6 General Anatomy and Physiology

Chapter Outline

- Why Study Anatomy and Physiology?
- Cells
- Tissues
- Organs and Body Systems
- The Skeletal System
- The Muscular System
- The Nervous System
- The Circulatory System
- The Lymphatic/Immune System
- The Endocrine System
- The Digestive System
- The Excretory System
- The Respiratory System
- The Integumentary System
- The Reproductive System

Learning Objectives

After completing this chapter, you will be able to:

- ☑ **LO1** Define and explain the importance of anatomy, physiology, and histology to the nail profession.
- ☑ **LO2** Describe cells, cell structure, and cell reproduction.
- ☑ **LO3** Define tissue and identify the types of tissues found in the body.
- ☑ **LO4** Name the 11 main body systems and explain their basic functions.

Key Terms

Page number indicates where in the chapter the term is used.

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abductor digiti minimi / 114
abductor hallucis / 114
adductors / 113
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Key Terms

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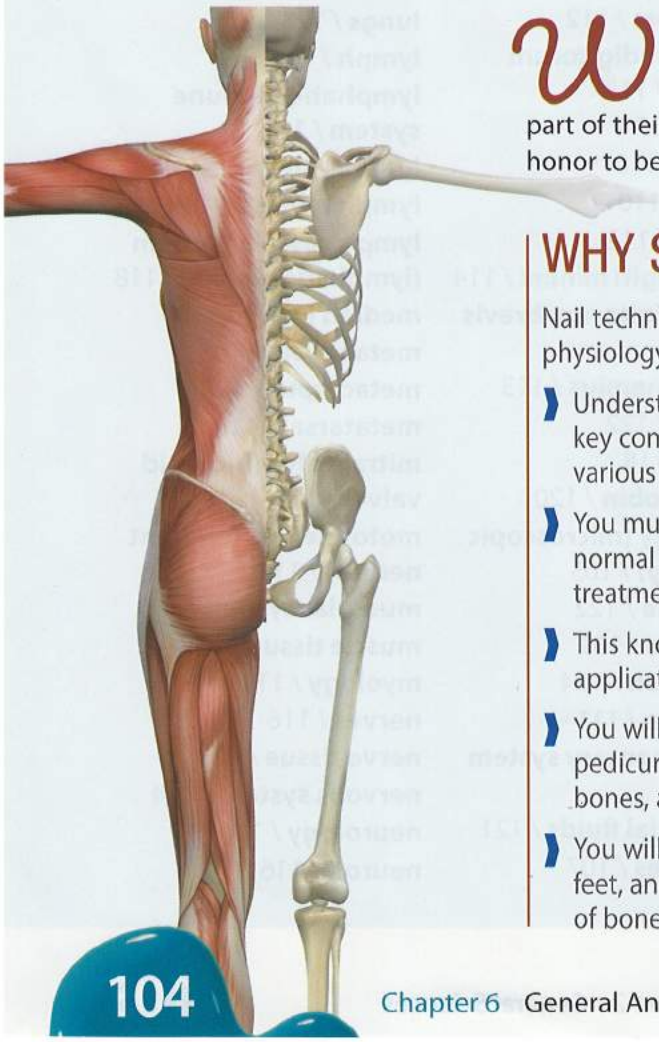


Whether applying a new set of tips or performing a manicure or foot massage, licensed nail technicians are permitted to touch people as part of their profession. This is true of very few other occupations, and it is an honor to be able to aid others in achieving a greater sense of well-being.

WHY STUDY ANATOMY AND PHYSIOLOGY?

Nail technicians should have a thorough understanding of anatomy and physiology because:

- Understanding how the human body functions as an integrated whole is a key component in understanding how a client's skin and nails may react to various treatments and services.
- You must be able to recognize the difference between what is considered normal and abnormal for the body in order to determine whether specific treatments and services are appropriate.
- This knowledge will help determine a scientific basis for the proper application of services and products.
- You will be responsible for performing safe and effective manicure and pedicure services aided by your knowledge of hand and foot nerves, bones, and muscle structure.
- You will be able to perform manipulations involving the hands, forearms, feet, and lower legs safely and effectively as a result of your understanding of bones, muscles, nerves, and circulation.

Anatomy is the study of the human body structures that can be seen with the naked eye as well as the various parts from which they are constructed. In other words, anatomy is the science of the structure of the human body or other organisms and their parts.

Physiology (fiz-ih-OL-oh-jee) is the study of the functions and activities performed by the body's structures.

Histology (his-TAHL-uh-jee) is the study of tiny structures found in tissue. It is also called **microscopic anatomy.** ☑ LO1

CELLS

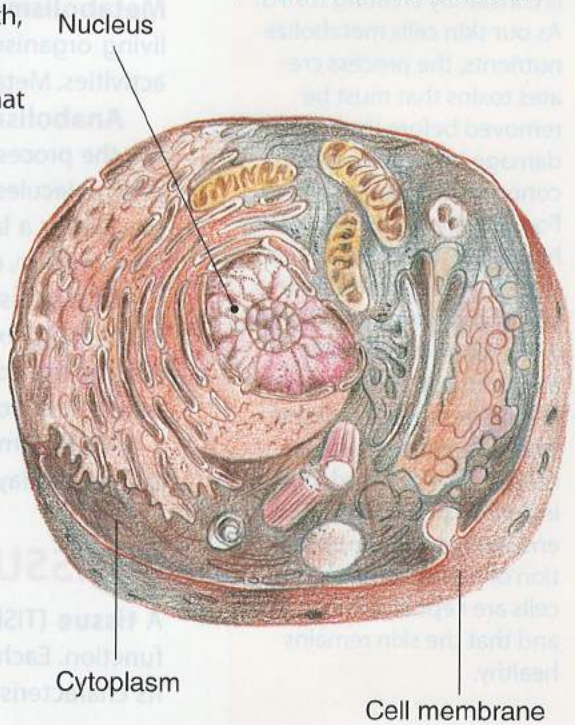
Cells are the basic units of all living things, from bacteria to plants and animals and including human beings. Without cells, life does not exist. As a basic functional unit, the cell is responsible for carrying on all life processes. There are trillions of cells in the human body, and they vary widely in size, shape, and purpose.

Basic Structure of the Cell

The cells of all living things are composed of a substance called **protoplasm** (PROH-toh-plaz-um), a colorless, jelly-like substance found inside cells in which food elements such as proteins, fats, carbohydrates, mineral salts, and water are present. You can visualize the protoplasm of a cell as being similar to the white of a raw egg. In addition to protoplasm, most cells also include the following components **(Figure 6–1)**:

- The **nucleus** (NOO-klee-us) is the dense, active protoplasm found in the center of the cell. It plays an important part in cell reproduction and metabolism. You can picture the nucleus as the yolk of a raw egg.
- The **cytoplasm** (sy-toh-PLAZ-um) is the part of the protoplasm that exists outside of the nucleus and inside the cell wall. The protoplasm surrounds the nucleus and is needed for growth, reproduction, and self-repair.
- The **cell membrane** (SELL MEM-brayn) is the cell part that encloses and holds the protoplasm while still allowing soluble substances (e.g., nutrients or waste by-products), to enter and leave the cell.

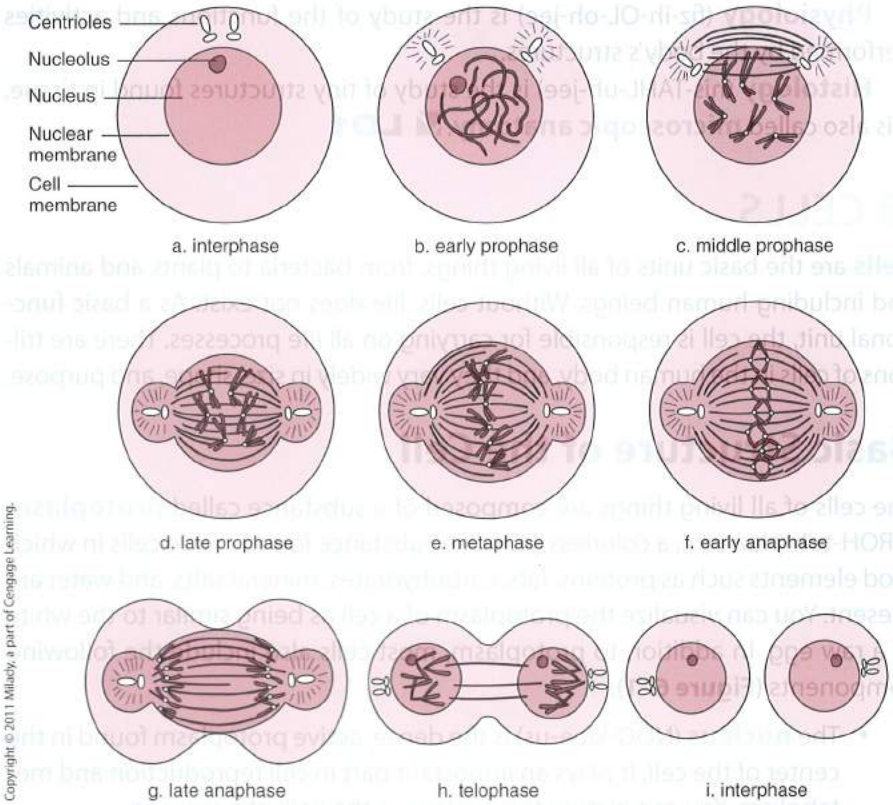
▼ **Figure 6–1** Anatomy of the cell.



Cell Reproduction and Division

Cells have the ability to reproduce, thus providing new cells for the growth and replacement of worn or damaged cells. The usual process of cell reproduction of human tissues occurs when the cell divides into two identical cells, called daughter cells, through a process known as "mitosis." As long as conditions are favorable, the cell will grow and reproduce. This is true of human cells, plant cells, and single-cell creatures such as bacteria. Favorable conditions include an adequate supply of food, oxygen, and water; suitable temperatures; and the ability to eliminate waste by-products. If conditions become unfavorable, the cell will become impaired or may die. For instance,

when blood flow is restricted to part of the body, such an unfavorable condition could lead to an unusual buildup in the levels of toxins within the cells, which in turn may cause the cell to die **(Figure 6–2).** LO2



▶ **Figure 6–2** Phases of mitosis.

