

# **CDC A4N051**

## **Aerospace Medical Service Journeyman**

### **Volume 2. Anatomy and Physiology**



**Air Force Career Development Academy  
The Air University  
Air Education and Training Command**

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THE AEROSPACE MEDICAL SERVICE TECHNICIAN is an integral piece to the success of the Air Force Medical Service (AFMS). We are standing on the brink of military service that is undergoing tremendous changes in personnel, equipment, and technology. The most exciting part is that you are the future of the Air Force and will experience new opportunities and challenges that have never been encountered before. Seize this opportunity to learn; grow in your career field as well as a military professional and pass on your knowledge and experience to others. In order to provide the world's best medical care to the world's best soldiers, sailors, and Airmen, you must stay abreast of the latest developments in medical doctrine, career opportunities, required training, customer care techniques, and technical responsibilities. To do this effectively, you must have a strong foundation in the basics, including a sound understanding of basic human science and fundamentals of the medical technician duties and responsibilities.

This career development course (CDC) is designed to build on the information you learned in technical school to teach you not only how to perform a task, but when and why to do so. Faithful study of the material provided in this course CDC A4N051, *Aerospace Medical Service Journeyman*, and in the course that follows this one (B4N051) will help you become a more competent medical team member and enable you to provide your patients with the best medical care possible.

Volume 2 addresses the principles of anatomy and the physiological processes in the human body. A solid background in anatomy and physiology is the cornerstone to providing quality patient care. Medical Service Journeymen can provide tremendous assistance in the provider-care process for each patient when they at least have a general knowledge of each situation. All of this helps to increase the effectiveness of the health care team as a whole.

Unit 1 is designed to get you oriented with anatomical terminology. This will assist you in understanding the following units and orientation of organs and musculoskeletal structure to one another. It also covers anatomy and physiology at its most basic structure: cells and tissues. We explain how the anatomical growth of the body expands from the smallest component of a cell, eventually into the large organs of the body. In addition, this unit addresses the sensory organs, the eyes, ears, and nose.

Unit 2 addresses the systematic anatomy of the human body. The structure of the skin and its function within the body are explained. It describes the musculoskeletal system, which includes both the bones and muscles of the body. While muscular and skeletal structures are two different systems, they are covered within the same unit because of their reliance on each other. The unit also covers the anatomy and physiological process of circulation and the respiratory system. The importance of a close working relationship between the respiratory and circulatory systems will be evident to you after studying this unit. It also discusses the complex nervous system of the body.

Unit 3 explains the body's digestive anatomy and physiology and covers the urinary system anatomy and physiology. In addition, it explains the male and female reproductive systems.

After completing the A4N051 course, students in upgrade training will be required to enroll in and complete the B4N051 course before award of the 5-skill level.

Code numbers on figures are for preparing agency identification only.

A glossary is included for your use.

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This volume is valued at 12 hours and 4 points.

## Acknowledgement

Special appreciation is extended to TSgt Bonnie Gerber for her extensive assistance with graphics coordination and unit review in this volume. Her dedication is greatly appreciated and instrumental in making this the best possible product.

### NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.



	<i>Page</i>
<b>Unit 1. Introduction to the Human Body.....</b>	<b>1-1</b>
1–1. Topographic Anatomy .....	1-1
1–2. Cells and Tissues.....	1-9
1–3. Anatomy and Physiology Sensory Organs.....	1-14
<b>Unit 2. Systematic Anatomy.....</b>	<b>2-1</b>
2–1. Anatomy and Physiology of the Integumentary System.....	2-1
2–2. Anatomy and physiology of the Musculoskeletal System .....	2-7
2–3. Anatomy and Physiology of the Circulatory System .....	2-24
2–4. Lymphatic System.....	2-31
2–5. Anatomy and physiology of the Respiratory System.....	2-34
2–6. Anatomy and Physiology of the Nervous System.....	2-39
<b>Unit 3. Other Systems of the Human Body.....</b>	<b>3-1</b>
3–1. Anatomy and Physiology of the Digestive System.....	3-1
3–2. Anatomy and Physiology of the Urinary System.....	3-9
3–3. Anatomy and Physiology of the Reproductive and Edocrine Systems .....	3-13
 <i>Glossary</i> .....	 <i>G–1</i>





# Unit 1. Introduction to the Human Body

<b>1-1. Topographic Anatomy .....</b>	<b>1-1</b>
201. Anatomical terminology .....	1-1
202. Medical abbreviations.....	1-6
<b>1-2. Cells and Tissues .....</b>	<b>1-9</b>
203. Cells.....	1-9
204. Tissues .....	1-11
<b>1-3. Anatomy and Physiology Sensory Organs .....</b>	<b>1-14</b>
205. Eyes and ears .....	1-14
206. Anatomy and physiology of the nose .....	1-19

Understanding and using correct medical terminology is paramount to accurate communication in the medical profession. Very often, the terms used can be difficult to remember if time is not dedicated to learning the language of the job. This unit focuses on many of the terms used in medical care. It is recommended that you refer to these lessons as often as necessary while studying this course and during your regular duty performance.

