintended weight gain, fatigue, constipation, cold sensitivity, and memory problems. A **goiter** (GOI-tēr) is a symptom of hypothyroidism and hyperthyroidism and is an abnormal enlargement of the thyroid gland. See Figure 17.8²² for an image of a goiter. Hypothyroidism is treated with lifelong thyroid hormone replacement medication and routine blood tests to maintain normal blood levels of thyroid hormones.²³

21. Mayo Clinic. (2022, May 11). *Hypoparathyroidism*. <https://www.mayoclinic.org/diseases-conditions/hypoparathyroidism/symptoms-causes/syc-20355375>

22. “Goiter.JPG” by Dr. J.S.Bhandari, India is licensed under [CC BY-SA 3.0](#)

23. Mayo Clinic. (2022, December 10). *Hypothyroidism*. <https://www.mayoclinic.org/diseases-conditions/hypothyroidism/symptoms-causes/syc-20350284>

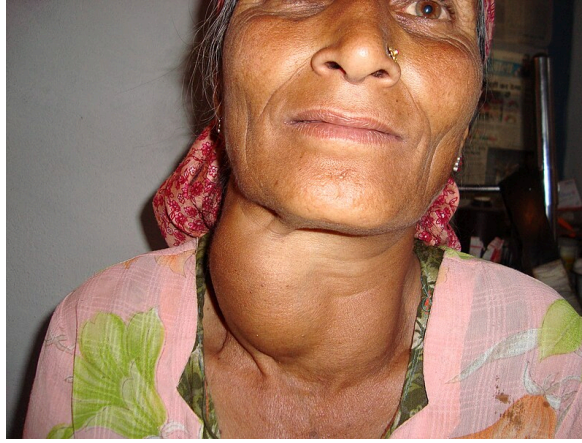


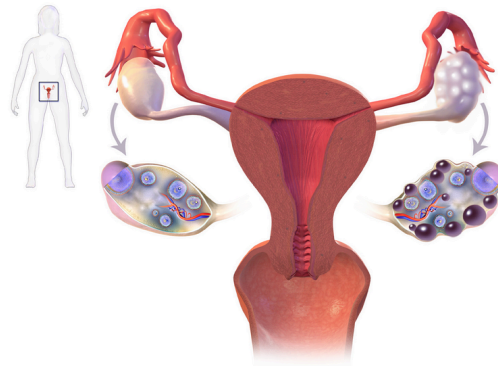
Figure 17.8 Goiter Caused by Hypothyroidism

POLYCYSTIC OVARY SYNDROME

Polycystic ovary syndrome (pŏl-ē-SĭS-tĭk Ō-vă-r-ē SĭN-drŏm) (**PCOS**) is a common hormone problem for women of childbearing age. Women with PCOS have multiple small cysts on the ovaries and may not ovulate. See Figure 17.9²⁴ for an illustration of PCOS. They may have high levels of androgens. PCOS can cause missed or irregular menstrual periods, hirsutism (excessive hair growth), acne, infertility, and unintended weight gain.²⁵

24. “PCOS_28Part_229.png” by BruceBlaus is licensed under CC BY-SA 4.0

25. Johns Hopkins Medicine. (n.d.). *Polycystic ovary syndrome (PCOS)*.
<https://www.hopkinsmedicine.org/health/conditions-and-diseases/polycystic-ovary-syndrome-pcos>



Polycystic Ovary Syndrome

Figure 17.9 PCOS

17.7 Medical Specialists, Diagnostic Testing, and Procedures Related to the Endocrine System

MEDICAL SPECIALISTS

Endocrinology (ĕn-dō-krĭ-NŌL-ŏ-jē) refers to the study of the endocrine system.

Endocrinologists

Endocrinologists (ĕn-dō-krĭ-NŌL-ŏ-jĭsts) are physicians who specialize in diagnosing and treating diseases associated with the endocrine system.

Endocrine surgeons (ĕn-dō-krĭn SŪR-jŏns) treat endocrine disease by removing affected endocrine gland or tissue.