Did You Know?

A toxin is a poisonous substance produced by microorganisms (bacteria and viruses). You know that a bee sting injects a toxin into the skin that causes a painful burning sensation, but did you know that your skin is constantly creating toxins? As our skin cells metabolize nutrients, the process creates toxins that must be removed before they cause damage by becoming too concentrated inside the cell. Fortunately, our bodies have highly efficient ways of dealing with these toxins. Tiny blood and lymph capillaries in the skin collect toxins and transport them away to be later removed from the body. So remember, the normal flow of blood moving through the skin helps ensure that the concentration of toxins in the skin cells are kept at safe levels and that the skin remains healthy.

Cell Metabolism

Metabolism (muh-TAB-uh-liz-um) is a chemical process that takes place in living organisms, through which the cells are nourished and carry out their activities. Metabolism occurs in two distinctly different phases.

Anabolism (uh-NAB-uh-liz-um) is called "constructive metabolism" because it is the process of combining smaller molecules to build larger and more complex molecules. During this process, the body focuses on storing water, food, and oxygen for a later time when these substances will be needed for cell growth, reproduction, or repair.

Catabolism (kuh-TAB-uh-liz-um) is the phase of metabolism in which larger, more complex molecules are broken down within the cells to create smaller, simpler molecules. As a result of this breakdown, energy is released so that it may be used or stored for later use.

Anabolism and catabolism are carried out simultaneously and continually, 24 hours a day, within the cells as part of their normal processes.

TISSUES

A **tissue** (TISH-oo) is a collection of similar cells that performs a specialized function. Each type of tissue has a specific function and can be recognized by its characteristic appearance. Body tissues are composed of large amounts of

water, along with various other substances. The human body is about 60 percent water.

There are four types of tissue in the body.

- **Connective tissue** is fibrous tissue that binds together, protects, and supports the various parts of the body. Examples include bone; cartilage; ligaments; tendons; fascia, which separates muscles; liquid tissue, such as blood, lymph, and fat; and **adipose tissue** (ADD-ih-pohz TISH-oo), which lends smoothness, contour, and cushioning.
- **Epithelial tissue** (ep-ih-THEE-lee-ul TISH-oo) is a protective covering on body surfaces. Skin, mucous membranes, the tissue inside the mouth, the lining of the heart, digestive and respiratory organs, and glands are all examples of epithelial tissue.
- **Muscle tissue** contracts and moves various parts of the body.
- **Nerve tissue** carries messages to and from the brain and controls and coordinates all bodily functions. Nerve tissue is composed of specialized cells known as neurons, which make up the nerves, brain, and spinal cord. LO3

Did You Know?

An average adult body is 50 to 65 percent water—which equals roughly 45 qt (42.5 l). Men's bodies contain more water than women's bodies do. A man's body is 60 to 65 percent water, compared to 50 to 60 percent for a woman. In infants, the figure is amazingly higher at 70 percent. Water content differs throughout various tissues in the body; for instance, blood is made up of 83 percent water, and muscle is 75 percent water.

ORGANS AND BODY SYSTEMS

Organs are structures composed of specialized tissues that allow them to perform specific functions. A body **system** consists of a group of body organs acting together to perform one or more functions. **Table 6–1, Some Major Body Organs and Their Functions,** lists some of the most important organs of the body.

Table 6–1 NINE MAJOR BODY ORGANS AND THEIR FUNCTIONS

ORGAN	FUNCTION
Brain	Controls the body
Eyes	Control the body's vision
Heart	Circulates the blood
Kidneys	Excrete water and waste products
Liver	Removes waste created by digestion
Lungs	Supply oxygen to the blood and exhale waste gases
Skin	External protective coating that covers the body
Stomach	Digests food, along with the intestines
Intestines	Digest food, along with the stomach

Table 6–2 ELEVEN MAIN BODY SYSTEMS AND THEIR FUNCTIONS

SYSTEM	FUNCTION
Circulatory	Controls the steady circulation of the blood through the body by means of the heart and blood vessels
Digestive	Changes food into nutrients and wastes; consists of mouth, stomach, intestines, salivary and gastric glands, and other organs
Endocrine	Affects the growth, development, sexual functions, and health of the entire body; consists of specialized glands
Excretory	Purifies the body by eliminating waste matter; consists of kidneys, liver, skin, large intestine, and lungs
Integumentary	Serves as a protective covering and helps regulate the body's temperature; consists of skin and its accessory organs, such as oil and sweat glands, sensory receptors, hair, and nails
Lymphatic or Immune	Protects the body from disease by developing immunities and destroying disease-causing toxins and bacteria
Muscular	Covers, shapes, and holds the skeletal system in place; the muscular system contracts and moves various parts of the body
Nervous	Controls and coordinates all other systems inside of the body and makes them work harmoniously and efficiently; consists of the brain, spinal cord, and nerves
Reproductive	Produces offspring and passes on the genetic code from one generation to another.
Respiratory	Enables breathing, supplying the body with oxygen, and eliminating carbon dioxide and other gases as waste products; consists of the lungs and air passages
Skeletal	Forms the physical foundation of the body; consists of 206 bones that vary in size and shape and are connected by movable and immovable joints

Did You Know?

People often complain of joint pain, which is usually caused by inflammation of the tissue surrounding the joint.

Body systems are groups of body organs acting together to perform one or more functions. The human body is composed of 11 major systems, as shown in **Table 6–2, Eleven Main Body Systems and Their Functions.** LO4

THE SKELETAL SYSTEM

The **skeletal system** is the physical foundation of the body. Humans are born with 300 bones; however, some of these fuse together over time, so eventually

the body ends up with 206 bones that vary in size and shape and are connected by movable and immovable joints. **Osteology** (ahs-tee-AHL-oh-jee) is the study of anatomy, structure, and function of the bones. **Os** (AHS) means bone, and is used as a prefix in many medical terms, such as osteoarthritis, (os-te-o-ar-thri-tis) a joint disease.

Except for the tissue that forms the major part of the teeth, bone is the hardest tissue in the body. It is composed of connective tissue consisting of about one-third organic matter, such as cells and blood, and two-thirds minerals, mainly calcium carbonate and calcium phosphate.

The primary functions of the skeletal system are to:

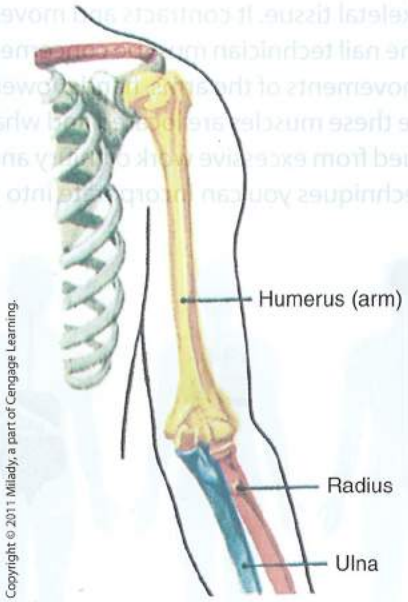
- Give shape and support to the body.
- Protect various internal structures and organs.
- Serve as attachments for muscles and act as levers to produce body movement.
- Help produce both white and red blood cells (one of the functions of bone marrow).
- Store most of the body's calcium supply, as well as phosphorus, magnesium, and sodium.

A **joint** is the connection between two or more bones of the skeleton. There are two types of joints: movable, such as elbows, knees, and hips; and immovable, such as the pelvis or skull, which allows little or no movement.

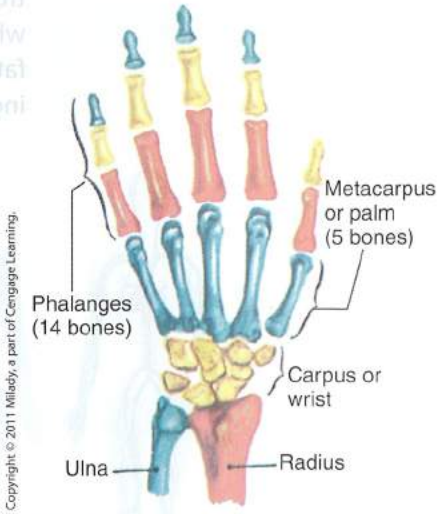
Bones of the Arms and Hands

Important bones of the arms and hands include the following:

- **Humerus** (HYOO-muh-rus). Uppermost and largest bone of the arm, extending from the elbow to the shoulder.
- **Ulna** (UL-nuh). The ulna is the longer bone of the forearm. It is larger at the elbow than at the wrist and is located on the little finger side of the hand.
- **Radius** (RAY-dee-us). The radius is the shorter of the two bones of the forearm. It is largest at the wrist and is located on the thumb side of the hand.
- **Carpus** (KAR-pus). The wrist: a flexible joint composed of a group of eight small, irregular bones held together by ligaments.
- **Metacarpus** (met-uh-KAR-pus). Bones of the palm of the hand; parts of the hand containing five bones between the carpus and phalanges.
- **Phalanges** (fuh-LAN-jeez). Bones of the fingers or toes, or **digits (Figures 6–3 and 6–4)**.



▲ **Figure 6–3** Bones of the arm.



▲ **Figure 6–4** Bones of the hand.

Did You Know?

Painful inflammation involving the carpus area can be caused by repetitive motions, such as flexing your wrist excessively or locking it in a bent position while using a nail file. Keeping the wrist straight, without flexing, while filing can help prevent these injuries.

Did You Know?

The purpose of fingernails is to provide protection for the delicate tips of the phalanges in the hand. If a phalange is accidentally broken, the finger loses much of its fine dexterity and has a more difficult time picking up very small objects, such as sewing needles and coins.