## 1-1. Topographic Anatomy

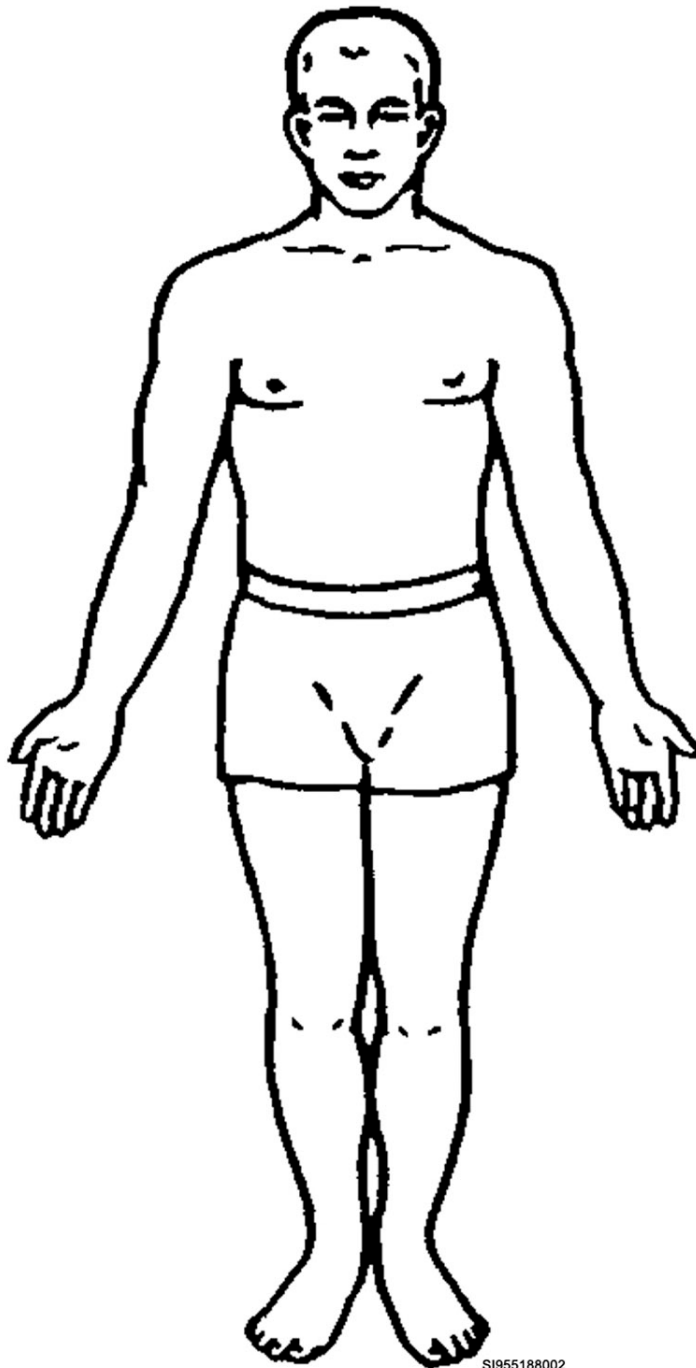
This lesson focuses on the descriptive terminology used to define body areas and movements. The use of topographic terminology is very important in the medical profession. Proper use of these terms will ensure that accurate information about patient assessment and care procedures is communicated appropriately.

### 201. Anatomical terminology

Specific terms are used to describe anatomical relationships of the human body. These terms are used to describe the location of one body part or marking in relationship to another part or marking. The table in this lesson lists each of the common terms used in the medical profession to describe body structure and area locations. It's important to remember that all of these terms are used when referring to the normal anatomical position of the human body, which is *standing upright, arms at the sides, palms facing forward*. Refer to figures 1-1 and 1-2 as you study this table.

Term	Definition	Examples
Anterior (ventral)	Located at or toward the front of the body or body part.	Stomach is anterior to the kidneys. The nose is on the anterior surface of the head.
Posterior (dorsal)	Located at or toward the back of the body or body part.	Spine is posterior to the sternum. The kidneys are posterior to the stomach.
Medial	Located at or near the midline of the body or body part.	Sternum is medial to the ribs. The septum of the heart is medial to the left ventricle.
Lateral	Located away from the midline of the body or body part and toward the side of the body or body part.	Ribs are lateral to the sternum. The left ventricle of the heart is lateral to the septum.
Superior	Located toward the head or area of the body that is closer to the head.	Stomach is superior to the cecum. Eyes are superior to the mouth.
Inferior	Located toward the feet or area of the body that is closer to the feet.	Cecum is inferior to the liver.

Term	Definition	Examples
		Kidneys are inferior to the scapula.
Proximal	Located toward or closer to a given point of origin. Usually used in relation to the trunk or midline of the body.	Elbow is proximal to the hand. The knee is proximal to the ankle.
Distal	Located farther from a given point of origin. Usually used in relation to the trunk or midline of the body.	Hand is distal to the elbow. Foot is distal to the knee.



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Figure 1-1. Normal Anatomical Position.

