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11

Anatomy and Physiology for the Pediatric Practitioner

KEY TERMS

Anatomical position
Skeletal system
Muscular system
Integumentary system
Cardiovascular system
Respiratory system
Nervous system
Endocrine system
Digestive system
Urinary system
Lymphatic system
Immune system
Reproductive system

CHAPTER *Objectives*

After studying this chapter, the reader will be able to accomplish the following:

- Distinguish between two branches of biology: anatomy and physiology.
- Understand and describe the hierarchy of organization of the human body.
- Describe the anatomical position.
- Understand and define the descriptive and movement terminology.
- Understand the cardinal planes and axes.
- Describe the structures and functions of the organ systems of the human body.
- Provide examples of pediatric health conditions or disorders of the organ systems of the human body.
- Understand and describe the relationship among body structures, the function of body structures, and one's successful engagement in daily occupations.

CHAPTER *outline*

The Occupational Therapy Practice Framework (OTPF) (American Occupational Therapy Association [AOTA], 2014) describes the domains and processes inherent to the profession of occupational therapy (OT). According to the OTPF *client factors* refers to those components that influence actions or occupations (AOTA, 2014). For example, a child's neuromuscular status is considered a client factor. Client factors include both body structures and functions. *Body structures* refer to the parts that make up the human body (AOTA, 2014; World Health Organization [WHO], 2001). For example, the structure of the hand includes bones, muscles, tendons, nerves, and blood vessels. A child with a missing thumb has a deficient body structure that may interfere with his occupational performance. The term *body functions* refer to how the body part, organ, or organ system works (AOTA, 2014; WHO, 2001). In the former example, body function includes the child's hand strength or coordination. Deficits in body functions interfere with occupational performance. OT practitioners use knowledge of body functions and body structures to understand occupational performance so they may provide intervention.

This chapter provides an overview of the structures and functions in each body system. While successful engagement in daily occupations is dependent on the interactions of many client factors, (e.g., one's values, beliefs, and spirituality), the focus of this chapter is on the client factors related to body structures and functions.

OVERVIEW

Anatomy is the branch of biology that studies the structures of the human body. Physiology is the branch of biology that examines the functions of the structures of the human body. One's successful engagement in chosen daily occupations may be impaired if client factors related to body structures and functions are impaired or atypical. Structure or shape determines function in all living matter. The human body comprises living matter.

The organization of the human body is hierarchical. *Atoms* are the smallest unit of matter. By definition, *matter* is anything that takes up space and has mass or weight. Atoms of different elements have unique masses and space requirements. The most abundant elements found in living matter are carbon, hydrogen, oxygen, nitrogen, and phosphorus. Atoms link together (bond) to form *molecules*. For example, two hydrogen atoms bond with one oxygen atom to form one molecule of water (H_2O). Molecules come together to form *cells*. Cells are the smallest units of living matter. Eukaryotic cells are those found in the human body. They have a membrane-bound nucleus that contains a person's genetic information, for example, DNA and genes. Cells come together to form *tissues*. There are four basic types of tissue found in the human body: epithelial, connective, muscle, and nervous (Table 11.1). Tissues come together to form organs. Organs, (e.g., the heart) are made of two or more types of tissues. Organs come together to form organ systems;

TABLE 11.1

Major Tissues of the Body

TISSUE TYPE	STRUCTURE	FUNCTION	EXAMPLES IN THE BODY
Epithelial	One or more layers of densely arranged cells with very little extracellular matrix May form either sheets or glands	Covers and protects the body surface Lines body cavities Movement of substances (absorption, secretion, excretion) Glandular activity	Outer layer of skin Lining of the respiratory, digestive, urinary, reproductive tracts Glands of the body
Connective	Sparsely arranged cells surrounded by a large proportion of extracellular matrix often containing structural fibers (and sometimes mineral crystals)	Supports body structures Transports substances throughout the body	Bones Joint cartilage Tendons and ligaments Blood Fat
Muscle	Long fiber-like cells, sometimes branched, capable of pulling loads; extracellular fibers sometimes hold muscle fiber together	Produces body movements Produces movements of organs such as the stomach, heart Produces heat	Heart muscle Muscles of the head/neck, arms, legs, trunk Muscles in the walls of hollow organs such as the stomach, intestines
Nervous	Mixture of many cell types, including several types of neurons (conducting cells) and neuroglia (support cells)	Communication between body parts Integration/regulation of body functions	Tissue of brain and spinal cord Nerves of the body Sensory organs of the body

for example, the cardiovascular system, or the circulatory system, which consists of the heart and associated vessels. Organ systems come together to form organisms (Table 11.2). The human body has numerous organ systems that work together to allow one's active participation in chosen daily occupations.

The OT practitioner uses knowledge of the interrelatedness of organs and organ systems in the human body to understand human performance. They begin by defining the terminology used in the study of the human body's structures and functions. Anatomical position is used as a reference point when studying the anatomy and physiology of the human body. The term **anatomical position** refers to a person standing upright with their arms resting at the side of the body, palms forward, and the head and feet pointing forward. The fingers of both hands are adducted (not spread apart) (Fig. 11.1). The human body has bilateral (two-sided) symmetry, whereas the right side of the body is a mirror image of the left side of the body (Patton & Thibodeau, 2016). The human body is divided into front (anterior/ventral) and back (posterior/dorsal) cavities. Organ systems are located in specific regions of the ventral and dorsal cavities. The ventral cavity is subdivided into thoracic, abdominal, and pelvic cavities. The dorsal cavity is subdivided into cranial and spinal cavities (Fig. 11.2).

TERMINOLOGY, PLANES, AND AXES

In the course of their work, OT practitioners use knowledge of terminology to examine, understand, and document the structures and functions of the human body. The terms *anterior* or *ventral* refer to the front of the body. The eyes are located in the sockets found on the anterior surface of the head. The terms *posterior* or *dorsal* refer to the back of the body. The spinous processes of the vertebra are found on the posterior surface of the neck and trunk. The terms *superior* or *cephalad* refer to the head, or above. The nose is superior to the lips. The terms *inferior* or *caudal* refer to the tail/foot, or below. On the face, the

TABLE 11.2

Body Systems

FUNCTIONAL CATEGORY	SYSTEM	PRINCIPAL ORGANS	PRIMARY FUNCTIONS
Support and movement	Integumentary	Skin	Protection, temperature regulation, sensation
	Skeletal	Bones, ligaments	Support, protection, movement, mineral and fat storage, blood production
	Muscular	Skeletal muscles, tendons	Movement, posture, heat production
Communication, control, and integration	Nervous	Brain, spinal cord, nerves, sensory organs	Control, regulation, and coordination of other systems, sensation, memory
	Endocrine	Pituitary gland, adrenals, pancreas, thyroid, parathyroids, and other glands	Control and regulation of other systems
Transportation and defense	Cardiovascular	Heart, arteries, veins, capillaries	Exchange and transport of materials
	Lymphatic/immune	Lymph nodes, lymphatic vessels, spleen, thymus, tonsils	Immunity, fluid balance
Respiration, nutrition, and excretion	Respiratory	Lungs, bronchial tree, trachea, larynx, nasal cavity	Gas exchange, acid-base balance
	Digestive	Stomach, small and large intestines, esophagus, liver, mouth, pancreas	Breakdown and absorption of nutrients, elimination of waste
	Urinary	Kidneys, ureters, bladder, urethra	Excretion of waste, fluid and electrolyte balance, acid-base balance
Reproduction and development	Reproductive	*Male:* Testes, vas deferens, prostate, seminal vesicles, penis *Female:* Ovaries, fallopian tubes, uterus, vagina, breasts	Reproduction, continuity of genetic information, nurturing of offspring

Table 1.2, p. 7 from Patton, K. (2019). *Anatomy and physiology-binder-ready* (10th ed.). St. Louis: Elsevier. ISBN: 978-0-323-52904-4.