▲ **Figure 6–5** Bones of the leg.

Bones of the Leg, Ankle, and Foot

The four bones of the leg are:

- The **femur** (FEE-mur) is a heavy, long bone that forms the leg above the knee.
- The **tibia** (TIB-ee-ah) is the larger of the two bones that form the leg below the knee. The tibia may be visualized as a bump on the big-toe side of the ankle.
- The **fibula** (FIB-ya-lah) is the smaller of the two bones that form the leg below the knee. The fibula may be visualized as a bump on the little-toe side of the ankle.
- The **patella** (pah-TEL-lah), also called the accessory bone, forms the cap of the knee joint **(Figure 6–5)**.

The ankle joint is made up of three bones:

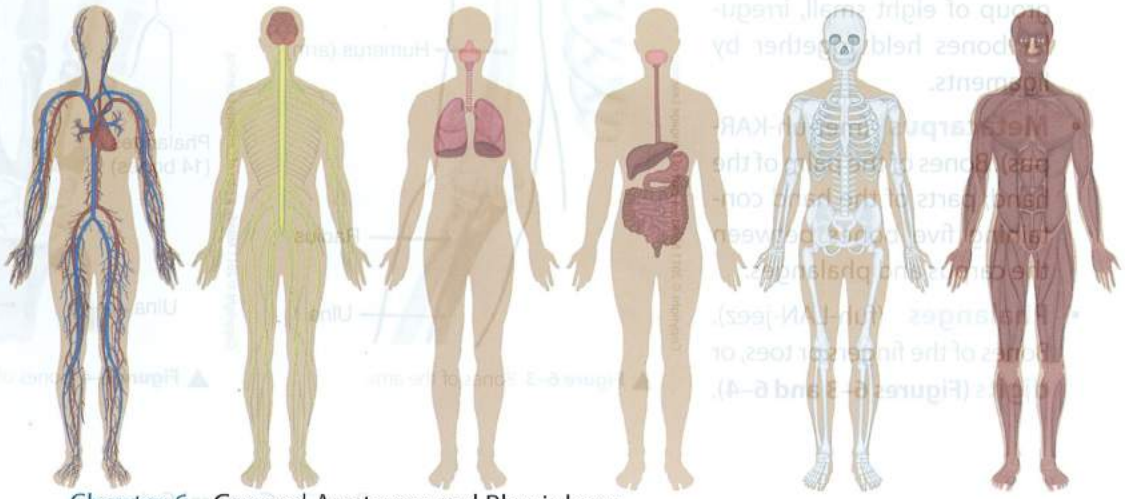
- The tibia, which comes down from the leg.
- The fibula, which comes down from the leg.
- The **talus** (TA-lus), or ankle bone, of the foot.

The foot is made up of 26 bones. These can be subdivided into three general categories: seven **tarsal** (TAHR-sul) bones (talus, calcaneous, navicular, three cuneiform bones, and the cuboid); five **metatarsal** (met-ah-TAHR-sul) bones, which are long and slender, like the metacarpal bones of the hand; and 14 bones called phalanges, which compose the toes. The phalanges of the feet are similar to the hand's phalanges, which are commonly called finger bones. There are three phalanges in each toe, except for the big toe, which has only two **(Figure 6–6)**.

THE MUSCULAR SYSTEM

The **muscular system** is the body system that covers, shapes, and supports the skeletal tissue. It contracts and moves various parts of the body.

The nail technician must be concerned with the voluntary muscles that control movements of the arms, hands, lower legs, and feet. It is important to know where these muscles are located and what they control. These muscles become fatigued from excessive work or injury and can benefit greatly from the massaging techniques you can incorporate into your services.



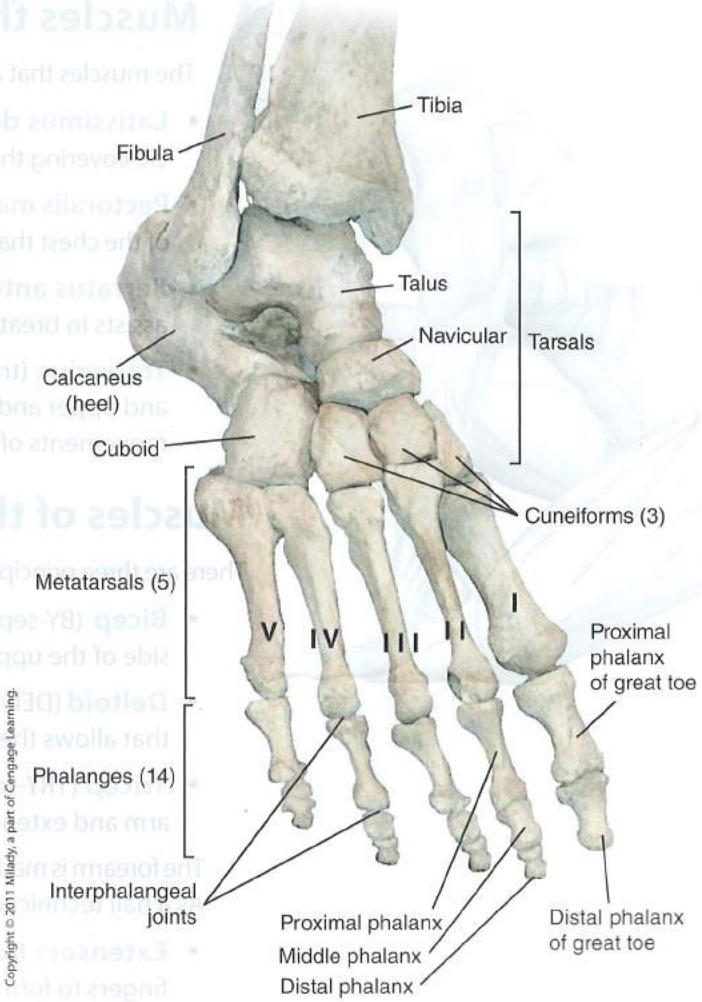
Myology (my-AHL-uh-jee) is the study of the structure, function, and diseases of the muscles. The human body has over 600 muscles, which are responsible for approximately 40 percent of the body's weight. Muscles are fibrous tissues that have the ability to stretch and contract according to the demands of the body's movements. There are three types of muscular tissue.

Striated muscles (STRY-ayt-ed), also called **skeletal muscles**, are attached to the bones and are voluntary or consciously controlled. Striated (skeletal) muscles assist in maintaining the body's posture and protect some internal organs **(Figure 6–7).**

Nonstriated muscles, or **smooth muscles**, are involuntary and function automatically, without conscious will. These muscles are found in the internal organs of the body, such as the digestive or respiratory systems **(Figure 6–8).**

Cardiac muscle is the involuntary muscle that is the heart. This type of muscle is not found in any other part of the body **(Figure 6–9).**

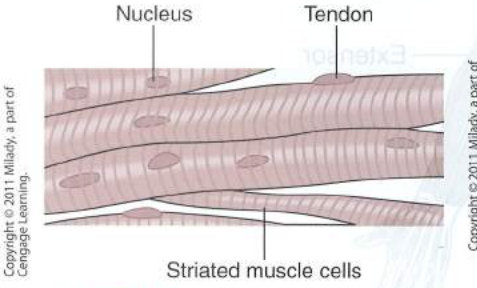
A muscle has three parts. The **origin** is the part that does not move; it is attached to the skeleton and is usually part of a skeletal muscle. The **insertion** is the part of the muscle at the more movable attachment to the skeleton. The **belly** is the middle part of the muscle. Pressure in massage is usually directed from the insertion to the origin and moving toward the belly of the muscle.



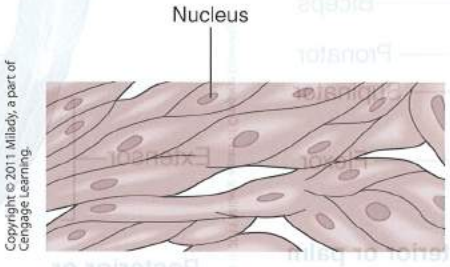
▲ **Figure 6–6** Bones of the foot and ankle.

Muscular tissue can be stimulated by:

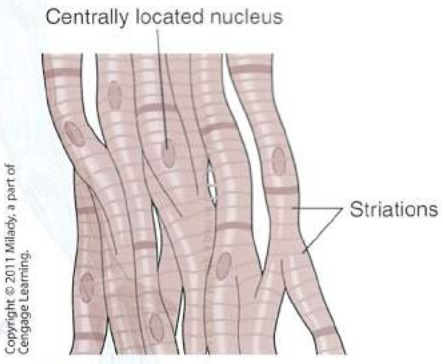
- Massage (pressure and friction created by hand, electric vibrator, or water jets)
- Electrical current (high frequency or faradic—alternating or interrupted—current)
- Infrared light (heating lamps and a normal component of natural sunlight)
- Dry heat (heating caps)
- Moist heat (steamers or warm steam towels)
- Nerve impulses (through the neurons of the nervous system)



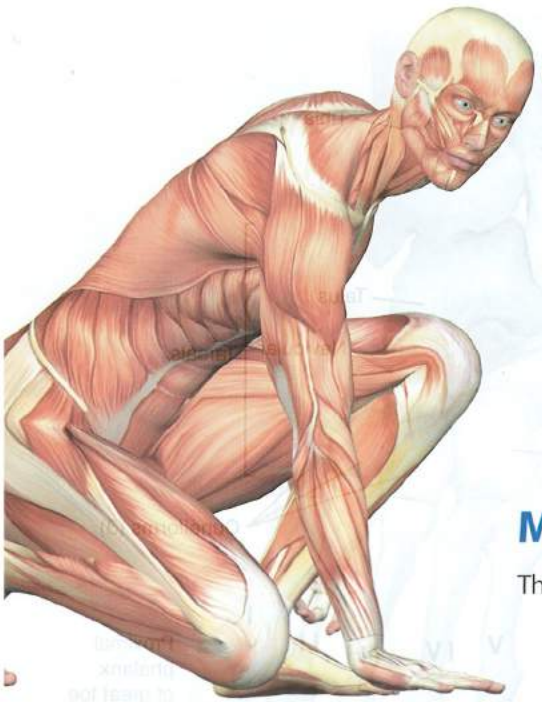
▲ **Figure 6–7** Striated muscle cells.