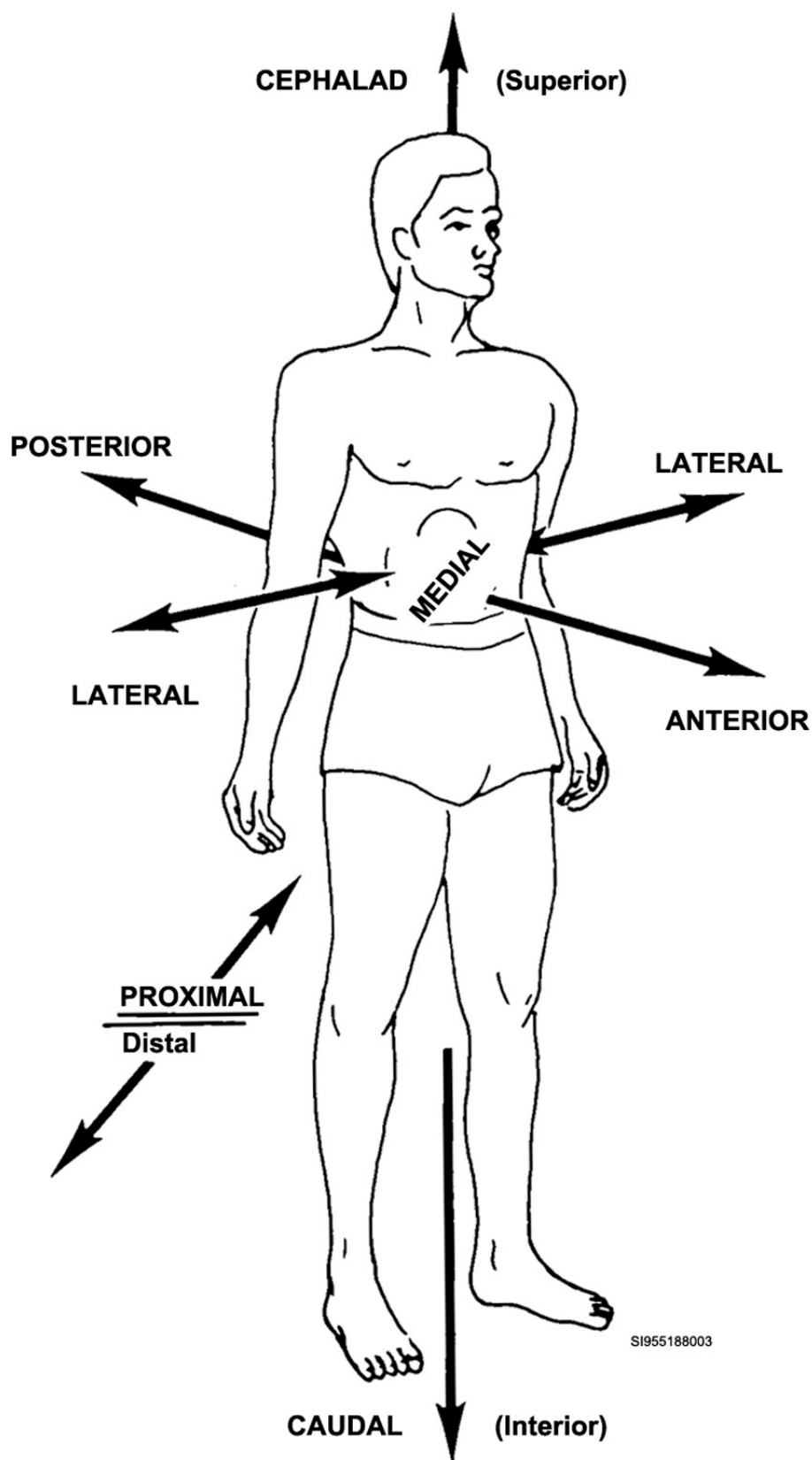


Figure 1-2. Anatomical Directions.

### Body movement terminology

Various terms are used to describe the movements of body parts. This section contains two lists of the terminology used to describe the movement of various body parts in relation to the action that occurs. The first table describes general body movement terminology and the second table contains a list of specific movements. Refer to figures 1-3, 1-4 and 1-5 as you study the tables.

General Body Movement Terminology	
Term	Definition
Range of motion	The range, measured in degrees of a circle, through which a body part can be rotated, extended or flexed at a joint.
Longitudinal axis	An imaginary line that passes lengthwise through a portion of the body or a bone. This line divides the part equally and symmetrically.
Axis of joint rotation	A line projecting at right angles to the plane of motion. The axis of rotation for most joints changes with the motion of the joint due to the joint's structure and the variety of angles in which it can be moved.

Specific Body Movements		
Term	Definition	Example
Rotation	A joint motion whereby a part moves or turns about its longitudinal axis.	Turning the head from side to side.
Circumduction	A movement whereby the distal end of a part makes a circle while the proximal portion of the part remains relatively stationary.	Making circles with the entire arm while it is stretched out.
Supination	The movement that rotates the forearm outward so that the palm of the hand faces forward.	Rotating the palms forward while the arms are hanging loosely at the side.
Pronation	The movement that rotates the forearm inward, causing the back of the hand to face forward.	Rotating the palms toward the back of the body while the arms are hanging loosely at the side.
Flexion	A motion described when adjacent body parts approach each other, thereby decreasing the angle between them. More simply stated, flexion is the act of folding, bending or withdrawing a body part.	Moving the forearm toward the head by bending the elbow (as in doing a "curl" with a weight).
Dorsiflexion	A special type of flexion used to describe ankle and foot movement where the top (dorsal) surface of the foot moves closer to the leg, causing the angle between the anterior surface of the leg and the foot to decrease.	Pointing the toes toward the face.
Plantar flexion	Another type of flexion used to describe ankle/foot movement. The bottom (plantar) surface of the foot moves away from the leg, causing the angle between the anterior surface of the leg and the foot to increase.	Pointing the toes away from the face.
Extension	A movement, which increases the angle between two adjacent, body parts. Refers to a movement that causes the parts of an extremity to line up in a straight manner.	Standing with the arms facing outward or forward, then bringing them straight to the side (the position of attention).
Hyperextension	A type of extension where a body part is extended or stretched beyond its normal anatomical position.	Standing in the normal anatomical position, then moving the head backward (as if looking up in the sky). Holding the forearm outward, then bringing the top of the hand closer to the forearm.
Abduction	Movement of a body part away from the midline or medial plane of the body.	Raising an arm from the side to shoulder level.
Adduction	Movement of a body part toward the midline or medial plane of the body.	Bringing the arm from shoulder level back to the side.
Inversion	A special term used to describe the movement that turns the bottom of the foot inward.	Turning the soles of the feet toward each other.
Eversion	A special term used to describe the movement that turns the bottom of the foot outward.	Turning the soles of the feet away from each other.