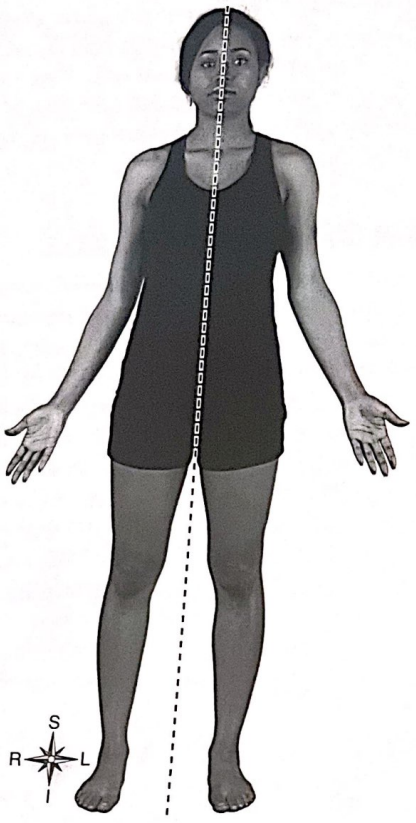


FIG. 11.1 Anatomical position and bilateral symmetry. (Patton, K. T., & Thibodeau, G. A. [2016]. *Structure and function of the body* [15th ed.]. St. Louis: Mosby. Figure 1-3, p. 7, ISBN: 978-0-323-35725-8.)

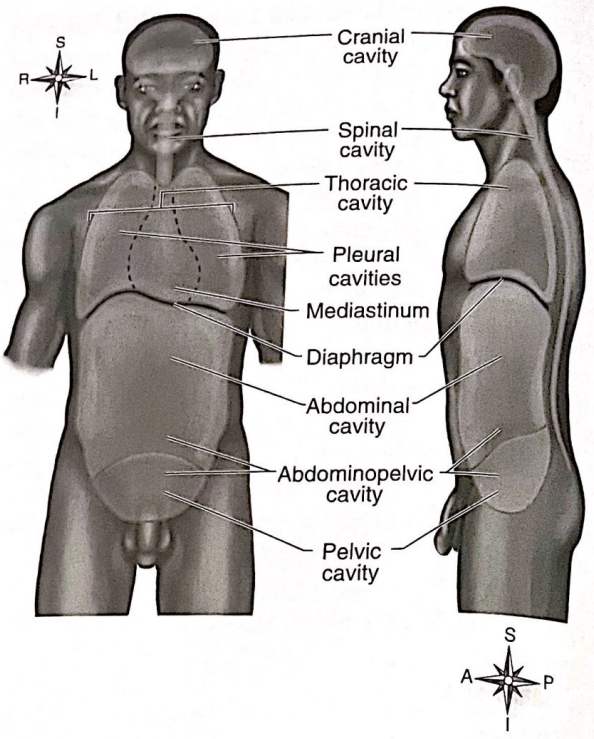


FIG. 11.2 Major body cavities. (Patton, K. T., & Thibodeau, G. A. [2016]. *Structure and function of the body* [15th ed.]. St. Louis: Mosby. Figure 1-5, p. 9, ISBN: 978-0-323-35725-8.)

lips are inferior to the nose. *Proximal* means closer to the body, whereas *distal* means farther away from the body. The shoulder is proximal to the hand, and the hand is distal to the elbow. *Medial* means closer to the midline or to the midsagittal plane of the body. *Lateral* means farther away from the midline of the body with reference to the anatomical position. When a person stands in the anatomical position, the styloid process of the ulna is medial to the styloid process of the radius.

Knowledge of the three cardinal planes and their axes is important to understand the anatomy and physiology of the human body, especially when analyzing the cross-sections of structures and movements at individual joints.

1. The *sagittal plane* divides the body into left and right sides. If the body is divided into equal left and right parts, then the plane is called the *midsagittal plane*. The axis for the sagittal plane is the *frontal axis*, which is perpendicular to the sagittal plane.
2. The *frontal plane* divides the human body into anterior and posterior parts. The axis for the frontal plane is the *sagittal axis*.
3. The *horizontal* or *transverse plane* divides the body into upper and lower parts. The axis for the horizontal plane is the *vertical axis*.

Specific movements occur in each of the three cardinal planes, and the axes are the points about which a body part rotates. For example, bending of the elbow occurs in the sagittal plane. The elbow joint rotates about the frontal axis. Understanding these concepts is crucial to the analysis and measurement of the range of motion (ROM) of joints (Fig. 11.3).

Knowledge of terms that are used to describe movements is useful when studying the muscular and skeletal systems and for analyzing the activity demands and client factors necessary for occupational performance. *Flexion* is the bending at a joint, which decreases the angle of the joint. *Extension* is the straightening of a joint, which increases the angle of the joint. Flexion and extension occur in the sagittal plane, with rotation about the frontal axis. *Abduction* is movement *away* from the midline of the body, whereas *adduction* is movement *toward* the midline of the body. Abduction and adduction occur in the frontal plane, with rotation about the sagittal axis. Horizontal abduction and adduction (e.g., moving the arm across the chest or toward the back of the body) are movements that occur in the horizontal plane. Internal (medial) and external (lateral) rotations (i.e., movements of the head of the humerus in and out of the glenoid fossa) occur in the transverse plane. Forearm supination is turning palms up. Forearm pronation is turning palms down so that the palms of the hands face

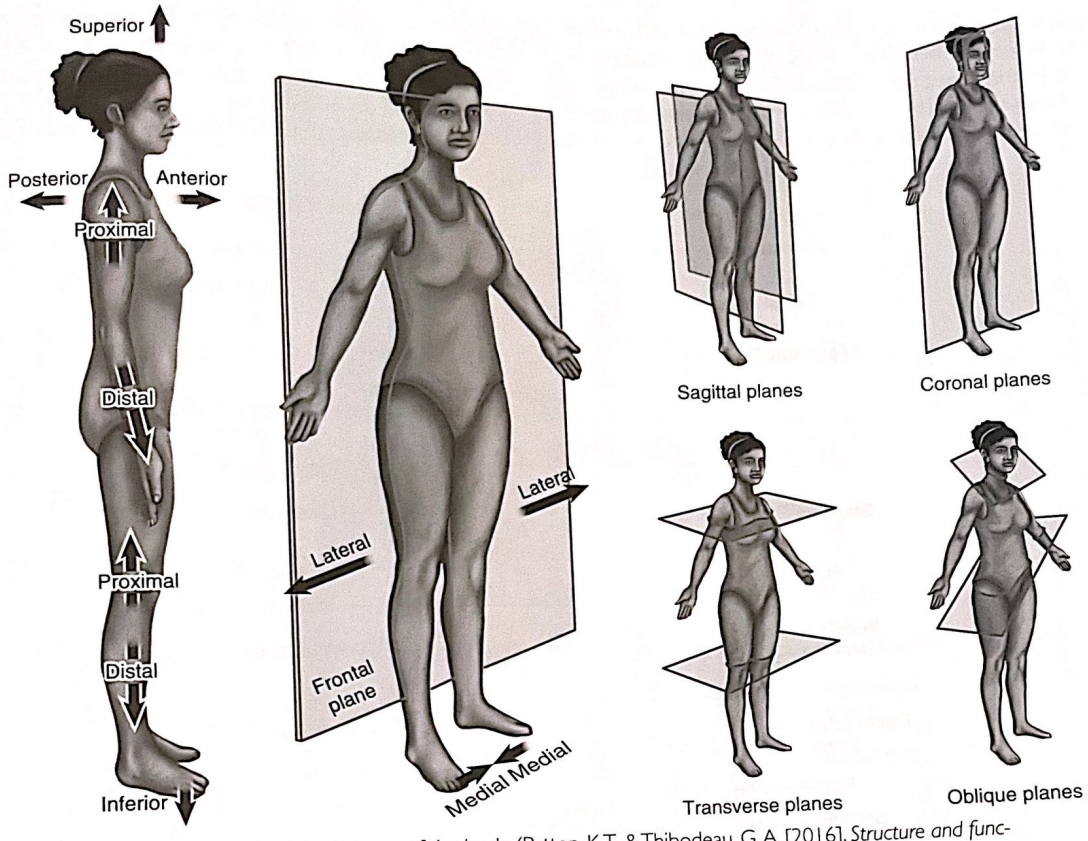


FIG. 11.3 Directions and planes of the body. (Patton, K.T., & Thibodeau, G.A. [2016]. *Structure and function of the body* [15th ed.]. St. Louis: Mosby. Figure 1-4, p. 8, ISBN: 978-0-323-35725-8).

the floor. *Supination* and *pronation* occur in the transverse or horizontal plane, with rotation about the vertical axis. All of these movements are possible with intact skeletal and muscular organ systems.