▲ **Figure 6–8** Nonstriated muscle cells.



▲ **Figure 6–9** Cardiac muscle cells.



Muscles that Attach the Arms to the Body

The muscles that attach the arms to the body are briefly summarized below.

- **Latissimus dorsi** (lah-TIS-ih-mus DOR-see). A large, flat triangular muscle covering the lower back.
- **Pectoralis major** (pek-tor-AL-is MAY-jor) and **Pectoralis minor**. Muscles of the chest that assist the swinging movements of the arm.
- **Serratus anterior** (ser-RAT-us an-TEER-ee-or). Muscle of the chest that assists in breathing and in raising the arm.
- **Trapezius** (trah-PEE-zee-us). Muscle that covers the back of the neck and upper and middle region of the back; rotates and controls swinging movements of the arm.

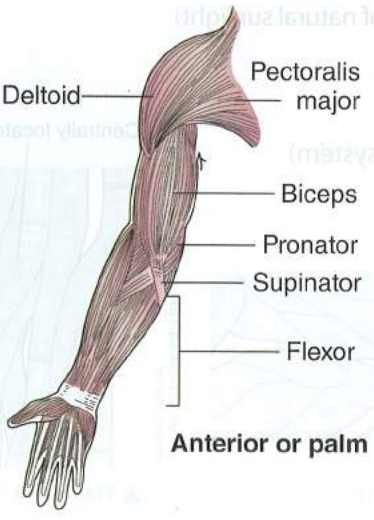
Muscles of the Shoulder and Arm

There are three principal muscles of the shoulders and upper arms **(Figure 6–10)**:

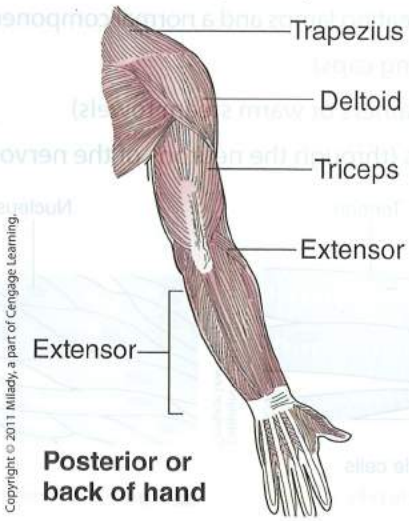
- **Bicep** (BY-sep). Muscle producing the contour of the front and inner side of the upper arm; they lift the forearm and flex the elbow.
- **Deltoid** (DEL-toyd). Large, triangular muscle covering the shoulder joint that allows the arm to extend outward and to the side of the body.
- **Tricep** (TRY-sep). Large muscle that covers the entire back of the upper arm and extends the forearm.

The forearm is made up of a series of muscles and strong tendons **(Figure 6–11).** As a nail technician, you will be concerned with:

- **Extensors** (ik-STEN-surs). Muscles that straighten the wrist, hand, and fingers to form a straight line.
- **Flexors** (FLEK-surs). Extensor muscles of the wrist, involved in bending the wrist.
- **Pronators** (proh-NAY-tohrs). Muscles that turn the hand inward so that the palm faces downward.
- **Supinator** (SOO-puh-nayt-ur). Muscle of the forearm that rotates the radius (forearm) outward and the palm upward.



▶ **Figure 6–10** Muscles of the anterior shoulder and arm.



◀ **Figure 6–11** Muscles of the posterior shoulder and arm.

Muscles of the Hand

The hand is one of the most complex parts of the body, with many small muscles that overlap from joint to joint, providing flexibility and strength to open and close the hand and fingers. Important muscles to know include the:

- **Abductors** (ab-DUK-turz). Muscles that separate the fingers **(Figure 6–12)**.
- **Adductors** (ah-DUK-turz). Muscles at the base of each finger that draw the fingers together (Figure 6–12).

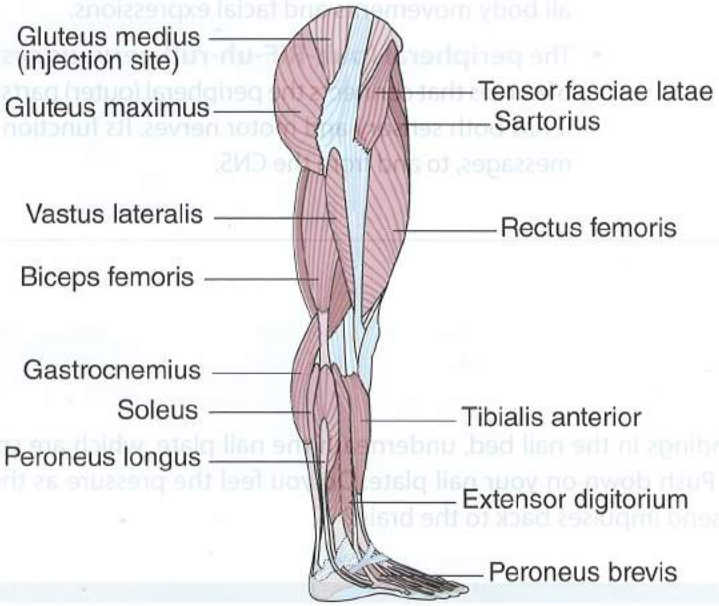
▲ **Figure 6–12** Muscles of the hand.

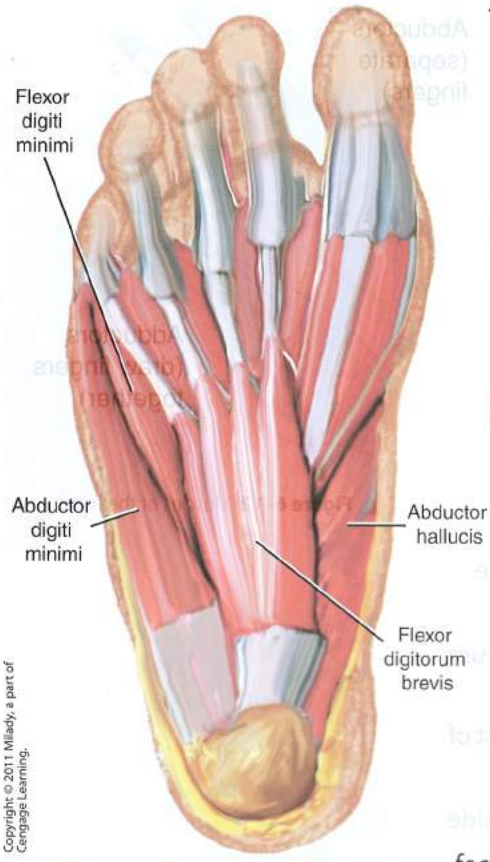
Muscles of the Lower Leg and Foot

As a nail technician, you will use your knowledge of the muscles of the foot and leg during a pedicure. The muscles of the foot are small and provide proper support and cushioning for the foot and leg **(Figure 6–13)**. The muscles of the lower leg include:

- The **extensor digitorum longus** (eck-STEN-sur dij-it-TOHR-um LONG-us) bends the foot up and extends the toes.
- The **tibialis anterior** (tib-ee-AHL-is an-TEHR-ee-ohr) covers the front of the shin. It bends the foot upward and inward.
- The **peroneus longus** (per-oh-NEE-us LONG-us) covers the outer side of the calf and inverts the foot and turns it outward.
- The **peroneus brevis** (BREV-us) originates on the lower surface of the fibula. It bends the foot down and out.
- The **gastrocnemius** (gas-truc-NEEM-e-us) is attached to the lower rear surface of the heel and pulls the foot down.
- The **soleus** (SO-lee-us) originates at the upper portion of the fibula and bends the foot down.

▶ **Figure 6–13** Muscles of the leg and foot.





▲ **Figure 6–14** Muscles of the foot (bottom).

The muscles of the feet include **(Figure 6–14)**:

- The **flexor digiti minimi** (FLEK-sur-dij-it-ty MIN-eh-mee) moves the little toe.
- The **flexor digitorum brevis** (FLEKS-or dij-it-TOHR-um BREV-us) moves lesser toes and helps maintain balance while walking.
- The **abductor hallucis** (ab-DUK-tohr ha-LU-sis) moves the great toe and helps maintain balance while walking and standing.
- The **abductor digiti minimi** separates the toes.

THE NERVOUS SYSTEM

The **nervous system** is an exceptionally well-organized body system, composed of the brain, spinal cord, and nerves, that is responsible for controlling and coordinating all other systems inside and outside of the body and making them work harmoniously and efficiently. Every square inch of the human body is supplied with fine fibers known as nerves; there are over 100 billion nerve cells, known as neurons, in the body. The scientific study of the structure, function, and pathology of the nervous system is known as **neurology** (nuh-RAHL-uh-jee).

An understanding of how nerves work will help you perform services in a more proficient manner when administering massage techniques during manicures and pedicures. It will also help you understand the effects that these treatments have on the body as a whole.