▶ Read more information about endocrinologists on the [American Association of Clinical Endocrinology's web page](#).

Diabetes Nurse Educator

Diabetes nurse educators are registered nurses who specialize in helping people effectively self-manage the chronic disease of diabetes mellitus. They

provide instruction on monitoring blood glucose levels, administering insulin, making healthy diet choices, and caring for feet and skin to prevent complications.¹

- ▶ Read more on Indeed's web page: [How to Become a Diabetes Educator in 5 Steps](#).

Dietitians and Nutritionists

Dietitians and nutritionists often help people diagnosed with diabetes mellitus plan appropriate diets to manage their disease and lead healthy lives. They typically have a bachelor's degree and work in many settings, including hospitals, nursing homes, and clinics.

- ▶ Read more information on the Bureau of Labor's web page about [Dietitians and Nutritionists](#).

Diagnostic Testing

Blood Tests

Blood serum testing is done to determine the levels of various endocrine hormones in the blood if an endocrine disorder is suspected. Additional testing may be performed to monitor electrolyte levels in the blood, such as

1. DailyNurse. (n.d.). *Diabetes educator*. <https://dailynurse.com/diabetes-educator/#:~:text=The%20diabetic%20nurse%20educator%20establishes,glucose%3B%20and%20administration%20of%20insulin>

sodium, potassium, and calcium. Read more about specific blood tests performed for specific diseases in the “[Diseases and Disorders of the Endocrine System](#)” section.

Radioactive Iodine Uptake

A **radioactive iodine uptake** (rā-dē-ō-ĀK-tīv Ī-ō-dīn ŪP-tāk) test evaluates how well the thyroid is functioning by administering radioactive iodine and then measuring how much is taken up by the thyroid. This test is often performed in combination with a thyroid scan.²

Thyroid Scan

A thyroid scan uses a radioactive iodine tracer to examine the structure and function of the thyroid gland. This test is often done in combination with a radioactive iodine uptake test. The scanner detects the location and intensity of the rays given off by the radioactive material, and a computer displays images of the thyroid gland.³

PROCEDURES

Surgeries related to the endocrine system include the following:

2. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Radioactive iodine uptake; [reviewed 2022, Jan 9; cited 2023, Dec 4). <https://medlineplus.gov/ency/article/003689.htm>
3. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2023. Thyroid scan; [reviewed 2022, Feb 1; cited 2023, Dec 4). <https://medlineplus.gov/ency/article/003829.htm>

- **Adrenalectomy** (ăd-rē-năl-ĔK-tŏ-mē): Surgical excision of one or more adrenal glands.
- **Hypophysectomy** (hī-pō-fī-SĔK-tŏ-mē): Surgical removal of the pituitary gland.
- **Pancreatectomy** (păn-krē-ă-TĔK-tŏ-mē): Surgical removal of the pancreas.
- **Parathyroidectomy** (păr-ă-thī-rŏi-DĔK-tŏ-mē): Surgical removal of one or more of the parathyroid glands.
- **Thyroidectomy** (thī-rŏi-DĔK-tŏ-mē): Surgical removal of all or part of the thyroid gland.

17.8 Endocrine Learning Activities

Interactive Learning Activity: Practice labelling the parts of the endocrine system.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=569#h5p-128>

Interactive Learning Activity: Study endocrine system medical terms discussed in this chapter.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=569#h5p-193>

Interactive Learning Activity: Test yourself on these endocrine system terms.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=569#h5p-159>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to

their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=569#h5p-131>

Interactive Learning Activity: Using the sample documentation provided, drag the terms on the right to their appropriate spaces within the documentation.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=569#h5p-132>



Interactive Learning Activity: Practice identifying and defining word parts for terms discussed in this chapter.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/medterm/?p=569#h5p-209>

- ▶ You can also print this as a [Chapter 17 Practice Worksheet](#) and check your answers with this [Answer Key PDF](#).