CLINICAL *Pearl*

To remember the definition of *supination*, think about how you carry a bowl of soup, palm up; *pronation* is the opposite (palm down) of supination.

SKELETAL SYSTEM

The **skeletal system** consists of bones, cartilage, ligaments, and joints. The two major subdivisions of the skeletal system are the axial and appendicular systems. The *axial skeletal system* consists of the bones, cartilage, ligaments, and joints of the neck and trunk. The *appendicular skeletal system* consists of the bones, cartilage, ligaments, and joints of the arms and legs (upper and lower extremities; Fig. 11.4).

CLINICAL *Pearl*

To remember the number of vertebrae in the first three regions of the vertebral column, know that breakfast is at 7 in the morning, lunch is at noon, and dinner is at 5 in the afternoon. This translates into 7 cervical vertebrae, 12 thoracic vertebrae, and 5 lumbar vertebrae. The vertebrae of the sacrum and coccyx are fused, and the number of vertebrae can be variable.

The primary function of the skeletal system is to support the human body and protect internal vital organs. In concert with the muscular system, the skeletal system allows movement at joints (articulations between two or more bones) or supports movement-related functions in the human body (AOTA, 2014). Different types of joints are found in the human body. Shoulder and hip joints are called *ball and socket joints*, which are freely movable in all three of the cardinal planes. During typical development, bones fully ossify and provide stability. Examples of disorders of the skeletal system include fractures and

congenital amputations. See Chapter 13 for a discussion of disorders and health conditions of the skeletal system.

When studying the skeletal and muscular systems a brief discussion of levers and lever systems helps the reader to better understand how bones, joints, and muscles work together to create movement in the human body. A lever is a rigid bone, which is bone in the body. A lever system consists of a lever, a fulcrum (axis), an input force (effort), and an output force (load or resistance). There are three classes of levers: first-class, second-class, and

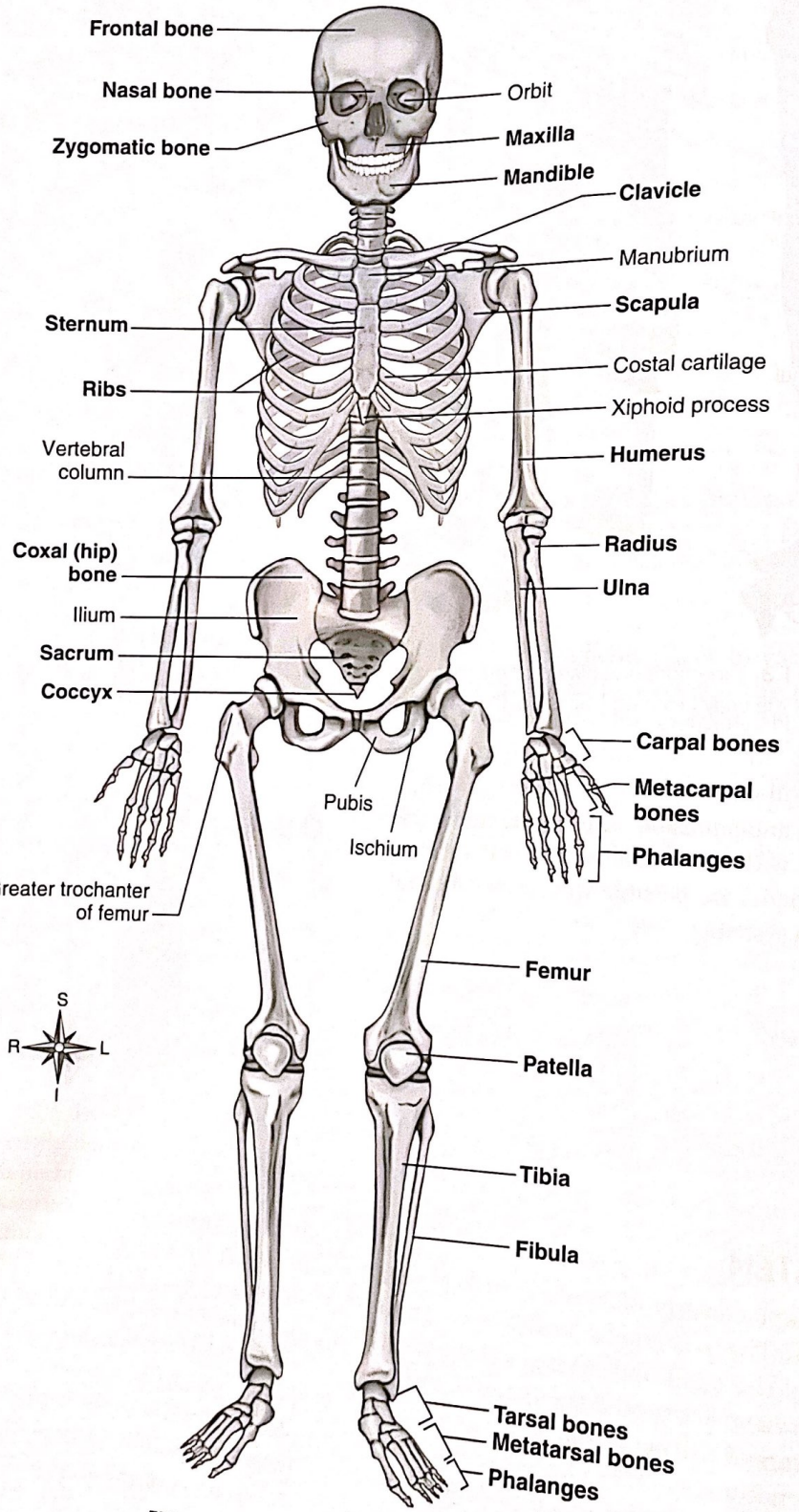
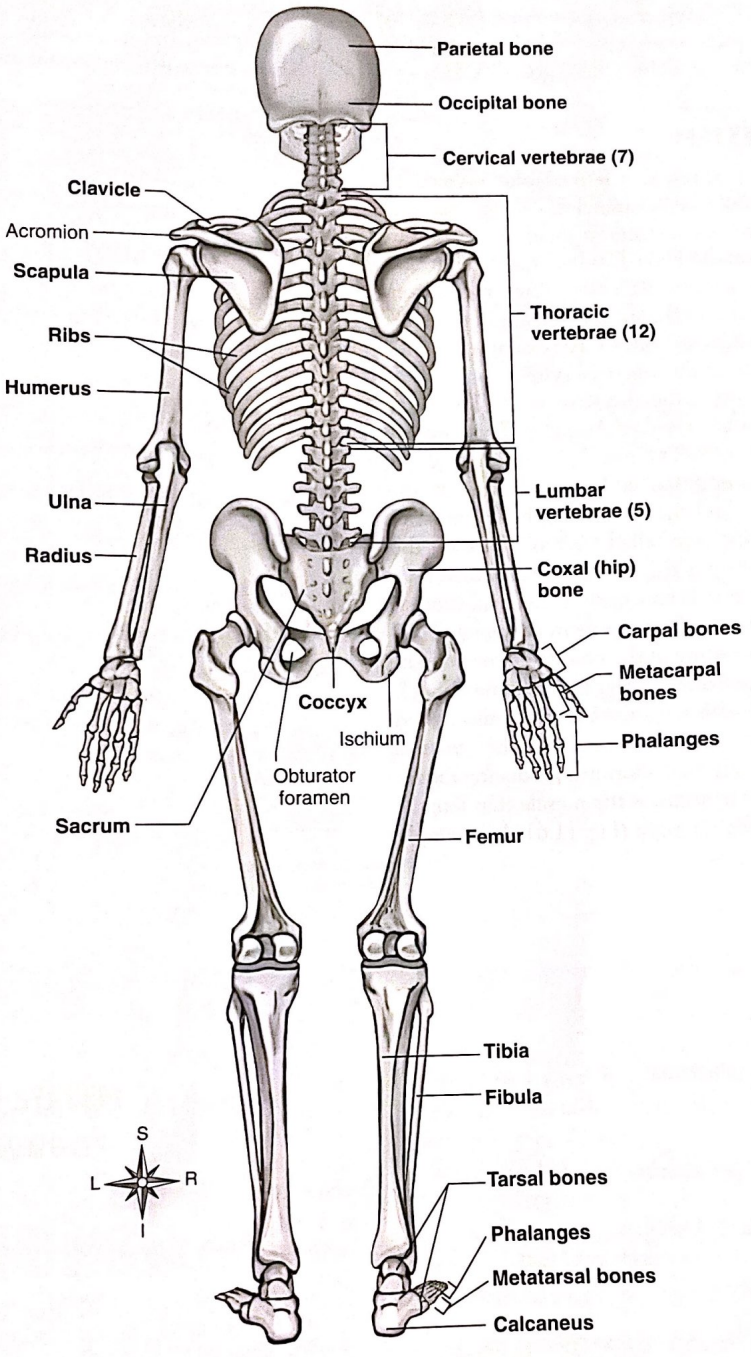