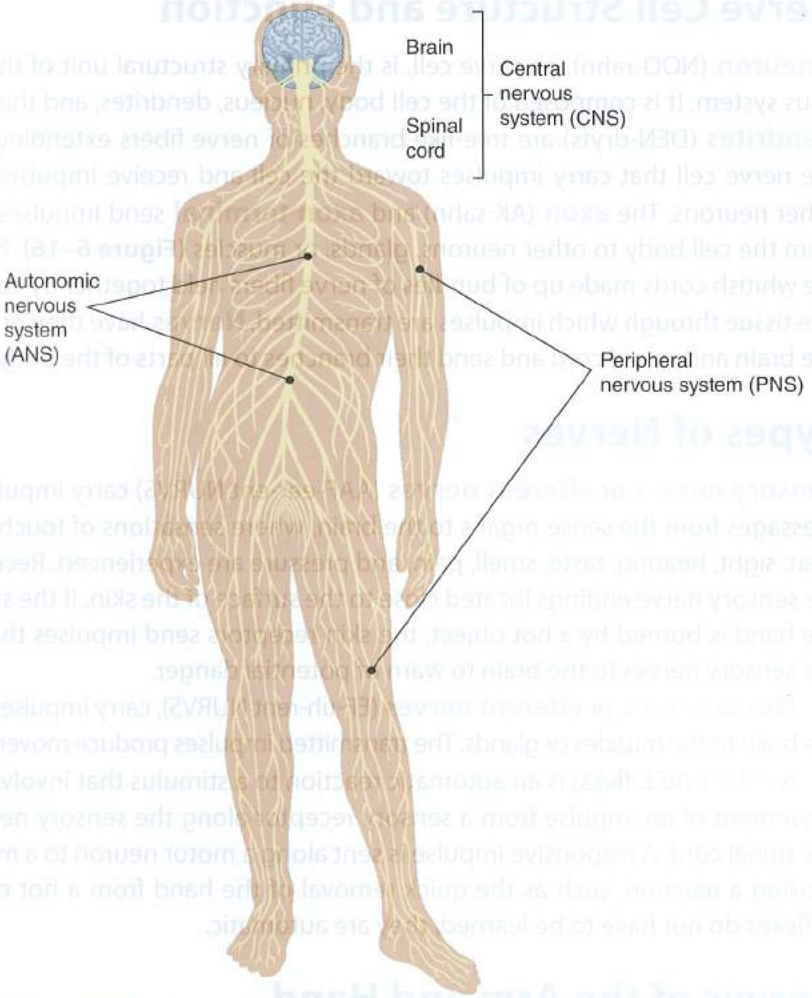
Divisions of the Nervous System

The nervous system, as a whole, is divided into three main subdivisions.

- The **central nervous system (CNS)** consists of the brain, spinal cord, spinal nerves, and cranial nerves. It controls consciousness and many mental activities, voluntary functions of the five senses (seeing, hearing, feeling, smelling, and tasting), and voluntary muscle actions, including all body movements and facial expressions.
- The **peripheral (puh-RIF-uh-rul) nervous system (PNS)** is a system of nerves that connects the peripheral (outer) parts of the body to the CNS; it has both sensory and motor nerves. Its function is to carry impulses, or messages, to and from the CNS.

Activity

There are sensory nerve endings in the nail bed, underneath the nail plate, which are specialized to detect pressure on the nail plate. Push down on your nail plate. Do you feel the pressure as these sensitive nerve endings are activated and send impulses back to the brain?



▲ **Figure 6–15** Principal parts of the nervous system.

- The **autonomic (aw-toh-NAHM-ik) nervous system (ANS)** is the part of the nervous system that controls the involuntary muscles; it regulates the action of the smooth muscles, glands, blood vessels, heart and even normal breathing **(Figure 6–15)**.

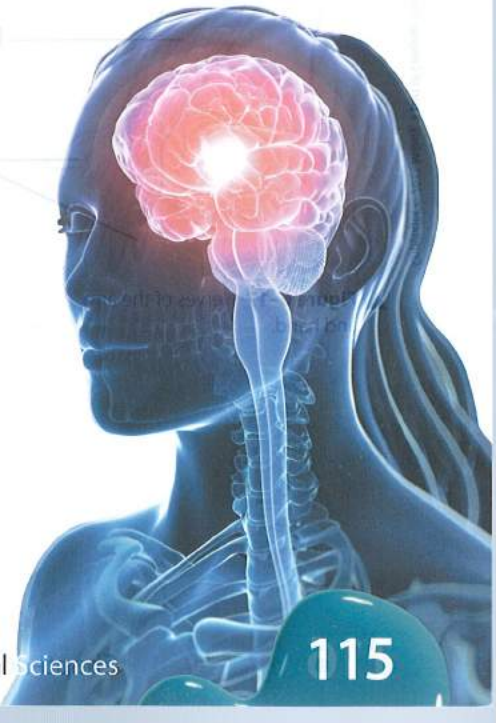
The Brain and Spinal Cord

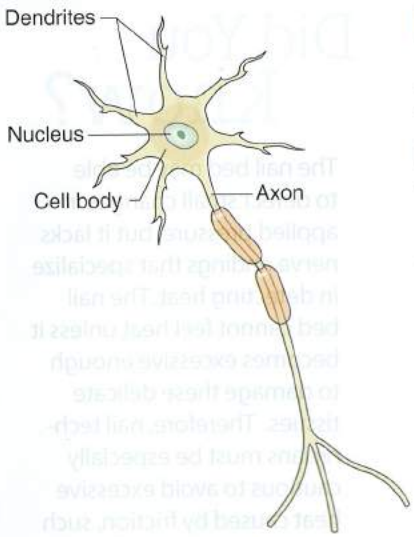
The **brain** is the largest and most complex nerve tissue in the body. The brain is contained in the cranium and weighs a little less than 3 pounds, on average. It controls sensation, muscles, activity of glands, and the power to think, sense, and feel. It sends and receives messages through 12 pairs of cranial nerves that originate in the brain and reach various parts of the head, face, and neck.

The **spinal cord** is the portion of the CNS that originates in the brain, extends down to the lower extremity of the trunk, and is protected by the spinal column. Thirty-one pairs of spinal nerves extending from the spinal cord are distributed to the muscles and skin of the trunk and limbs.

Did You Know?

The nail bed may be able to detect small changes in applied pressure, but it lacks nerve endings that specialize in detecting heat. The nail bed cannot feel heat unless it becomes excessive enough to damage these delicate tissues. Therefore, nail technicians must be especially cautious to avoid excessive heat caused by friction, such as overaggressively filing the nail plate. By the time a client notices the heat buildup, it may be too late, and nail bed damage may already have occurred. Friction burn injuries can cause the client's nail beds to release part of the nail plate and create an open space underneath; a condition known as **onycholysis**.





▲ **Figure 6–16** A neuron or nerve cell.

Nerve Cell Structure and Function

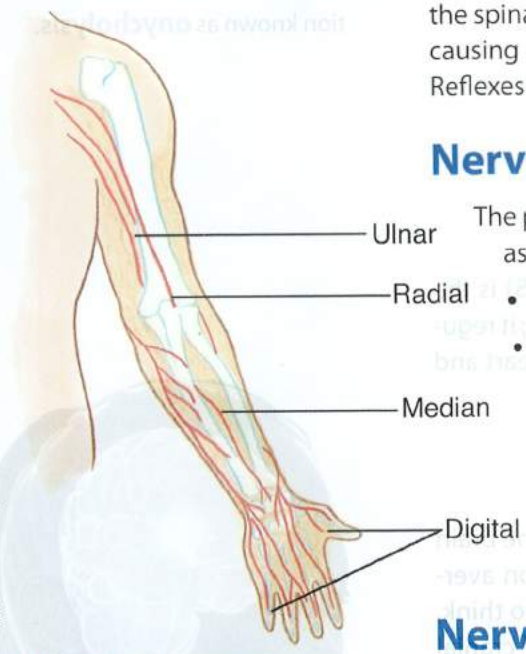
A **neuron** (NOO-rahn), or nerve cell, is the primary structural unit of the nervous system. It is composed of the cell body, nucleus, dendrites, and the axon. **Dendrites** (DEN-dryts) are tree-like branches of nerve fibers extending from the nerve cell that carry impulses toward the cell and receive impulses from other neurons. The **axon** (AK-sahn) and **axon terminal** send impulses away from the cell body to other neurons, glands, or muscles **(Figure 6–16)**. Nerves are whitish cords made up of bundles of nerve fibers held together by connective tissue through which impulses are transmitted. **Nerves** have their origin in the brain and spinal cord and send their branches to all parts of the body.

Types of Nerves

Sensory nerves or **afferent nerves** (AAF-eer-ent NURVS) carry impulses or messages from the sense organs to the brain, where sensations of touch, cold, heat, sight, hearing, taste, smell, pain, and pressure are experienced. Receptors are sensory nerve endings located close to the surface of the skin. If the skin on the hand is burned by a hot object, the skin receptors send impulses through the sensory nerves to the brain to warn of potential danger.

Motor nerves, or **efferent nerves** (EF-uh-rent NURVS), carry impulses from the brain to the muscles or glands. The transmitted impulses produce movement.

A **reflex** (REE-fleks) is an automatic reaction to a stimulus that involves the movement of an impulse from a sensory receptor along the sensory nerve to the spinal cord. A responsive impulse is sent along a motor neuron to a muscle, causing a reaction, such as the quick removal of the hand from a hot object. Reflexes do not have to be learned; they are automatic.



▲ **Figure 6–17** Nerves of the arm and hand.

Nerves of the Arm and Hand

The principal nerves supplying the superficial parts of the arm and hand are as follows:

- **Digital** (DIJ-ut-tul) **nerve**. With its branches, supplies the fingers.
- **Radial** (RAY-dee-ul) **nerve**. With its branches, supplies the thumb side of the arm and back of the hand.
- **Median** (MEE-dee-un) **nerve**. A smaller nerve than the ulnar and radial nerves that, with its branches, supplies the arm and hand.
- **Ulnar** (UL-nur) **nerve**. With its branches, affects the little finger side of the arm and palm of the hand **(Figure 6–17)**.