17.9 Glossary

Acromegaly (ak-rō-MEG-ă-lē): A disorder in adults caused by excessive production of growth hormone, leading to enlargement of bones in face, hands, and feet. ([Chapter 17.6](#))

Addison's disease (ăd-ĭ-Sōnz dī-ZĒZ): A disorder where the adrenal glands produce insufficient cortisol and aldosterone, leading to symptoms like hypoglycemia and hypotension. ([Chapter 17.6](#))

Adenoma (ăd-ě-NŌ-mă): A benign tumor that arises in or resembles glandular tissue. ([Chapter 17.6](#))

Adrenal cortex (ă-DRĒ-nal KŌR-těks): The outer portion of the adrenal glands that produces hormones like cortisol, aldosterone, and androgens. ([Chapter 17.4](#))

Adrenalectomy (ăd-rē-năl-ĖK-tŏ-mē): Surgical excision of one or more of the adrenal glands. ([Chapter 17.7](#))

Adrenal glands (ă-DRĒ-nal glandz): Endocrine glands located on top of each kidney, consisting of the adrenal cortex and adrenal medulla, producing various hormones including aldosterone, cortisol, and catecholamines. ([Chapter 17.4](#))

Adrenal insufficiency (ă-drē-năl ĩn-sŭ-fĭsh-ĕn-sē): A medical condition where the adrenal glands fail to produce sufficient amounts of steroid hormones, particularly cortisol and aldosterone, leading to symptoms like fatigue, muscle weakness, and low blood pressure. ([Chapter 17.6](#))

Adrenocorticotrophic hormone (ă-drē-nŏ-kŏr-tĭ-kŏ-TRŌP-ik HŌR-mŏn) (ACTH): A hormone produced by the pituitary gland, stimulating the adrenal cortex to produce cortisol and other hormones. ([Chapter 17.4](#))

Aldosterone (ăl-DŌS-tě-rŏn): A hormone produced by the adrenal cortex that helps regulate blood pressure and electrolyte balance by signaling the kidneys to absorb sodium and excrete potassium. ([Chapter 17.4](#))

Androgens (ĂN-drŏ-jĕnz): Male sex hormones produced in small amounts by both sexes, primarily in the adrenal cortex, and involved in the development of male characteristics. ([Chapter 17.4](#))

Antidiuretic hormone (ăn-tī-dī-yū-RĚT-ik HŌR-mōn) (ADH): A hormone produced by the pituitary gland that regulates water balance in the body by controlling the amount of water reabsorbed by the kidneys. ([Chapter 17.4](#))

Basal metabolic rate (BĀ-sāl MĚT-ă-bŏl-ĭk RĀT) (BMR): The rate at which the body uses energy while at rest to maintain vital functions such as breathing and temperature regulation. ([Chapter 17.4](#))

Beta endorphin (BĀ-tă ěn-DŌR-fĭn): A natural opioid peptide hormone produced in the brain and pituitary gland, involved in pain relief and feelings of well-being. ([Chapter 17.4](#))

Calcitonin (kăl-sĭ-TŌ-nĭn): A hormone produced by the thyroid gland that helps regulate calcium levels in the blood by reducing the concentration of calcium. ([Chapter 17.4](#))

Catecholamines (kăt-ě-KŌL-ă-mēns): Hormones produced by the adrenal medulla, including epinephrine and norepinephrine, which are involved in the body's stress response. ([Chapter 17.4](#))

Cortisol (KŌR-tĭ-sŏl): A glucocorticoid hormone produced by the adrenal cortex, playing a vital role in stress response, metabolism, and immune response regulation. ([Chapter 17.4](#))

Cushing's disease (KŪSH-ĭngz dĭ-ZĚZ): A condition caused by excessive cortisol production, often due to a pituitary tumor, leading to symptoms like weight gain and high blood sugar. ([Chapter 17.6](#))

Cushing's syndrome (KŪSH-ĭngz SĪN-drŏm): A condition characterized by the body's prolonged exposure to high levels of cortisol, which may be caused by the use of steroid medication or by tumors that increase cortisol production. ([Chapter 17.6](#))