FIG. 11.4 Skeleton. (A) Anterior view.



B

FIG. 11.4, Cont'd (B) Posterior view. (From Patton, K.T., & Thibodeau, G. A. [2014]. *The human body in health & disease* [6th ed.]. St. Louis: Mosby.)

third-class. A first-class lever has the fulcrum between the input and output forces. First-class levers are rare in the human body (e.g., the atlanto-occipital joint). An example of a first-class lever is a seesaw. A second-class lever has the fulcrum on one end, the input force (effort), and then the output force (load or resistance). An example of a second-class lever is observed as the child stands on his tiptoes (metatarsal-phalangeal). A third-class is the most common type of lever found in the human body. The fulcrum is on one end, then the output force (load or resistance) and the input force (load) is on the opposite end of the fulcrum. An example of a

third-class lever is a hammer or elbow joint, such as the movement that occurs when a person holds a weight in the hand and bends the elbow (Muscolino, 2006).

MUSCULAR SYSTEM

The three types of muscle in the **muscular system** are cardiac, smooth, and skeletal muscles. *Cardiac muscle* is found in the heart; it contracts to maintain blood circulation throughout the body. Cardiac muscle contracts involuntarily and is controlled by its own pacemaker. *Smooth muscle* is found in the internal organs of the body and is not under conscious control. For example, smooth muscle in the organs of the digestive system contracts to move nutrients through the digestive tract. The third type of muscle is *skeletal* or *striated muscle(s)*. The contraction and relaxation of skeletal muscle is under conscious control. Skeletal muscle has at least two attachments to bone—the origin and the insertion, which consist of bands of connective tissue called *tendons*. Between the origin and the insertion is the *muscle bulk* or *muscle belly* (Fig. 11.5). Skeletal muscle contracts to create movement at joints. Skeletal muscles have a role in *thermoregulation* (regulating the temperature of the body) and *osmoregulation* (regulating the amount of water in the human body). Skeletal muscles function as agonists or antagonists when contracting to create movement at a joint. The *agonist* is the prime mover muscle that shortens, producing movement at a joint. The *antagonist* is the muscle that lengthens to allow movement at a joint (Fig. 11.6). An example of a minor disorder of the muscular system is a [illegible]. See Chapter 13 for a discussion of health conditions and disorders associated with the muscular system.

CLINICAL *Pearl*

Skeletal muscles are named in a variety of ways that include the location, the action, and the shape of the muscle. Extensor carpi radialis is located on the radial or thumb side of the forearm (radialis) and extends (extensor) the wrist (carpi). Pronator quadratus is shaped like a rectangle with four sides (quadratus) and pronates (pronator) the forearm.

CLINICAL *Pearl*

Agonists and antagonists simultaneously shorten and lengthen because of reciprocal innervation that results in the coactivation (simultaneous contraction) of both muscle groups to allow for coordinated movement.

CLINICAL *Pearl*

Co-contraction is a term used to describe agonistic and antagonistic muscle groups contracting simultaneously at a joint to provide stability proximally or distally to support movement. For example, when you brush your hair, the muscles of the shoulder and wrist contract to stabilize these joints, whereas the elbow straightens and bends moving the brush through your hair.

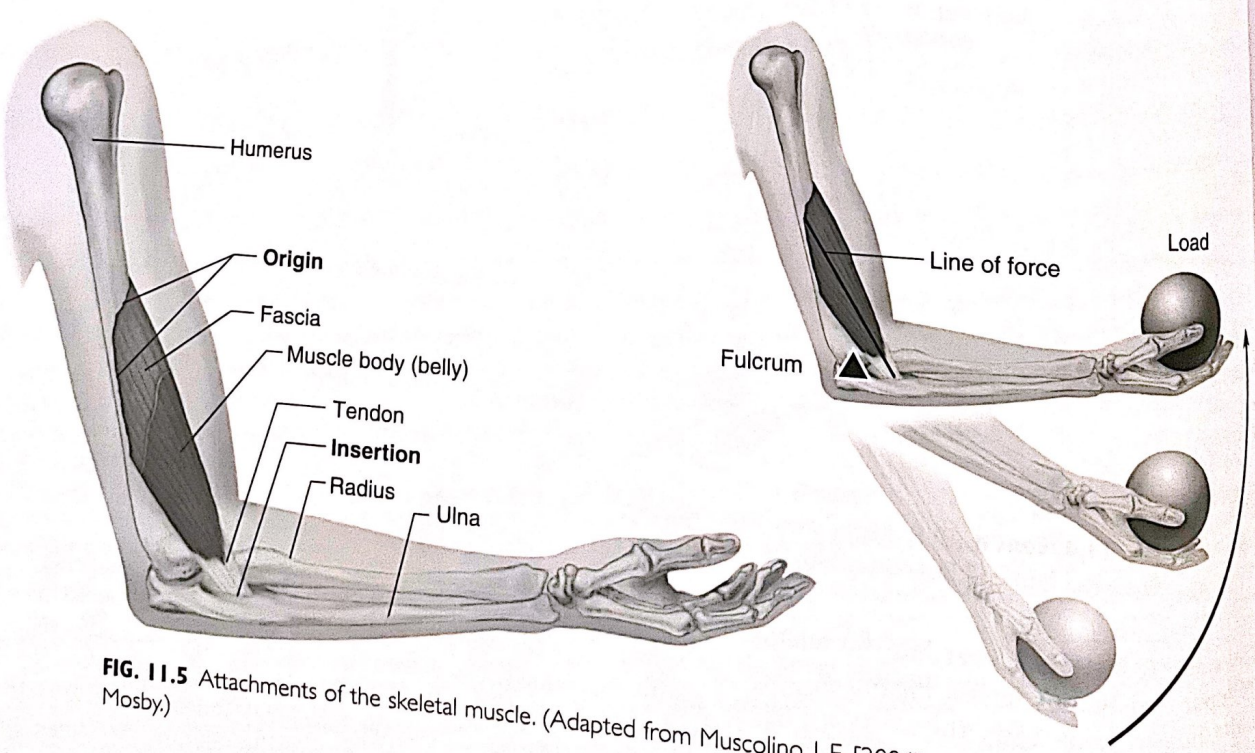


FIG. 11.5 Attachments of the skeletal muscle. (Adapted from Muscolino, J. E. [2006]. *Kinesiology.* St. Louis: Mosby.)