Nerves of the Lower Leg and Foot

- The **tibial nerve** (TIB-ee-al NURV), a division of the sciatic nerve, passes behind the knee. It subdivides and supplies impulses to the knee, the muscles of the calf, the skin of the leg, and the sole, heel, and underside of the toes.
- The **common peroneal nerve** (KAHM-un per-oh-NEE-al NURV), also a division of the sciatic nerve, extends from behind the knee to wind

around the head of the fibula to the front of the leg where it divides into two branches. The **deep peroneal nerve**, also known as the **anterior tibial nerve**, extends down the front of the leg, behind the muscles. It supplies impulses to these muscles and also to the muscles and skin on the top of the foot and adjacent sides of the first and second toes. The **superficial peroneal nerve**, also known as the **musculocutaneous nerve** (MUS-kyoo-lo-kyoo-TAY-nee-us NURV), extends down the leg, just under the skin, supplying impulses to the muscles and the skin of the leg, as well as to the skin and toes on the top of the foot, where it is called the **dorsal nerve** (DOOR-sal NURV) or **dorsal cutaneous nerve**.

- The **saphenous nerve** (sa-FEEN-us NURV) supplies impulses to the skin of the inner side of the leg and foot.
- The **sural nerve** (SUR-ul NURV) supplies impulses to the skin on the outer side and back of the foot and leg **(Figure 6–18)**.

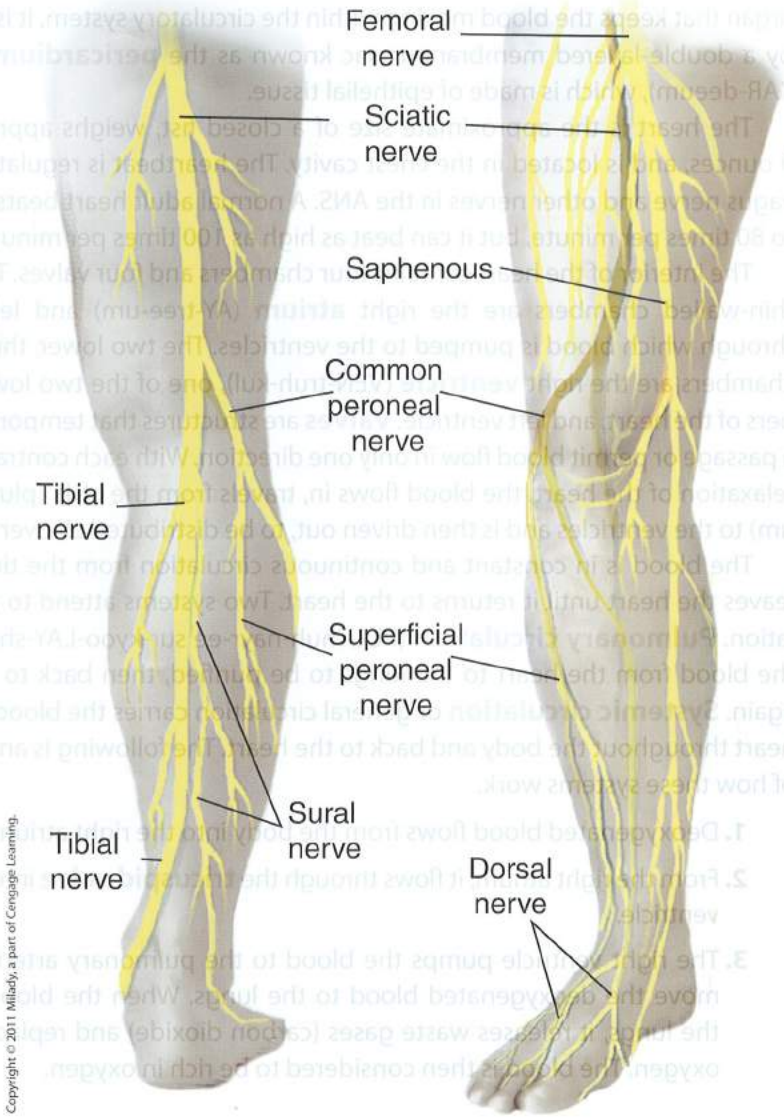


Figure 6–18 Nerves of the lower leg and foot.

THE CIRCULATORY SYSTEM

The **circulatory system**, also referred to as the **cardiovascular system** (KAHRD-ee-oh-VAS-kyoo-lur SIS-tum) or **vascular system**, controls the steady circulation of the blood through the body by means of the heart and blood vessels. The circulatory system is made up of two divisions:

The **blood vascular system**, which consists of the heart, arteries, veins, and capillaries that distribute blood throughout the body.

The **lymph vascular system** (LIMF VAS-kyoo-lur SIS-tum), or **lymphatic system**, which acts as an aid to the blood system and consists of the lymph spaces; lymphatics (lymph vessels); **lymph nodes** (LIMF NOHDS), which are special structures found inside the lymphatic vessels that filter lymph; and other structures. **Lymph** is a clear fluid that circulates in the lymphatics of the body, where it helps to carry wastes and impurities away from the cells, and is routed back into the circulatory system.

The Heart

The **heart** is often referred to as the body's pump. It is a muscular, cone-shaped organ that keeps the blood moving within the circulatory system. It is enclosed by a double-layered membranous sac known as the **pericardium** (payr-ih-KAR-deeum), which is made of epithelial tissue.

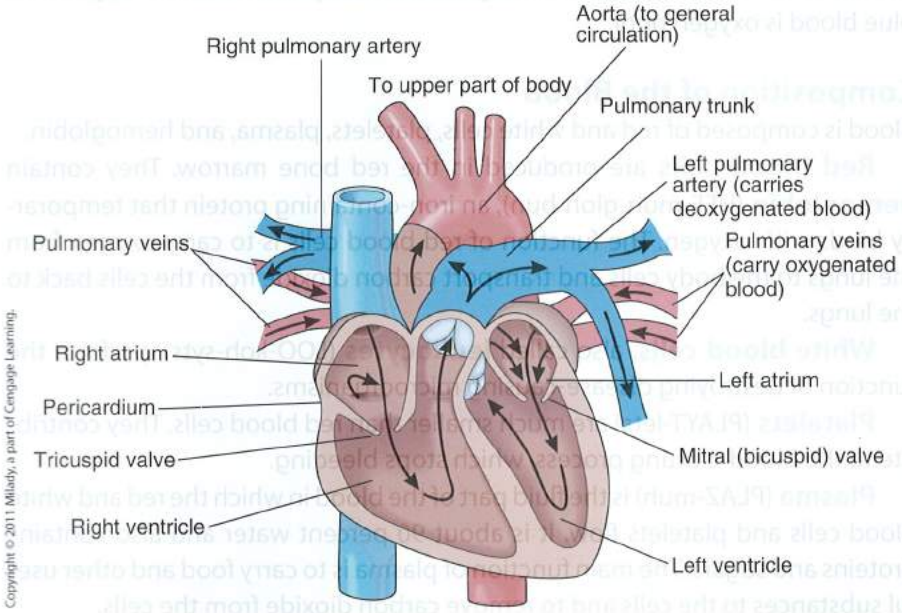
The heart is the approximate size of a closed fist, weighs approximately 9 ounces, and is located in the chest cavity. The heartbeat is regulated by the vagus nerve and other nerves in the ANS. A normal adult heart beats about 60 to 80 times per minute, but it can beat as high as 100 times per minute.

The interior of the heart contains four chambers and four valves. The upper, thin-walled chambers are the right **atrium** (AY-tree-um) and left atrium, through which blood is pumped to the ventricles. The two lower, thick-walled chambers are the right **ventricle** (VEN-truh-kul), one of the two lower chambers of the heart, and left ventricle. **Valves** are structures that temporarily close a passage or permit blood flow in only one direction. With each contraction and relaxation of the heart, the blood flows in, travels from the atria (plural of atrium) to the ventricles and is then driven out, to be distributed all over the body.

The blood is in constant and continuous circulation from the time that it leaves the heart until it returns to the heart. Two systems attend to this circulation. **Pulmonary circulation** (PUL-muh-nayr-ee sur-kyoo-LAY-shun) sends the blood from the heart to the lungs to be purified, then back to the heart again. **Systemic circulation** or general circulation carries the blood from the heart throughout the body and back to the heart. The following is an overview of how these systems work.

1. Deoxygenated blood flows from the body into the right atrium.
2. From the right atrium, it flows through the **tricuspid valve** into the right ventricle.
3. The right ventricle pumps the blood to the pulmonary arteries, which move the deoxygenated blood to the lungs. When the blood reaches the lungs, it releases waste gases (carbon dioxide) and replaces it with oxygen. The blood is then considered to be rich in oxygen.

4. The oxygen-rich blood returns to the heart through the pulmonary veins and enters the left atrium.
5. From the left atrium, the blood flows through the **mitral valve** (MY-trul VALV), or **bicuspid valve** (by-KUS-pid VALV), into the left ventricle.
6. The blood then leaves the left ventricle and travels to all parts of the body **(Figure 6–19)**.

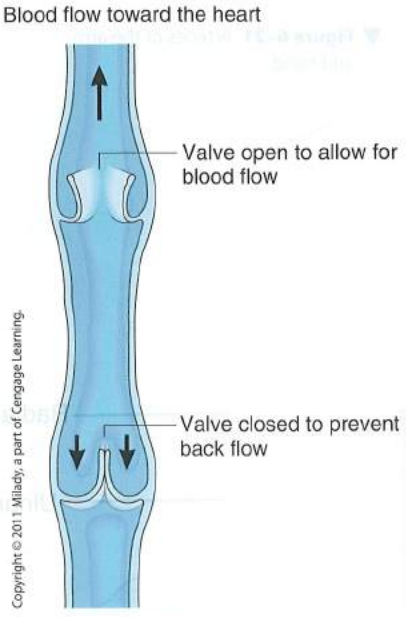


◀ **Figure 6–19** Anatomy of the heart.

Blood Vessels

Blood vessels are tube-like structures that include the arteries, capillaries, and veins. The function of these vessels is to transport blood to and from the heart and then on to various tissues of the body.