Diabetes insipidus (dĭ-ă-BĚ-tēz in-SIP-ĭ-dŭs) (DI): A condition characterized by excessive production of dilute urine, due to a deficiency in antidiuretic hormone (ADH). ([Chapter 17.6](#))

Diabetes mellitus (DM) (dĭ-ă-BĚ-tēz MĚL-ĭ-tŭs): A group of metabolic disorders characterized by high blood sugar levels over a prolonged period due to insulin deficiency and/or resistance. ([Chapter 17.6](#))

Diabetic ketoacidosis (dĭ-ă-BĚT-ĭk kē-tŏ-ăs-ĭ-DŌ-sĭs) (DKA): A serious complication of diabetes that occurs when the body produces high levels of

blood acids called ketones, typically due to a severe lack of insulin. ([Chapter 17.6](#))

Dwarfism (DWÔR-fîz-əm): A condition characterized by short stature, often resulting from a genetic or medical condition, such as a deficiency in growth hormone. ([Chapter 17.4](#))

Endocrine (ĖN-dō-krīn): Pertaining to glands that secrete hormones directly into the bloodstream. The pancreas serves an endocrine function by producing hormones like insulin and glucagon. ([Chapter 17.4](#))

Endocrine surgeons (Ėn-dō-krīn SŪR-jōns): Medical specialists who perform surgical procedures on the endocrine glands, such as the thyroid, parathyroid, and adrenal glands, to treat various endocrine disorders and diseases. ([Chapter 17.7](#))

Endocrinologists (Ėn-dō-krī-NŌL-ō-jĭsts): Physicians who specialize in studying and treating diseases associated with the endocrine system. ([Chapter 17.7](#))

Endocrinology (Ėn-dō-krī-NŌL-ō-jē): The study of the structure, function, and disorders of the endocrine system. ([Chapter 17.7](#))

Epinephrine (Ėp-ĭ-NĖF-rĭn): Also known as adrenaline, a hormone produced by the adrenal medulla, playing a key role in the fight-or-flight response by increasing heart rate and blood flow. ([Chapter 17.4](#))

Estrogen (ĖS-trō-jĕn): A group of hormones primarily responsible for the development and regulation of female reproductive system and secondary sex characteristics. ([Chapter 17.4](#))

Euthyroid (yū-THĭ-rōid): A term that describes normal thyroid gland functioning, with the production of the correct amount of thyroid hormones. ([Chapter 17.4](#))

Exocrine (ĖK-sō-krīn): Referring to glands that secrete their products through ducts to the surface of an organ or tissue or into a vessel. In the context of the pancreas, it refers to the production of digestive enzymes. ([Chapter 17.4](#))

Exophthalmos (ek-saaf-thal-muhs): A medical term for bulging eyes, a symptom of hyperthyroidism. ([Chapter 17.6](#))

Fasting blood glucose (FĀST-ing blŭd GLŪ-kōs) (FBG): A test that

measures blood sugar levels after an individual has not eaten for at least 8 hours, used to diagnose diabetes. ([Chapter 17.6](#))

Fight-or-flight response (fĭt-ŏr-flĭt rĭ-spŏns): A physiological reaction characterized by the increased production of hormones like adrenaline and norepinephrine in response to a perceived threat or stress, resulting in various bodily changes like increased heart rate, blood pressure, and energy levels, preparing the body for either confrontation or rapid retreat. ([Chapter 17.5](#))

Follicle-stimulating hormone (FŎL-ĭ-kŭl STĭM-yŭ-lāt-ing HŎR-mŏn) (FSH): A hormone produced by the pituitary gland that stimulates the growth of ovarian follicles in females and sperm production in males. ([Chapter 17.4](#))

Gestational diabetes (jĕs-TĀ-shŭn-ăl dĭ-ă-BĒ-tĕz): A form of diabetes that manifests during pregnancy, involving elevated blood glucose levels, and generally resolves after the baby's birth, although it can increase the risk of developing type 2 diabetes later in life. ([Chapter 17.6](#))