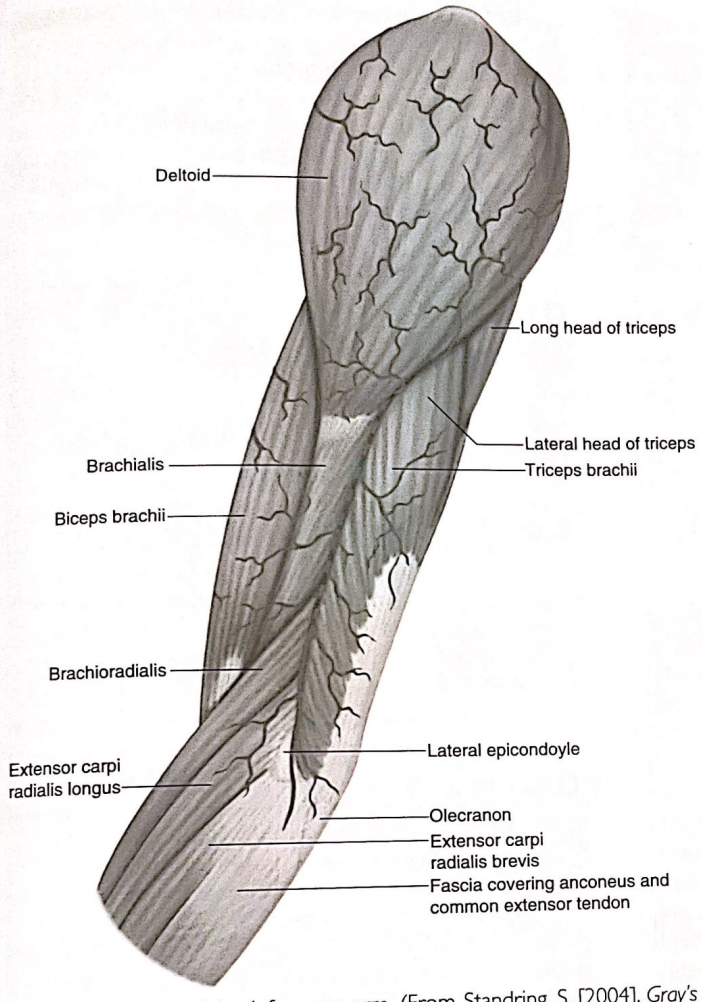


FIG. 11.6 Muscles of the left upper arm. (From Standring, S. [2004]. *Gray's anatomy: The anatomical basis of clinical practice* [39th ed.]. Philadelphia: Churchill Livingstone.)

INTEGUMENTARY SYSTEM

The structures of the **integumentary system** are the skin, hair, nails, and sebaceous glands. The skin is the largest organ in the human body. Skin has two primary layers: the epidermis and the dermis. The *epidermis* is the thin outer layer that is composed of epithelial cells. Epithelial tissue or thin skin also lines the internal organs. The *dermis* is the deeper, thicker layer of skin that consists of dense connective tissue. The skin functions as the body's first line of defense against potential invading microbes, acting as an external barrier associated with the immune system (AOTA, 2014). It also functions in *homeostasis*; that is, thermoregulation (relatively stable internal body temperature) and osmoregulation (balance among water and electrolytes). The skin also has a role in sensory functions and pain (AOTA, 2014). Acne, typically seen in adolescents and young adults, is a disorder involving the skin and its associated structures. Another integumentary condition is decubitus ulcers (pressure sores), which can be serious. Decubitus ulcers develop from extended pressure on bony prominences that causes skin cells to die. OT practitioners can help prevent decubitus ulcers by recommending a variety of positioning options. See Chapters 3 and 18 for more about positioning children and youth to prevent pressure sores.

CLINICAL *Pearl*

In the absence of sensation, the child or adolescent can be taught to relieve pressure through weight shifting. Simple adaptations also may be useful. Using a foam doughnut to distribute pressure around the elbow on the olecranon process (funny bone) can prevent skin breakdown while the child lying on the floor props himself or herself on the elbows to read, watch TV, and so on.

CLINICAL *Pearl*

The skin is the largest organ of the human body. One of the functions of skin is absorption. Skin absorbs substances that we apply to it as well as those substances that we are exposed to in our environment. The pediatric practitioner needs to be aware of all of the ingredients applied topically to a child's or adolescent's skin.

CLINICAL *Pearl*

Eczema is one of the most common disorders of the skin in infants and young children. Eczema is characterized by inflamed patches of skin that are red, cracked, and rough. Eczema is primarily caused by genetic and environmental factors. It can be caused by bacterial, fungal, and/or viral infections. Typically, eczema is not contagious, but may cause the infant or child discomfort when touched by another person.

CARDIOVASCULAR SYSTEM

The **cardiovascular system** consists of the heart, blood, blood vessels (arteries, veins, and capillaries), and bone marrow (which is the site of blood cell formation). The cardiovascular system functions in the transport and exchange of oxygen, nutrients, and waste products. It also has hematologic (blood) function. Three circuits of blood flow are found in the cardiovascular system: pulmonary, systemic, and coronary paths. The *pulmonary circuit* allows transport and exchange between the heart and lungs. Oxygen-poor blood is pumped from the right atrium to the right ventricle into the left and right pulmonary arteries going to the capillary beds at the alveoli of the lungs. Carbon dioxide diffuses out of the cardiovascular system and oxygen diffuses in. The pulmonary veins return the oxygen-rich blood to the left atrium of the heart.

The blood is transported by two different circuits in the body. In the *systemic circuit*, blood is pumped into the left ventricle and then into the aorta to the entire body. The blood returns to the heart via the superior and inferior vena cava. The *coronary circuit* transports and exchanges oxygen, nutrients, and waste products between heart cells and the pulmonary system (Fig. 11.7). Common disorders or health conditions associated with the cardiovascular system are presented in subsequent chapters.

CLINICAL *Pearl*

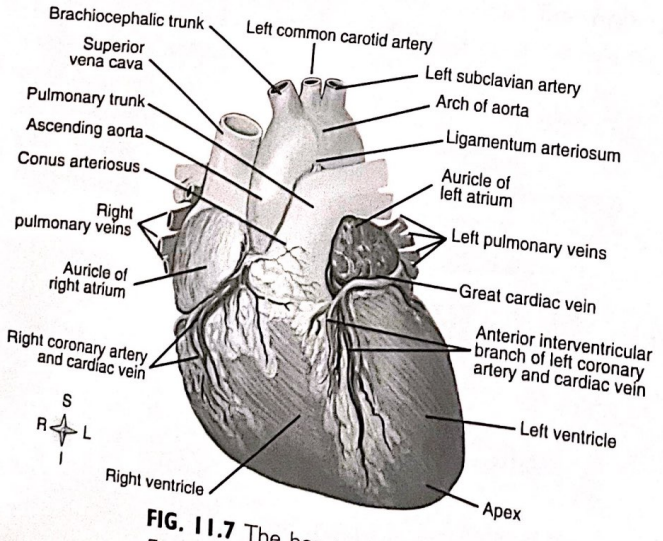
When stabilizing the blood pressure cuff, use the pads of the index and middle fingers on the dial. If you use the thumb to stabilize the stethoscope, your radial pulse may be heard instead.