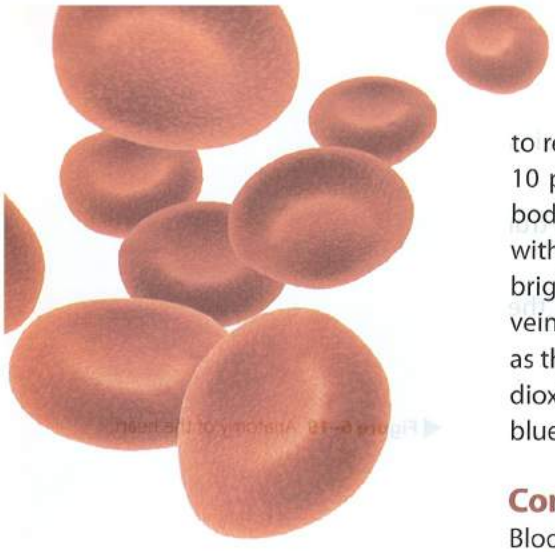
- **Arteries** (AR-tuh-rees) are thick-walled, flexible tubes that carry oxygenated blood away from the heart to the capillaries. The largest artery in the body is the **aorta** (ay-ORT-uh). The arterial trunk carries oxygenated blood from the heart to be distributed by branch arteries through the body.
- **Capillaries** are tiny, thin-walled blood vessels that connect the smaller arteries to the veins. They bring nutrients to the cells and carry away waste materials.
- **Veins** are thin-walled blood vessels that are less flexible than arteries. They contain cup-like valves that prevent backflow and carry blood containing waste products from the capillaries back to the heart and lungs for cleaning and to pick up oxygen. Veins are located closer to the outer skin surface of the body than arteries **(Figure 6–20).**



▲ **Figure 6–20** Valves in the veins.

The Blood

Blood is a nutritive fluid circulating through the circulatory system (heart, veins, arteries, and capillaries) to supply oxygen and nutrients to cells and tissues and



to remove carbon dioxide and waste from them. There are approximately 8 to 10 pints of blood in the human body, which contribute about 1/20th of the body's weight. Blood is approximately 80 percent water. It is sticky and salty, with a normal temperature of 98.6 degrees Fahrenheit (36 degrees Celsius). It is bright red in the arteries (except for the pulmonary artery) and dark red in the veins. The color change occurs with the exchange of carbon dioxide for oxygen as the blood passes through the lungs, and the exchange of oxygen for carbon dioxide as the blood circulates throughout the body. Red blood is oxygen rich; blue blood is oxygen poor.

Composition of the Blood

Blood is composed of red and white cells, platelets, plasma, and hemoglobin.

Red blood cells are produced in the red bone marrow. They contain **hemoglobin** (HEE-muh-gloh-bun), an iron-containing protein that temporarily binds with oxygen. The function of red blood cells is to carry oxygen from the lungs to the body cells and transport carbon dioxide from the cells back to the lungs.

White blood cells, also called **leukocytes** (LOO-koh-syts), perform the function of destroying disease-causing microorganisms.

Platelets (PLAYT-lets) are much smaller than red blood cells. They contribute to the blood-clotting process, which stops bleeding.

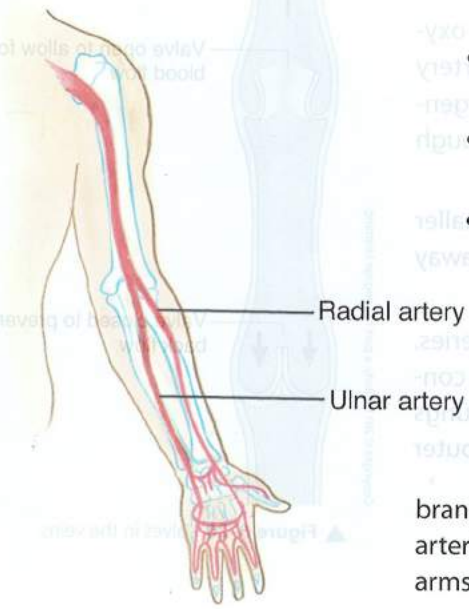
Plasma (PLAZ-muh) is the fluid part of the blood in which the red and white blood cells and platelets flow. It is about 90 percent water and also contains proteins and sugars. The main function of plasma is to carry food and other useful substances to the cells and to remove carbon dioxide from the cells.

Chief Functions of the Blood

Blood performs the following critical functions:

- Carries water, oxygen, and food to all cells and tissues of the body.
- Carries away carbon dioxide and other waste products to be eliminated through the lungs, skin, kidneys, and large intestines.
- Helps to equalize the body's temperature, thus protecting the body from extreme heat or cold.
- Works with the immune system to protect the body from potentially harmful bacteria or toxins.
- Seals leaks found in injured blood vessels by forming clots which prevent further blood loss.

▼ **Figure 6–21** Arteries of the arm and hand.



Blood Supply to the Arm and Hand

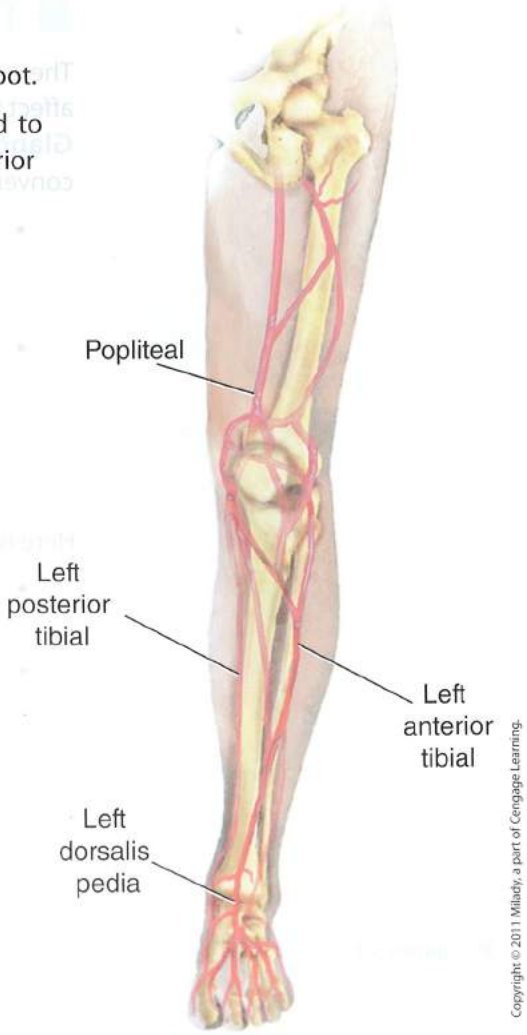
The ulnar and radial arteries are the main blood supply of the arms and hands. The **ulnar artery** and its numerous branches supply the little-finger side of the arm and palm of the hand. The **radial artery** and its branches supply the thumb side of the arm and the back of the hand. While the arteries are found deep in the tissues, the veins lie nearer to the surface of the arms and hands **(Figure 6–21)**.

Blood Supply to the Lower Leg and Foot

There are several major arteries that supply blood to the lower leg and foot.

- The **popliteal (pop-lih-TEE-ul) artery**, which supplies blood to the foot, divides into two separate arteries known as the anterior tibial artery and the posterior tibial artery.
- The **anterior tibial (TIB-ee-al) artery** supplies blood to the lower leg muscles and to the muscles and skin on the top of the foot and adjacent sides of the first and second toes. This artery goes to the foot and becomes the dorsalis pedis artery.
- The **posterior tibial artery** supplies blood to the ankles and the back of the lower leg.
- The **dorsalis pedis artery** supplies the foot with blood.

As in the arm and hand, the important veins of the lower leg and foot are almost parallel with the arteries and take the same names **(Figure 6–22).**



▲ **Figure 6–22** Arteries of the lower leg and foot.

THE LYMPHATIC/IMMUNE SYSTEM

The **lymphatic/immune system** is made up of lymph, lymph nodes, the thymus gland, the spleen, and lymph vessels that act as an aid to the blood system. Lymph is a colorless, watery fluid derived from blood plasma that has filtered through the capillary walls into the tissue space. The function of lymph is to protect the body from disease by helping to develop immunities that destroy disease-causing microorganisms as well as to drain the tissue spaces of excess **interstitial fluids** (in-tur-STISH-al FLOO-id) (blood plasma found in the spaces between tissue cells) to the blood. It then carries collected waste impurities away from the cells.

The lymphatic system is closely connected to the blood and the cardiovascular system. They both transport fluids, like rivers throughout the body. The difference is that the lymphatic system transports lymph, which eventually returns to the blood where it originated.

The lymphatic vessels start as tubes that are closed at one end. Clusters of these tubes form **lymph capillaries**, which are distributed throughout most of the body (except the nervous system).

The lymph from these vessels is filtered by the lymph nodes, which are gland-like structures found inside the lymphatic vessels. This filtering process helps to fight infection.

The primary functions of the lymphatic system are to:

- Carry nourishment from the blood to the body cells.
- Act as a defense against toxins and invading bacteria.
- Remove waste material from the body cells to the blood.
- Provide a suitable fluid environment for the cells.