Gigantism (jĭ-GĀN-tĭz-əm): A rare condition caused by excessive production of growth hormone in childhood, leading to abnormal increase in height and size. ([Chapter 17.4](#), [Chapter 17.6](#))

Glucagon (GLŪ-kă-gŏn): A hormone produced by the pancreas that raises blood glucose levels by stimulating the liver to release stored glucose. ([Chapter 17.4](#))

Glucose (GLŪ-kŏs): A simple sugar that is an important energy source in living organisms and a component of many carbohydrates. ([Chapter 17.4](#))

Goiter (GOI-tĕr): An enlargement of the thyroid gland, which can be a symptom of both hypothyroidism and hyperthyroidism or result from iodine deficiency. ([Chapter 17.4](#), [Chapter 17.6](#))

Grave's disease (GRĀVZ dĭ-ZĒZ): An autoimmune disorder that is the most common cause of hyperthyroidism, where the immune system attacks the thyroid gland causing it to produce too much thyroid hormone. ([Chapter 17.6](#))

Hemoglobin A1C (HĒ-mŏ-glŏ-bĭn Ā-wŭn-SĒ) (HbA1C): A blood test that indicates the average level of blood sugar over the past two to three months, used to diagnose and manage diabetes. ([Chapter 17.6](#))

Hirsutism (HĭR-sŭ-tĭz-əm): The excessive growth of dark or coarse hair in a male-like pattern in women, often due to increased androgen levels. ([Chapter 17.6](#))

Hormones (HÖR-mōnz): Chemical messengers secreted by endocrine glands, traveling through the bloodstream to target organs to initiate specific physiological responses. ([Chapter 17.4](#))

Human growth hormone (HYOO-măñ GRÖTH HÖR-mōn) (HGH): A hormone produced by the anterior pituitary gland, crucial for growth and metabolic processes in the body. ([Chapter 17.4](#))

Hypercalcemia (hī-pěr-kăĭ-SĒ-mē-ă): A condition characterized by an abnormally high level of calcium in the blood. ([Chapter 17.6](#))

Hyperglycemia (hī-pěr-glī-SĒ-mē-ă): A condition characterized by an abnormally high level of glucose in the blood, often associated with diabetes. ([Chapter 17.4](#), [Chapter 17.6](#))

Hyperparathyroidism (hī-pěr-PĂR-ă-THĪ-rōid-izm): A condition in which the parathyroid glands produce too much parathyroid hormone, leading to high levels of calcium in the blood (hypercalcemia). ([Chapter 17.6](#))

Hyperthyroidism (hī-pěr-THĪ-rōid-izm): A condition characterized by excessive production of thyroid hormones by the thyroid gland, leading to symptoms like weight loss, increased heart rate, and anxiety. ([Chapter 17.6](#))

Hypocalcemia (hī-pō-kăĭ-SĒ-mē-ă): Low levels of calcium in the blood, which can be a symptom of hypoparathyroidism. ([Chapter 17.6](#))

Hypoglycemia (hī-pō-glī-SĒ-mē-ă): Low blood sugar levels, which can be a side effect of diabetes treatment. ([Chapter 17.4](#), [Chapter 17.6](#))

Hypoparathyroidism (hī-pō-păr-ă-THĪ-rōid-izm): A condition in which the parathyroid glands produce insufficient parathyroid hormone, leading to low levels of calcium in the blood (hypocalcemia). ([Chapter 17.6](#))

Hypophysectomy (hī-pō-fĭ-SĔK-tō-mē): Surgical removal of the pituitary gland. ([Chapter 17.7](#))

Hypopituitarism (hī-pō-pĭ-TŪ-ĭt-ă-rizm): A condition where the pituitary gland produces insufficient amounts of one or more of its hormones, leading to a variety of symptoms depending on which hormones are affected. ([Chapter 17.4](#))

Hypotension (hī-pō-TĔN-shŭn): Abnormally low blood pressure. ([Chapter 17.6](#))