Specific Body Movements		
Term	Definition	Example
Protraction	Movement of a body part forward, away from the middle of the body.	Jutting the jaw forward.
Retraction	Movement of a body part backwards or inwards, closer to the middle of the body.	Bringing the jaw back to its normal position.

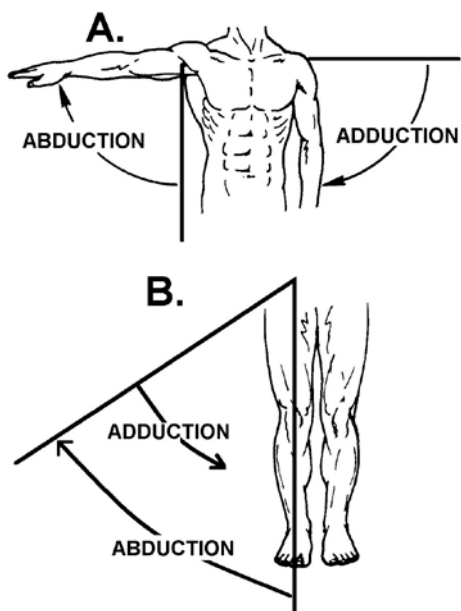


Figure 1-3. Abduction.

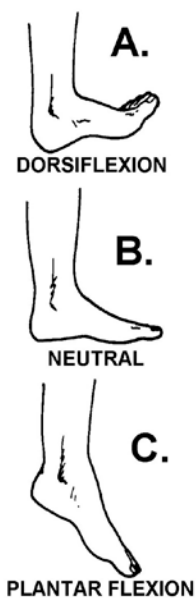


Figure 1-4. Flexion.

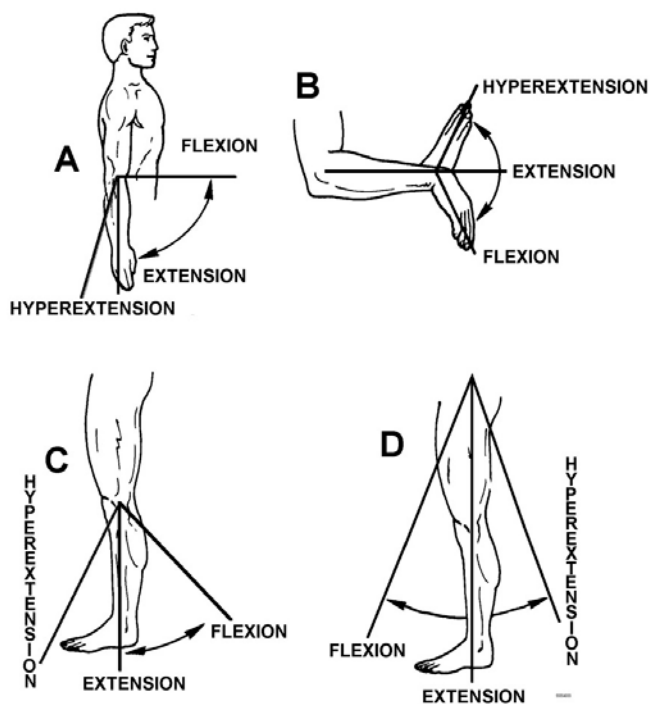


Figure 1-5. Extension.

## 202. Medical abbreviations

There are many different abbreviations used in medical terminology and for drug dosages. These abbreviations are the medical shorthand and are a quick, clear and concise way to communicate through documentation. For legal reasons and to provide safe and accurate care to your patients, you must write so that others can read and understand what you wrote. There have been many errors, some fatal, due to the inability of someone to read or understand documented information or orders that were written on or for a patient. Due to the frequency of errors for some medications, terminology and abbreviations, the Joint Commission (JC) established a list of abbreviations that are unsafe and not allowed to be used anymore. You may also have a local policy that restricts the use of abbreviations even further, so make sure you stay up to date with safe and unsafe usage of abbreviations. The safest action is to spell out all documentation in a legible manner; that way there will not be any question about the intent of the written message. Also remember that local policy may dictate stricter guidelines but never a less restrictive guideline. Some common approved abbreviations and the abbreviations that are not to be used anymore are listed in the following tables. This list is not all inclusive because there are abbreviations that are used in specialty areas and within medical treatment facilities (MTF). Ensure you familiarize yourself with your local policy regarding medical terminology and medication abbreviations. Remember that legible and accurate documentation is critical to adherence to accrediting agency standards and patient safety!