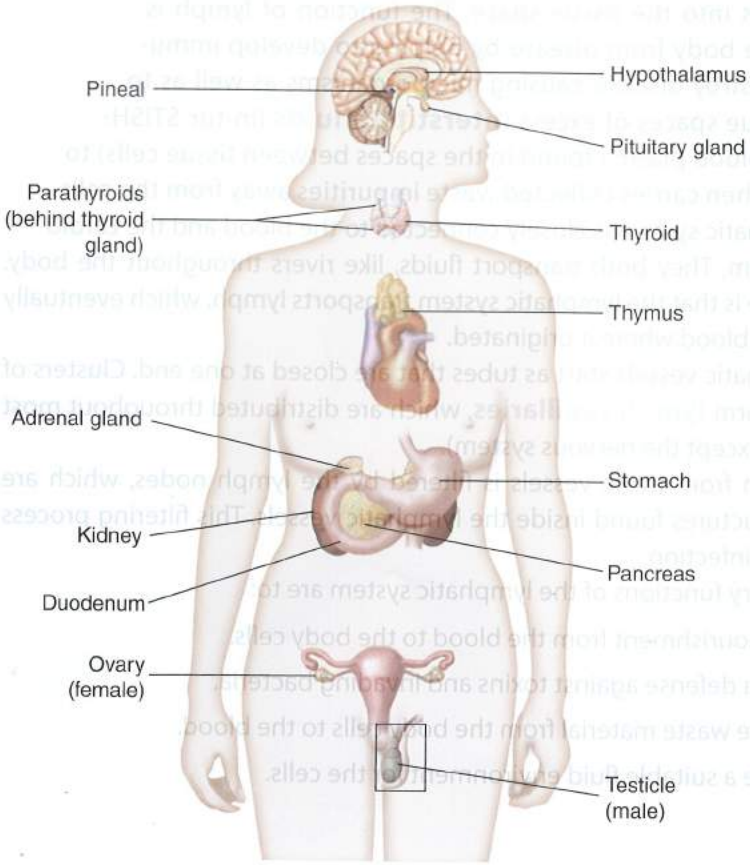
THE ENDOCRINE SYSTEM

The **endocrine** (EN-duh-krin) **system** is a group of specialized glands that affect the growth, development, sexual activities, and health of the entire body. **Glands** are specialized organs that remove certain elements from the blood to convert them into new compounds. There are two main types of glands.

- **Exocrine glands** (EK-suh-krin GLANDZ), or **duct glands**, produce a substance that travels through small, tube-like ducts. Sweat and oil glands of the skin belong to this group.
- **Endocrine glands** or **ductless glands**, such as the thyroid and pituitary glands, release secretions called **hormone** (HOR-mohnz) directly into the bloodstream, which, in turn, influence the welfare of the entire body. Hormones, such as insulin, adrenaline, and estrogen, stimulate functional activity or secretion in other parts of the body.

Here is a list of the endocrine glands **(Figure 6–23)** and their functions.

- The **pineal gland** (PY-nee-ul GLAND) plays a major role in sexual development, sleep, and metabolism.
- The **pituitary gland** (puh-TOO-uh-tair-ee GLAND) is the most complex organ of endocrine system. It affects almost every physiologic process of the body: growth, blood pressure, contractions during childbirth, breast milk production, sex organ functions in both women and men, and thyroid gland function, the conversion of food into energy (metabolism).



▶ **Figure 6–23** The endocrine glands.

- The **thyroid gland** (THY-royd GLAND) controls how quickly the body burns energy (metabolism), makes proteins, and how sensitive the body should be to other hormones.
- The **parathyroid glands** (payr-uh-THY-royd GLANDZ) regulate blood calcium and phosphorus levels so that the nervous and muscular systems can function properly.
- The **pancreas** (PANG-kree-us) secretes enzyme-producing cells that are responsible for digesting carbohydrates, proteins, and fats. The islet of Langerhans cells within the pancreas control insulin and glucagon production.
- The **adrenal glands** (uh-DREEN-ul GLANDZ) secrete about 30 steroid hormones and control metabolic processes of the body, including the flight-or-flight response.
- The **ovaries** and **testes** function in sexual reproduction as well as determining male and female sexual characteristics.

Did You Know?

If you consider the tremendous influence the endocrine glands and the hormones they secrete have over the body, you'll see that they are just as important to us as our brains.

THE DIGESTIVE SYSTEM

The **digestive system** (dy-JES-tiv SIS-tum), also called the **gastrointestinal** (gas-troh-in-TES-tunul) **system**, is responsible for breaking down food into nutrients and waste.

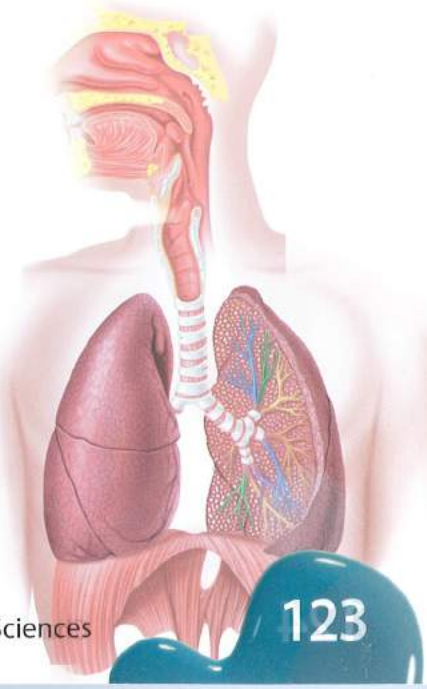
Digestive enzymes (EN-zymz) are chemicals that change certain kinds of food into a form that can be used by the body. The food, now in soluble form, is transported by the bloodstream and used by the body's cells and tissues. The entire process of digesting food that has been eaten takes about 9 hours.

THE EXCRETORY SYSTEM

The **excretory system** (EK-skre-tor-ee SIS-tum) is responsible for purifying the body by eliminating waste matter. The metabolism of body cells forms toxic substances that, if retained, could poison the body.

Each of the following organs plays a crucial role in the excretory system:

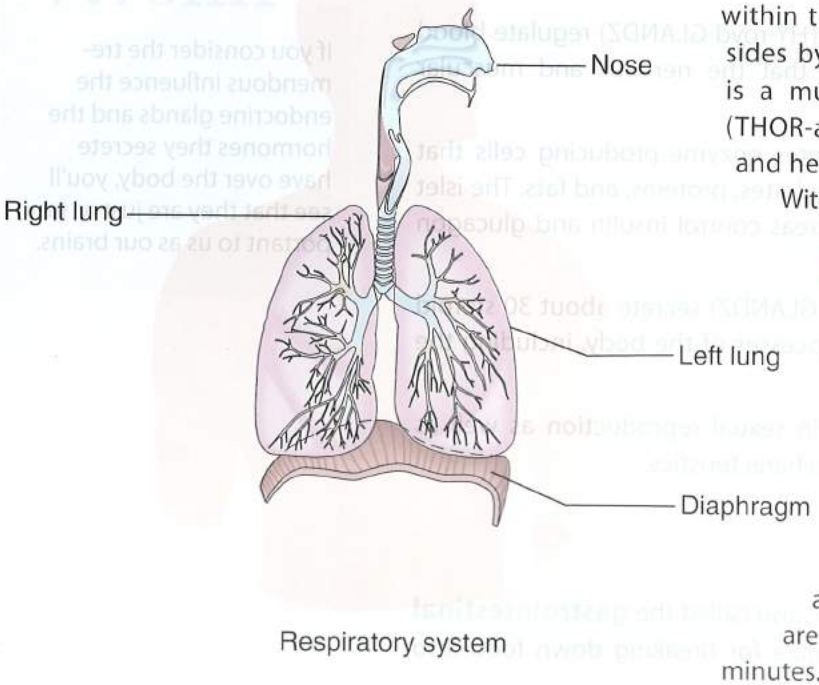
- The kidneys excrete waste containing urine.
- The liver discharges waste containing bile.
- The skin eliminates waste containing perspiration.
- The large intestine eliminates decomposed and undigested food.
- The lungs exhale carbon dioxide and other gases, such as formaldehyde, which is a normal by-product of metabolism that the body uses to build other important substances.



THE RESPIRATORY SYSTEM

The **respiratory system** (RES-puh-ra-tor-ee SIS-tum) enables breathing (**respiration**, the exchange of carbon dioxide and oxygen in the lungs and within each cell) and consists of the lungs and air passages. The **lungs** are

▼ **Figure 6–24** Respiratory system.



Respiratory system

spongy tissues composed of microscopic cells in which inhaled air is exchanged for carbon dioxide during one breathing cycle. The respiratory system is located within the chest cavity and is protected on both sides by the ribs. The **diaphragm** (DY-uh-fram) is a muscular wall that separates the **thorax** (THOR-aks), or chest, from the abdominal region and helps control breathing **(Figure 6–24).**

With each breathing cycle, an exchange of gases takes place. For instance, during **inhalation** (in-huh-LAY-shun), or breathing in through the nose or mouth, oxygen is passed into the blood. During **exhalation** (eks-huh-LAY-shun), or breathing outward, carbon dioxide (collected from the blood) is expelled from the lungs.

Oxygen is more essential than either food or water. Although people may survive for more than 60 days without food, and several days without water, if they are deprived of oxygen, they will die within minutes.

Did You Know?

The world record for holding one's breath is 19 minutes and 21 seconds, set by Peter Colat of Switzerland in 2009.

THE INTEGUMENTARY SYSTEM

The **integumentary system** (in-TEG-yuh-ment-uh-ree SIS-tum) is made up of the skin and its various accessory organs, such as the oil and sweat glands, sensory receptors, hair, and nails. (Skin structure and growth are discussed in detail in Chapter 7.)

THE REPRODUCTIVE SYSTEM

The **reproductive system** (ree-proh-DUK-tiv SIS-tum) performs the function of reproducing and perpetuating the human race. Although important to the perpetuation of the species, it is not of major importance to the nail tech.

Review Questions

1. Why is the study of anatomy, physiology, and histology important to the nail technician?
2. Define anatomy, physiology, and histology.
3. Name and describe the three basic structures of a cell.
4. Define metabolism and list the two phases of cell metabolism and their purpose.
5. List and describe the functions of the four types of tissue found in the human body.
6. What are organs?
7. List and describe the functions of the main organs found in the body.
8. Name the 11 body systems and their main functions.
9. List the primary functions of the skeletal system.
10. Name and describe the three types of muscular tissue found in the body.
11. Name and describe the types of nerves found in the body and how they react.
12. Name and briefly describe the three types of blood vessels found in the body.
13. List and describe the composition of blood.
14. Name and discuss the two main types of glands found in the human body.
15. List the organs of the excretory system and their functions.