CLINICAL *Pearl*

To determine heart rate, locate the radial (volar surface of forearm slightly proximal to the wrist on thumb side) or the coronary (neck region) pulse, and then place your index and middle fingers firmly over the artery. Count the number of beats for 15 seconds, and then multiply by 4 to determine the beats per minute.

CLINICAL *Pearl*

To determine breaths per minute, watch and count the number of times the client inhales/exhales for 15 seconds. Multiply this number by 4 to determine the number of breaths per minute. If a person is aware that he or she is being watched, the rate of respiration may change. This is one of the very few instances in which you do not tell the child or adolescent what is happening. Under most circumstances, you should verbally and physically let a client know what is happening.



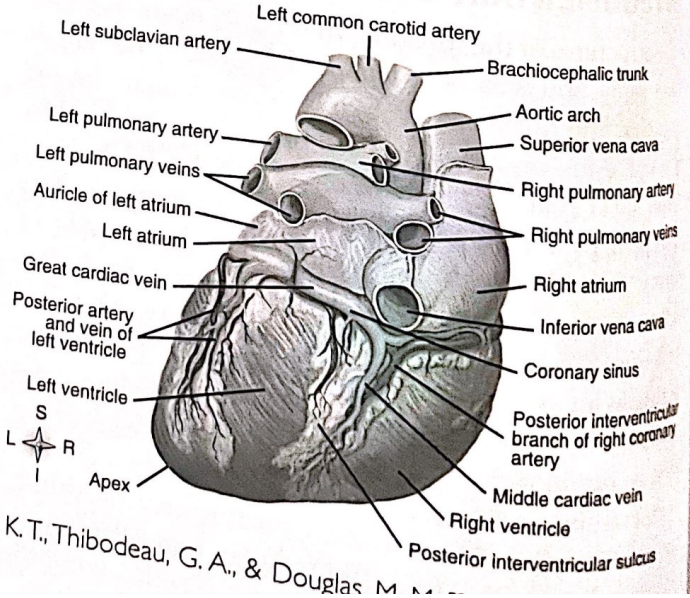


FIG. 11.7 The heart and great vessels. (From Patton, K. T., Thibodeau, G. A., & Douglas, M. *Essentials of anatomy & physiology.* St. Louis: Mosby.)

RESPIRATORY SYSTEM

The structures of the respiratory (pulmonary) system are the nose, mouth, pharynx, larynx, trachea, diaphragm, and lungs. The nose and mouth are the organs of entrance and exit of materials transported and exchanged with the environment by the **respiratory system**. Breathing, the primary function of the respiratory system, involves ventilation and respiration. *Ventilation* is the movement of gases into and out of the lungs. *Respiration* involves an exchange of gases between the alveoli (plural for alveolus) of the lungs and the capillaries of the cardiovascular system. The diaphragm is the major muscle of ventilation. It is a dome-shaped muscle that sits below the lungs separating the thorax from the abdomen of the body. When the diaphragm contracts, the vertical volume increases, thus allowing air to come in (inspiration). When the diaphragm relaxes, the vertical volume decreases, thus forcing air out of the lungs (exhalation). The two major categories of diseases of the respiratory system are obstructive and restrictive. *Obstructive diseases* cause a decrease in airflow. *Restrictive diseases* cause a decrease in the volume or the amount of air that is able to enter the respiratory system. Asthma and cystic fibrosis are examples of obstructive diseases. An example of a restrictive disease is idiopathic fibrotic disease (Medscape, 2019). Respiratory distress syndrome is a health condition associated with prematurity. Other pediatric disorders associated with the pulmonary system are presented in subsequent chapters.

NERVOUS SYSTEM

The **nervous system** is one of the two organ systems in the human body that functions in communication and control throughout the body, integrating the functions of all other organ systems. It functions in rapid communication. Refer to Chapter 12 for detailed information on the nervous system. The nervous system has a primary role in mental, sensory, neuromuscular, and movement-related functions (AOTA, 2014). The structures of the nervous system include the brain, spinal cord, cranial nerves, peripheral nerves, and the special sense organs. The two major subdivisions of the nervous system are the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS consists of the brain and the spinal cord. The PNS consists of the network of peripheral nerves, the autonomic nervous system, and the special sense organs such as eyes and ears. The autonomic nervous system consists of the sympathetic (flight or fight) and parasympathetic (rest and digest) nervous systems. The neuron is the basic unit of the nervous system. There are efferent (motor) and afferent (sensory) neurons. Motor nerves carry electrical messages to effectors such as muscles. Sensory nerves carry sensory information from the periphery to the CNS for processing. Most neurons consist of cell body, dendrite, and axon. The capacity of neurons to communicate rapidly is dependent on the myelin sheath. In certain health conditions (e.g., Guillain-Barré syndrome) demyelination occurs and results in temporary paralysis of the muscles innervated by the affected nerves. The disorders associated with the nervous system are presented in Chapter 13.

CLINICAL *Pearl*

The nervous system stimulates skeletal muscles to contract in order to create movement at the joints. The agonist shortens while the antagonist lengthens because of reciprocal innervation.

CLINICAL *Pearl*

The lower motor neuron (LMN) system includes the cell bodies of the anterior horn of the spinal cord and the spinal and cranial nerves that effect target muscles. The upper motor neuron (UMN) system includes nerve cells in the spinal cord (excluding the cells located in the anterior horn) and all superior structures. Disorders of the LMN system result in flaccidity, decreased or absent deep tendon reflexes, and muscle atrophy. Disorders of the UMN system result in spasticity, exaggerated deep tendon reflexes, and the emergence of primitive reflexes.

ENDOCRINE SYSTEM

The **endocrine system** is the second organ system that functions in communication and control and integrates the functions of other organ systems throughout the human body. The endocrine system is responsible for digestive, metabolic, and hormonal function. Unlike the nervous system, the endocrine system does not necessarily communicate rapidly with other organ systems. The endocrine system contains glands that secrete hormones, which travel to target cells. The circulatory system is the primary means of transport of hormones throughout the body. The endocrine system has hormones that act as agonists and antagonists. Most agonistic and antagonistic hormones function via negative feedback mechanisms. Negative feedback involves the presence of one synergistic hormone signaling another not to be released. The glands of the endocrine system are widespread throughout the body. The nervous and endocrine systems often work in concert with one another. A comparison of the two systems is depicted in Table 11.3. Cushing's syndrome, in which there is redistribution of body fat resulting in a moon face and reddening of the skin, is an example of a disorder of the endocrine system.

TABLE 11.3

Comparison of the Endocrine System and Nervous System

FEATURE	ENDOCRINE SYSTEM	NERVOUS SYSTEM
Overall function	Regulation of effectors to maintain homeostasis	Regulation of effectors to maintain homeostasis
Control by regulatory feedback loops	Yes (endocrine reflexes)	Yes (nervous reflexes)
Effector tissues	Endocrine effectors: virtually all tissues	Nervous effectors: muscle and glandular tissues only
Effector cells	Target cells (throughout the body)	Postsynaptic cells (in muscle and glandular tissue only)
Chemical messenger	Hormone	Neurotransmitter
Cells that secrete the chemical messenger	Glandular epithelial cells or neurosecretory cells (modified neurons)	Neurons
Distance traveled (and method of travel) by chemical messenger	Long (by way of circulating blood)	Short (across a microscopic synapse)
Location of receptor in effector cell	On the plasma membrane or within the cell	On the plasma membrane
Characteristics of regulatory effects	Slow to appear, long lasting	Appear rapidly, short lived

Table 25.1, p. 557 taken from Patton, K. (2019). *Anatomy and physiology-binder-ready* (10th ed.). St. Louis: Elsevier. IBSN: 978-0-323-52904-4.