The abbreviations included in this table are approved for use:

Abbreviation	Meaning
ac	before meals
ad lib	as desired
bid	twice a day
— c	with
gtt (s)	drop(s)
IM	intramuscular
IV	intravenous
kg	kilogram
l	liter
mg	milligram
ml	milliliter
mm	millimeter
NPO	nothing by mouth
— p	After
po	by mouth
prn	as needed
pt	patient

Abbreviation	Meaning
q	every
qh	every hour
s	without
stat	at once
tab	tablet
Tbs	tablespoon
tsp	teaspoon
qid	four times a day
tid	three times a day
q2h	every two hours

Because there is a possibility of the following abbreviations being mixed up or mistaken for another abbreviation, JCAHO has declared these abbreviations unusable. DO NOT use these:

Abbreviation	Meaning
AD	right ear
AS	left ear
AU	both ears
cc	cubic centimeter
hs	at bedtime
OD	right eye
OS	left eye
OU	both eyes
sc	subcutaneous
qd	everyday
qod	every other day

## Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

### 201. Anatomical terminology

- Describe the normal anatomical position.
- What does superior mean?

3. What is the correct anatomical position of the eyes as they relate to the mouth?
4. What does proximal mean?
5. Describe the anatomical position of the elbow as it relates to the hand.
6. What is the longitudinal axis?
7. What type of movement occurs when the entire arm makes circles while stretched out to the side?
8. What type of movement occurs when the toes are pointed away from the face while lying supine?
9. What is adduction?
10. What is protraction?

## **202. Medical abbreviations**

1. What is the purpose of medical abbreviations?
2. What accrediting agency established a list of unsafe and unusable abbreviations?
3. The doctor's orders state a patient's vital signs must be completed qid. How often should you take the patient's vitals?
4. Why did JCAHO declare abbreviations such as AS, OS, qd and cc unusable?
5. Match the terms in column B with the correct abbreviation in column A. Items in column B may be used once, more than once or not at all.



*Column A*

- \_\_\_\_ (1) IM
- \_\_\_\_ (2) IV
- \_\_\_\_ (3) gtt
- \_\_\_\_ (4) kg
- \_\_\_\_ (5) l
- \_\_\_\_ (6) mg
- \_\_\_\_ (7) mm
- \_\_\_\_ (8) po
- \_\_\_\_ (9) qh
- \_\_\_\_ (10) Tbs
- \_\_\_\_ (11) tid
- \_\_\_\_ (12) NPO

*Column B*

- a. milligram
- b. three times a day
- c. tablespoon
- d. liter
- e. nothing by mouth
- f. drop
- g. intramuscular
- h. by mouth
- i. intravenous
- j. kilogram
- k. millimeter
- l. every hour
- m. four times a day
- n. after

## 1-2. Cells and Tissues

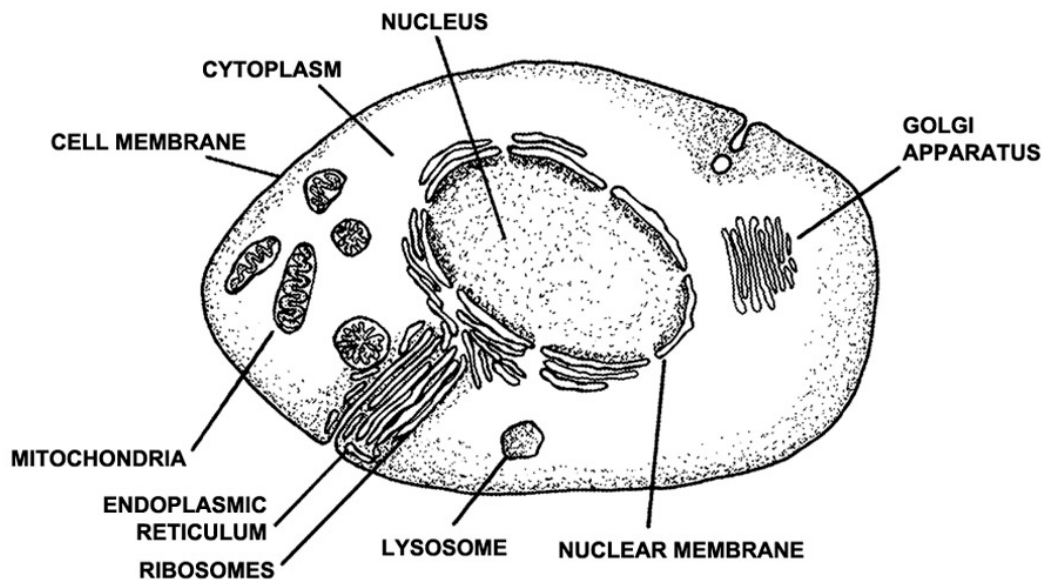
The basic unit of the human body is the cell. Cells are responsible for the entire organization of all body structures and for the continuation of life processes. The grouping of many cells forms tissues; the various tissues then join together to make up the organs of the body. In this unit you will briefly examine the basic structures of both cells and tissues.

### 203. Cells

The adult human body contains approximately 75 trillion cells. This section focuses on the structure and life cycle of cells.

#### Cell structure

Cells differ in size and shape; however, they all have a common structure. In this lesson, you will take a brief look at the three general parts of the structure of a cell—cell membrane, cytoplasm, and cell nucleus. Take a couple of minutes to study the cell structure pictured in figure 1–6.



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Figure 1-6. Cell Structure.