Hypothyroidism (hī-pō-THĪ-rōid-izm): A condition in which the thyroid

gland doesn't produce enough thyroid hormones, leading to symptoms like fatigue, weight gain, and cold intolerance. ([Chapter 17.4](#), [Chapter 17.6](#))

Insulin (ĪN-sū-lĭn): A hormone produced by the pancreas that regulates blood glucose levels by facilitating the uptake of glucose into cells. ([Chapter 17.4](#))

Luteinizing hormone (LŪ-tē-ĭ-nīz-ing HŌR-mōn) (LH): A hormone produced by the pituitary gland, involved in triggering ovulation in females and testosterone production in males. ([Chapter 17.4](#))

Melatonin (MĔL-ă-tō-nĭn): A hormone produced by the pineal gland, affecting reproductive development and daily physiological cycles, including sleep patterns. ([Chapter 17.4](#))

Norepinephrine (nôr-ĕp-ĭ-NĔF-rĭn): A hormone produced by the adrenal medulla, involved in the body's response to stress and also acts as a neurotransmitter. ([Chapter 17.4](#))

Oral glucose tolerance test (ŌR-ăL GLŪ-kōs TŌL-ĕr-ăns tĕst) (OGTT): A test where a person consumes a glucose-rich beverage, and their blood sugar levels are tested over several hours to assess glucose metabolism. ([Chapter 17.6](#))

Oxytocin (ŏk-sē-TŌ-sĭn): A hormone produced by the pituitary gland, involved in childbirth, lactation, and social bonding. ([Chapter 17.4](#))

Pancreas (PĀN-krē-ăs): An organ with both exocrine and endocrine functions, producing digestive enzymes and hormones like insulin and glucagon. ([Chapter 17.4](#))

Pancreatectomy (păn-krē-ă-TĔK-tŏ-mē): Surgical removal of the pancreas. ([Chapter 17.7](#))

Parathyroid glands (PĀR-ă-THĪ-rŏid glandz): Small glands located on the thyroid gland that produce parathyroid hormone, which regulates calcium levels in the blood. ([Chapter 17.4](#))

Parathyroid hormone (PĀR-ă-THĪ-rŏid HŌR-mōn) (PTH): A hormone produced by the parathyroid glands that regulates calcium and phosphate balance in the blood and bone metabolism. ([Chapter 17.4](#))

Parathyroidectomy (păr-ă-thī-royd-ĔK-tŏ-mē): A surgical procedure to remove one or more of the parathyroid glands. ([Chapter 17.6](#), [Chapter 17.7](#))

Pineal gland (PĪ-nē-ăL gland): A small cone-shaped structure in the brain

that produces melatonin, influencing reproductive development and physiological cycles. ([Chapter 17.4](#))

Pituitary gland (pĭ-TŪ-ĭ-tĕr-ē gland): A pea-sized gland at the base of the brain, producing various hormones including GH, TSH, ACTH, FSH, LH, endorphins, and prolactin, influencing numerous bodily functions. ([Chapter 17.4](#))

Polycystic ovary syndrome (pŏl-ē-SĪS-tĭk Ō-vār-ē SĪN-drŏm) (PCOS): A hormonal disorder common among women of reproductive age characterized by prolonged or infrequent menstrual periods, excess androgen levels, and polycystic ovaries. ([Chapter 17.6](#))

Polydipsia (pŏl-ē-DĪP-sē-ă): Excessive thirst, often a symptom of diabetes. ([Chapter 17.6](#))

Polyphagia (pŏl-ē-FĀ-jē-ă): Excessive hunger or increased appetite, often a symptom of diabetes. ([Chapter 17.6](#))

Polyuria (pŏl-ē-YŌŌR-ē-ă): Excessive or an abnormally large production or passage of urine, frequently seen in diabetes. ([Chapter 17.6](#))

Progesterone (prŏ-JĔS-tĕ-rŏn): A hormone released by the ovaries that regulates the condition of the endometrium, which is important for maintaining pregnancy. ([Chapter 17.4](#))

Prolactin (prŏ-LĀK-tĭn): A hormone produced by the pituitary gland, primarily involved in milk production in breastfeeding mothers. ([Chapter 17.4](#))