DIGESTIVE SYSTEM

The structures of the **digestive system** are the mouth, pharynx, esophagus, stomach, small intestine, large intestine, and accessory organs. The *mouth*, or *oral cavity*, is composed of the teeth, mandible, maxilla, hard and soft palates, and the muscles of the tongue. Certain muscles of facial expression create movement of the lips and the temporomandibular joint (jaw, or the articulation between the maxilla and mandible). Solid, semisolid, or liquid food enters the digestive system through the mouth. Solids are chewed and mixed with saliva to form a bolus in preparation for the food to be digested throughout the digestive system (oral preparation phase of swallow). There are three phases of swallow: oral preparation, oral transit, and pharyngeal phases. The oral transit phase of swallow involves the bolus being actively moved from the front of the mouth to the back. Both the oral preparation and oral transit phases of swallow are voluntary. After the bolus passes into the pharynx, the movement of the bolus is involuntarily controlled by smooth muscles. The movement of food through the digestive system is caused by the involuntary contraction and relaxation of smooth muscle. This movement is known as *peristalsis*. The bolus goes from the pharynx into the esophagus, into the stomach, into the small intestine, and then into the large intestine. The food continues to be chemically digested by these organs. (See Fig. 11.8A and B.) Most of the nutrient resorption occurs in the small intestine, whereas most of the water resorption occurs in the large intestine. Waste products are eliminated though the anus by defecation. Examples of disorders of the digestive system are dysphagia and gastroesophageal reflux disease. *Dysphagia* means difficulty swallowing. Gastroesophageal reflux disease (GERD) is a condition in which the acidic contents of the stomach involuntarily lift/move from the stomach back into the esophagus. Both dysphagia and gastroesophageal reflux may have negative impact on one's successful occupational performance.

URINARY SYSTEM

The **urinary system** is also known as the *genitourinary system*. The structures of the urinary system are the kidneys, ureters, urinary bladder, and urethra. The functional unit of the kidney is the nephron. The ureters connect the kidneys with the urinary bladder. The urinary bladder is the storage organ for urine. Urine is excreted from the body through the urethra. The primary functions of the urinary system are filtering blood plasma and excreting urine.

An important developmental hallmark is a toddler's gaining control of the urinary bladder. The sphincter muscle that prevents urine from flowing from the urinary bladder into the urethra must be intact for a child to control urination. Disorders of this system, such as conditions leading to incontinence, can have a significant effect on occupational performance and self-esteem. Toilet hygiene is covered in detail in Chapter 19.

LYMPHATIC SYSTEM

The **lymphatic system** is closely associated with the cardiovascular (also referred to as the circulatory system). The primary structures of the lymphatic system are the tonsils, spleen, thymus, lymph, lymphatic vessels, and lymph nodes. The lymph, or lymphatic fluid, is a watery

substance that is similar to the fluid found in the spaces between cells throughout the human body. The lymph circulates freely through the lymphatic vessels. The lymphatic system is critical in maintaining homeostasis, or the relatively stable internal environment, within the human body. The lymphatic system plays an important role in fighting disease-causing organisms (i.e., microbes) in concert with the immune system (immunologic function). An example of a disorder of the lymphatic system is tonsillitis.

CLINICAL *Pearl*

If a word ends in "-itis," it means that inflammation is present in the organ whose name mostly forms the word root. For example, *tonsillitis* means inflammation of the tonsils; *pericarditis* means inflammation of the pericardium of the heart.

IMMUNE SYSTEM

The **immune system** does not have a distinct structure. Blood cells, skin cells, brain cells, and many other cells support the function of the immune system. The primary function of the immune system is to maintain homeostasis of the body and to fight diseases and disorders. Immunity is either nonspecific or specific. *Nonspecific immunity* mechanisms provide a more general defense. The skin is the body's first line of defense against potentially harmful microbes. *Specific immunity* involves different types of mechanisms that target only certain foreign agents called *antigens*. Examples of specific immunity cells are phagocytes and natural killer cells. An inflammatory response occurs when there is injury. The cardinal signs of an inflammatory response are swelling, redness, pain, decreased movement, and warmth to touch (heat). An

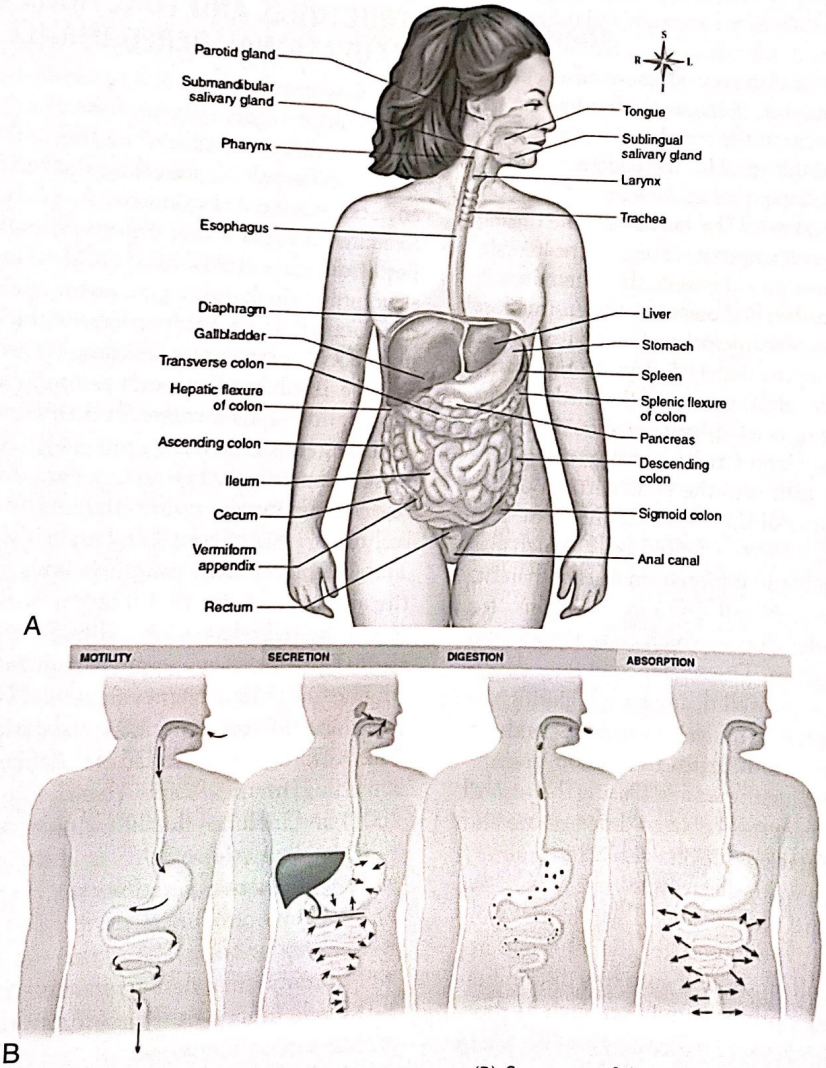


FIG. 11.8 (A) Location of major digestive organs. (B) Summary of digestive function. (Patton, K. T., & Thibodeau, G. A. [2016]. *Structure and function of the body* [15th ed.]. St. Louis: Mosby. Figure 11-8, p. 484 for [A] and Figure 21-1, p. 509 for [B], ISBN: 978-0-323-35725-8.)

allergy is a hypersensitivity to a particular substance that is relatively harmless. Allergens are antigens that cause an allergic response. Juvenile idiopathic arthritis is an example of a disease of the immune system (see Chapter 13).