### Cell membrane

The *cell membrane* is the outermost layer of the cell. It's flexible and protects the entire cell by sealing tiny breaks in the membrane surface whenever they occur. Extensive damage to the membrane will result in the contents of the cell leaking out and eventual cell destruction. The membrane is composed mainly of lipids and proteins; a small amount of carbohydrates also is included. The cell membrane is designed in such a way that it permits the entrance of nourishment to the cell.

### Cytoplasm

With the exception of the nucleus, the *cytoplasm* contains all of the living substances of the cell. It is a clear liquid that is alive with constant cellular activity. The word *metabolism*—often used in discussions regarding the human body—actually refers to the activity that occurs in the cytoplasm of each cell. The workings of the cell that occur within the cytoplasm are very complex. This lesson, however, focuses only on naming the 10 components found within the cytoplasm and providing a brief description of each.

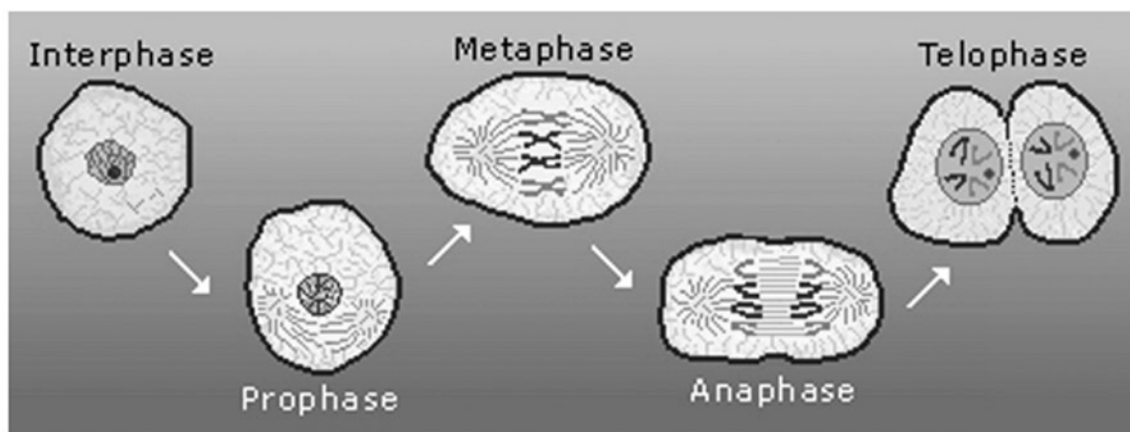
Component	Description
Endoplasmic reticulum	A tubular system within the cell that transports molecules.
Ribosomes	Important for the processing of proteins, both within the cell itself and in other parts of the body.
Golgi apparatus	Located near the nucleus and responsible for distributing proteins the ribosomes processed.
Mitochondria	Principal source of cellular energy. Contains the enzymes involved with electron transport and the citric and fatty acid cycles.
Lysosomes	Tiny membranous sacs that contain enzymes used to break down protein, carbohydrates, acids, and foreign substances that may enter the cell.
Peroxisomes	Found most commonly in cells of the liver and kidneys. Mainly serve to break down toxic substances.
Centrosomes	Vital for cellular reproduction. Centrosomes distribute chromosomes, which carry deoxyribonucleic acid (DNA) information to newly forming cells.
Cilia and flagella	Tiny projections that extend outward from cell surfaces. Responsible for cell movement and the movement of cell products.
Vesicles	Membranous sacs that vary in size. Vesicles are actually an extension of the cell membrane that folds inward into the cytoplasm.
Microfilaments and microtubules	Microfilaments are responsible for cell contraction. Microtubules serve as an internal cell "skeleton" that helps maintain the shape of a cell.

### Cell nucleus

The *nucleus* is located near the center of the cell. It's responsible for directing all cellular activity, serving as the "brain" of the cell. The role of the nucleus is explained further in the next lesson.

### Cell life cycle

The series of changes that occurs within a cell from the time it is first formed until it reproduces is known as the "cell life cycle" (fig. 1-7). The cell life cycle is the process involving the growth of a cell until it divides and becomes two new cells. This cycle consists of four general processes: mitosis, cytoplasmic division, interphase, and cell differentiation. In this lesson, you'll learn about each of these processes.



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Figure 1-7. Cell Life Cycle

### *Mitosis*

During cellular reproduction cells divide creating new cellular structures. The process of the nucleus dividing is known as “mitosis.” Mitosis occurs in four phases: prophase, metaphase, anaphase, and telophase. The following table explains each phase.

Phase	Explanation
Prophase	The first sign that mitosis is occurring is the appearance of chromosomes. Chromosomes contain the DNA and protein molecules that give the cell its specific characteristics.
Metaphase	Chromosomes line up in an orderly fashion and prepare to divide.
Anaphase	The chromosomes actually divide and move apart from each other.
Telophase	The divided chromosomes change in shape and size and a new nucleus forms around each set to complete the cycle. Two new cells have now been created.

### *Cytoplasmic division*

Cytoplasmic division is the division of the contents of cytoplasm. It begins during anaphase and continues through telophase.

### *Interphase*

Interphase is simply the continuation of cell growth from the time it becomes a new cell until mitosis occurs again.

### *Cell differentiation*

Cell differentiation is a complicated process that is best explained as the distinction of cell characteristics. The body has many types of cells that must perform various functions. Cell differentiation is the process that gives each cell its specific characteristic.