Radioactive iodine uptake (rā-dē-ō-ĀK-tĭv Ī-ŏ-dĭn ŬP-tāk): A diagnostic test that measures how much radioactive iodine is absorbed by the thyroid gland, used to evaluate thyroid function. ([Chapter 17.7](#))

Random blood glucose (răn-dŏm blŭd GLŪ-kŏs): A test measuring the sugar levels in the blood at any given time, regardless of when the last meal was consumed, utilized to monitor and manage blood sugar levels in individuals with diabetes. ([Chapter 17.6](#))

Striae (STRĪ-ē): Streaks or lines on the skin, typically caused by rapid stretching and hormone changes, as seen in Cushing's syndrome. ([Chapter 17.6](#))

Syndrome (SĪN-drŏm): A set of medical signs and symptoms that are correlated with each other and, often, with a specific disease. ([Chapter 17.6](#))

Testosterone (tĕs-TŌS-tĕ-rŏn): The primary male sex hormone responsible

for the development of male reproductive tissues and secondary sexual characteristics. ([Chapter 17.4](#))

Thyroid gland (THĪ-rōid gland): An endocrine gland in the neck producing hormones like thyroxine and triiodothyronine, crucial for regulating metabolism and other body functions. ([Chapter 17.4](#))

Thyroid-stimulating hormone (THĪ-rōid-STĪM-yū-lāt-ing HŌR-mōn) (TSH): A hormone produced by the pituitary gland that stimulates the thyroid gland to produce thyroid hormones. ([Chapter 17.4](#))

Thyroidectomy (thī-rōi-DĚK-tō-mē): Surgical removal of all or part of the thyroid gland. ([Chapter 17.6](#), [Chapter 17.7](#))

Thyroiditis (thī-royd-ĪT-īs): Inflammation of the thyroid gland, which can cause either high or low levels of thyroid hormones. ([Chapter 17.6](#))

Thyroxine (thī-RŌK-sĭn) (T4): A hormone produced by the thyroid gland, involved in regulating metabolism, heart rate, and growth and development in children. ([Chapter 17.4](#))

Triiodothyronine (trī-ī-ō-dō-THĪ-rō-nēn) (T3): A hormone produced by the thyroid gland, playing a vital role in metabolism, heart rate, and body temperature regulation. ([Chapter 17.4](#))

Type 1 diabetes (tĭp wŭn dī-ă-BĒ-tēz): An autoimmune condition where the body's immune system attacks and destroys the insulin-producing beta cells in the pancreas, resulting in a lack of insulin and the need for life-long insulin therapy. ([Chapter 17.6](#))

Type 2 diabetes (tĭp tōō dī-ă-BĒ-tēz): A chronic condition characterized by insulin resistance, where body cells do not respond effectively to insulin, often combined with a deficiency in insulin production, leading to high blood sugar levels. ([Chapter 17.6](#))

Appendix: Instructor Resource - How to Remix H5P Activities For Your Courses

How to Remix H5P Activities For Your Courses

- In the H5P activity that you would like to remix, press the “Reuse” button located in the bottom left corner of the activity.
- Select the option to “Download as an .h5p file” and to save the content to your device.
- Log in to your H5P account.
 - *Helpful hints: If your institution does not have an H5P subscription, a free basic version of H5P is available at h5p.org. It is helpful to create a folder within your H5P account for remixing content so that your activities are easily accessible.*
- Click on “Content,” then click on “Create New Content,” then click on “Upload.” Select the H5P file that you downloaded to your device, then click on “Use” to upload the activity into your personal H5P account.
- Remix the content according to your preferences. For example, for flashcard activities provided in the book, you can delete or add flashcards. See the demonstration video below. (However, if you use the free, basic version of H5P, the audio pronunciations on the flashcards will not transfer.)
- Click “Save” to save the activity in your H5P account.
- The URL to this remixed activity in your personal H5P account can be added to your course in your learning management system for students to access.



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/medterm/?p=9387#video-9387-1>