REPRODUCTIVE SYSTEM

The **reproductive system** is necessary for sexual reproduction, but not for other forms of reproduction; for example, mitosis (cell division) or budding (reproduce a new organism from a single parent from a bud). The structures of the human male and female reproductive systems are different. However, both men and women have essential organs known as *gonads*, which produce *gametes* (sex cells that are haploid). Gametes have half the amount of genetic information of the parent cell.

The structures of the male reproductive system include the testes (male gonads), accessory reproductive glands, and supporting organs such as the scrotum and the penis. The function of the male reproductive system is to produce and store gametes. During sexual intercourse, ejaculation of sperm occurs, and subsequently fertilization of the ovum (egg) can occur in the female.

The structures of the female reproductive system include the ovaries, fallopian tubes, uterus, vagina, and accessory reproductive glands. The ovaries are the organs that produce the female gametes, or eggs. The female reproductive system has a cycle between the years of onset of menstruation (menarche) and cessation of menstruation (menopause). The typical menstrual cycle is 28 days, with menstruation lasting approximately 5 days. During menstruation, the outer layer of the uterine wall is shed in preparation for the implanting of a fertilized egg, should it occur.

In the event that a sperm fertilizes an egg, the resulting embryo implants itself into the endometrium of the uterine wall within several days after fertilization. The fertilized egg is called a *zygote* (diploid cell), which has the same amount of genetic information as each parent. The embryo goes through cell division, or *mitosis*, for approximately 9 months, during which cells, tissues, and organs grow and specialize. The sequence of fetal development is predictable and well documented. During the first trimester, the tactile (touch) system responds to stimuli, the vestibular system begins to develop, and the fetus begins to move inside the womb. During the second trimester, the tactile receptors begin to differentiate and specialize. The fetus begins to process visual and auditory stimuli. The fetus has a wake–sleep cycle. The movement patterns of the fetus are reciprocal and symmetric. During the third trimester, the muscles of the fetus mature. The fetus has tactile, olfactory, and gustatory discrimination. The fetus exhibits primitive reflexes such as rooting and palmar grasp reflexes. Following 36 to 42 weeks of gestation (the average being 40 weeks), a neonate is born. See Chapters 6 through 9 for an overview of the development from birth through adolescence and Chapter 13 for a description of genetic disorders.

CLINICAL *Pearl*

Identical twins have identical genetic information but different finger- and footprints. Finger- and footprints develop as a result of the tactile experiences of the fetus in the womb.

CLINICAL *Pearl*

A child's genetic makeup consists of genetic information from both parents. Therefore, a family history of health conditions provides information on one's predisposition to certain diseases and disorders.

RELATIONSHIP BETWEEN BODY STRUCTURES AND FUNCTIONS AND OCCUPATIONAL PERFORMANCE

This chapter provides a discussion of the structures and functions of organ systems from the perspective of a biologist. OT practitioners use this knowledge to better understand how body structures and body functions influence occupational performance to provide interventions to address areas of deficit. For example, the OT practitioner examines a child's hands to determine whether the structure of the hand (e.g., congenital deformity, edema, or structural anomaly) interferes with the child's performance. OT intervention focusing on body structures may involve rehabilitation, such as improving the structure (e.g., splinting to increase ROM); remediation, such as regaining impaired structures (e.g., increasing muscle mass through activity); or compensation for the deficit (e.g., completing activities differently or using assistive technology due to congenital anomaly of missing digits). The OT practitioner examines body structures to identify areas of concern that interfere with the child engaging in desired occupations. If body structures are intact, the OT practitioner examines body functions.

The OT practitioner evaluates and observes how body functions influence a child's occupational performance. The OTPF (AOTA, 2014) defines body functions according to the World Health Organization (WHO, 2001) and includes the following categories:

- Mental functions;
- Specific mental functions;
- Global mental functions;
- Sensory functions;
- Neuromuscular and movement-related functions;
- Muscle functions;
- Movement functions;
- Cardiovascular, hematologic, immunologic, and respiratory system functions;

- Voice and speech functions;
- Digestive, metabolic, and endocrine system functions;
- Genitourinary and reproductive functions; and
- Skin and related structures functions (AOTA, 2014).

Each of these factors may influence a child's ability to initiate, carry through and complete an activity. For example, the OT practitioner examines neuromuscular and movement-related functions such as joint mobility ROM, muscle power (strength), and control of voluntary movements (eye–hand coordination and oculomotor control). A child with hypertonicity may have adequate body structures in that the muscles, bones, and joints are all intact, but have difficulty with body functions, including moving through the range, controlling muscle tone, and carrying out voluntary movements.

Functions of the cardiovascular and respiratory systems include aerobic capacity and endurance. The OT practitioner uses knowledge of the involved body structures and functions to determine the best way to intervene. For example, a child may show decreased endurance secondary to prolonged inactivity, not due to structural dysfunction of the cardiac or respiratory system, such as might be observed when a child has a cardiac abnormality. The OT practitioner acknowledges that the child is showing difficulty in terms body function of the cardiovascular system and that it is interfering with the child's ability to play with peers on the playground, complete activities of daily living (ADLs), and perform other occupations.

An immunologic response may be inflammation. Children who have juvenile idiopathic arthritis may have inflammation in the joints of the wrists and hands that interferes with their ability to engage in everyday activities. OT practitioners suggest techniques to lessen the workload (i.e., energy conservation) and protect the inflamed joint (i.e., joint protection), thus reducing inflammation. Chapter 13 provides an overview of specific joint protection and energy-conservation techniques.

Functions of the digestive, endocrine, genitourinary, reproductive, and integumentary systems may affect movement and daily activities in children and youth. Children may develop eating/feeding issues or have difficulty with weight gain or loss. The OT practitioner considers how body functions may be influencing the child's motor, behavior, processing, and daily activity.

OT practitioners examine children's performances in the following occupations: ADLs, instrumental ADLs, rest and sleep, education, work, play, leisure, and social participation. ADLs may also be referred to as *basic ADLs*, or *personal ADLs*. Practitioners analyze children's ability to perform occupations taking into consideration the structures and functions of the associated body systems. For example, eating is an ADL that involves the digestive system and the neuromuscular movement-related system. The OT practitioner considers the body structures by evaluating the child's oral motor structures (e.g., palate, tongue) and consulting with the child's physician to rule out an abnormality in the digestive system function or structure. The OT practitioner analyzes the movement-related functions of the child's oral motor structures and their ability to prepare food to be digested through the digestive tract.

OT practitioners analyze children's ability to perform meaningful activities (i.e., occupations) by evaluating their body structures and body functions. OT practitioners understand that many factors influence a child's performance. It is the OT practitioners' job to consider the multiple interactions between systems, environments (e.g., home, school, community), and contexts (e.g., culture, periods, life span) that affect a child's occupational engagement.

SUMMARY

This chapter has presented an overview of human anatomy and physiology to help OT practitioners understand how body structures and body functions influence occupational performance. The author reviewed basic terminology, planes and their associated axes, as well as levers and lever systems. Following general information about the organs and organ systems of the human body, the author presented body functions from an OT perspective and described the relationship between body structures and functions to occupational performance.

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REVIEW *Questions*

1. What is the difference between anatomy and physiology?
2. Describe the hierarchy of organization of the human body.
3. What is *anatomical position*?
4. What are the structures and functions of the organ systems of the human body?
5. How do body structures and functions impact a child's or adolescent's occupational performance?

SUGGESTED *Activities*

1. Create a table of the organ systems of the human body with three columns for each system: structure, function, and potential effect on occupational performance.
2. Design a three-dimensional model representing planes and axes.
3. Demonstrate the movements of the upper extremity (arm).
4. Conduct an activity analysis carefully describing movement for a given activity.
5. Choose one system and describe how it develops over time. Present this to classmates through a creative project.