## **204. Tissues**

Cells with similar characteristics group together to form tissues. Tissues with similar characteristics then join together to form the organs of the body.

### **Types of tissue**

There are four general types of tissue in the body: epithelial, connective, muscle, and nervous tissues (fig. 1-8). This lesson introduces each of these types of tissue.

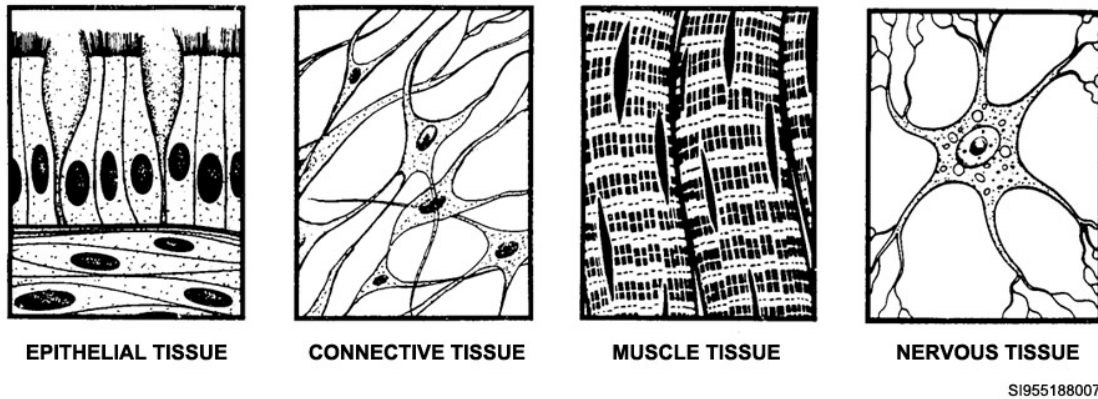


Figure 1-8. Types of Body Tissue

### *Epithelial tissue*

Epithelial tissue is found throughout the body, covering all body surfaces, both inside and out (fig. 1-8). Epithelial tissue covers all organs, forms the inner lining of body cavities, and lines the inside of hollow organs. It also is the major type of tissue found in the glands.

### *Connective tissue*

By weight, connective tissue is the most abundant type of body tissue. Like epithelial tissue, connective tissue is found throughout the body. The main purpose of this type of tissue is to provide support and protection, fill spaces, store fat, produce blood cells, and help repair tissue damage. Connective tissue is, in essence, the tissue that provides the body with its framework.

### *Muscle tissue*

Muscle tissue is unique because it has the ability to change shape by becoming either shorter or thicker. This ability to change shape is made possible by the construction of the muscle tissue, which is mainly fibrous. There are three types of muscle tissue: skeletal, smooth, and cardiac. Let's take a brief look at each.

#### *Skeletal muscle tissue*

Skeletal muscle tissue is found in muscles that are usually attached to bones. Skeletal muscle tissue (fig. 1-9) can be controlled by conscious effort. Because of this, it is sometimes referred to as *voluntary* muscle tissue. The appearance of skeletal muscle tissue is referred to as "striated" because of its string-like construction.

#### *Smooth muscle tissue*

Smooth muscle tissue does not have a striated construction (fig. 1-9). This type of tissue is not under conscious control to move; therefore, it is under *involuntary* control. It is shorter than skeletal muscle tissue and can be found in the walls of internal hollow organs.

#### *Cardiac muscle tissue*

This type of muscle tissue is found only in the heart (fig. 1-9). It is similar in appearance to skeletal muscle tissue because it has a striated appearance.

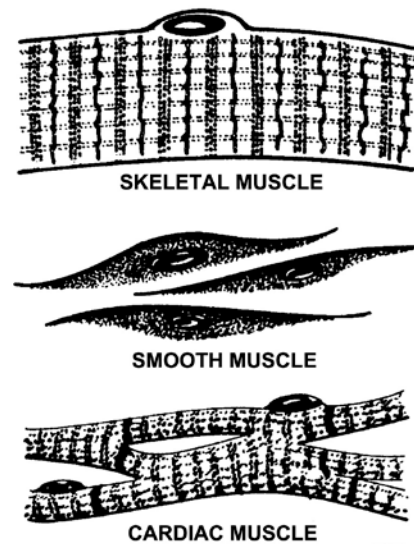


Figure 1-9. Types of muscle tissue.

***Nervous tissue***

Nervous tissue is found in the brain, spinal cord, and peripheral nerves of the body (fig. 1-8). The basic cells of this type of tissue are called “nerve cells.” (Nerve cells are discussed in greater detail in Unit 2.)

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**Self-Test Questions**

**After you complete these questions, you may check your answers at the end of the unit.**

**203. Cells**

1. How do the structures of the cells in the human body differ?
2. What is the outermost layer of a cell called?
3. Where are most living substances contained within a cell?
4. Which part of a cell carries vital DNA information to newly forming cells?
5. Which part is considered as the “brain” of the cell?
6. When does the life cycle of a cell begin and end?
7. How many general processes are involved in the cell life cycle?
8. What is the dividing of a cell’s nucleus called?
9. In which phase of mitosis do chromosomes line up in an orderly fashion and prepare to divide?
10. In which phase of mitosis does cytoplasmic division begin?

**204. Types of tissues**

1. What are the four general types of tissue found in the body?

2. Where can you find the epithelial tissue?
3. What are the three types of muscle tissue?

### 1-3. Anatomy and Physiology Sensory Organs

Humans have five separate senses (sight, sound, smell, touch, and taste) that aid in their awareness of our surroundings. As you know, the sense of touch is attributed to the organs of the integumentary and nervous systems. You also know that taste is a sense that is attributed to the tongue and the nervous system. But what about sight, sound, and smell? This section describes the anatomy and physiology of the three sensory organs that receive these stimuli and some of the illnesses and injuries you may see in these organs.

#### 205. Eyes and ears

The eye is one of the most complex organs of the body. In this lesson, you will study the parts of the eye and learn some of the terms that are used to identify them. This information will be particularly helpful to you when you're writing your medical notes and otherwise communicating with other personnel in the medical facilities.

##### Structure of the eye

The eye is a sphere-shaped structure, approximately one inch in diameter. Most of the eyeball itself is not visible, but rather is located within a socket in the skull. This socket is called the "orbit." The lacrimal gland is located within the orbit on the side of the eye.

The outer portion of the eye is covered by two protective flaps (the upper and lower eyelids) comprised of skin, muscle, connective tissue, and conjunctiva. The two main muscles attached to the eyelids are the orbicularis oculi and the levator palpebrae superioris. Six extrinsic muscles extend from the outer surface of the eye to the bones of the orbit. These muscles include the superior rectus, inferior rectus, medial rectus, lateral rectus, superior oblique, and the inferior oblique.

##### Layers of the eye

Many parts actually make up the eye; each of these parts is located in one of three layers. The outer layer is called the outer tunic, the center area is the middle tunic, and the deepest layer is the inner tunic. As you read the following descriptions of the parts of the eye, refer to figure 1-10 to make sure you know where they are and how together they form the whole eye.

##### Outer tunic

The outer tunic includes the cornea and the sclera. Cornea is the outer transparent covering of the eye. It is primarily composed of connective tissue. The sclera is the white portion of the eye, which is made of a tough fibrous tissue that is resistant to stretching and tearing. The sclera is covered with a

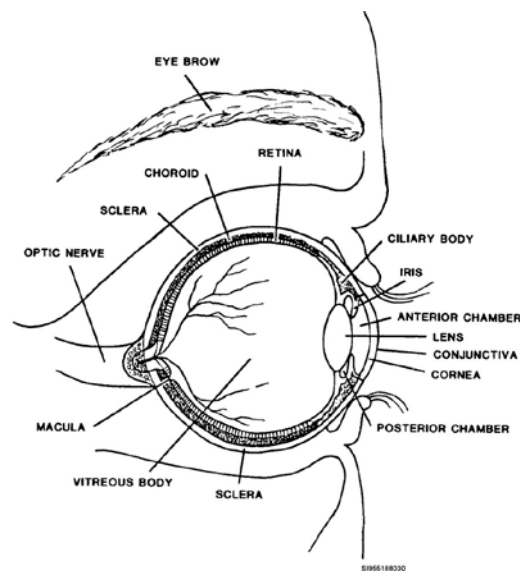


Figure 1-10. Layers of the eye



thin mucous membrane layer known as the conjunctiva, which also lines the inner surface of the eyelids

### *Middle tunic*

This layer has a rich supply of blood vessels. The middle tunic contains the choroid coat, ciliary body, iris, and lens. The choroid coat is joined loosely with the sclera, and extends around the entire eyeball from the iris to the optic nerve.

The ciliary body is the thickest part of the middle tunic. It extends forward from the choroid coat, and forms a ring around the anterior portion of the eyeball. Muscles called “ciliary muscles” are a prominent part of the ciliary body.

The iris is a circular muscle that is located posterior to the sclera. The iris is composed of both connective tissue and smooth muscle fibers. These fibers give the eye the distinctive color that you can see from the exterior of the body. The center opening of the iris is called the pupil.

The lens is located posterior to the iris. This is a transparent portion of the eye that is held in position by fibers called “suspensory ligaments.” The main body of the lens is composed of specialized epithelial cells and does not contain any blood vessels.

### *Inner tunic*

The inner tunic contains only one primary structural component of the eye– the retina. The entire length of the retina extends from an area behind the ciliary body to the optic nerve. The retina is composed of visual receptor cells called “photoreceptors.” These receptor cells include two distinct types of receptor cells: rods and cones. Midway along the length of the retina are various neurons that transmit impulses toward the optic nerve. The nerve fibers of the retina join to the optic nerve at an area called the optic disk.

**NOTE:** The human eye contains approximately 100 million rods and 3 million cones.

### *Optic nerve*

The optic nerve is the pathway of vision. It extends from the optic disk along nerve pathways to the brain.

### *Aqueous humor*

Two chambers make up the part of the eye between the cornea and the lens. The anterior chamber (sometimes referred to as the aqueous chamber) is located between the cornea and the iris. This chamber is filled with a watery fluid called “aqueous humor.” Aqueous humor also fills the space between the cornea and the lens to help provide nourishment to these parts. The fluid is regularly circulated from the anterior chamber through the pupil and into the posterior chamber. The posterior chamber is the area of the eye that is occupied by the lens.

### *Vitreous humor*

The largest portion of the eye is the vitreous body (also referred to as the posterior cavity), which is located behind the lens. It is filled with a gelatin-like substance called “vitreous humor.” This substance is responsible for supporting the internal structures of the eye as well as ensuring that the eyeball maintains its round shape.

### **Protection of the eye**

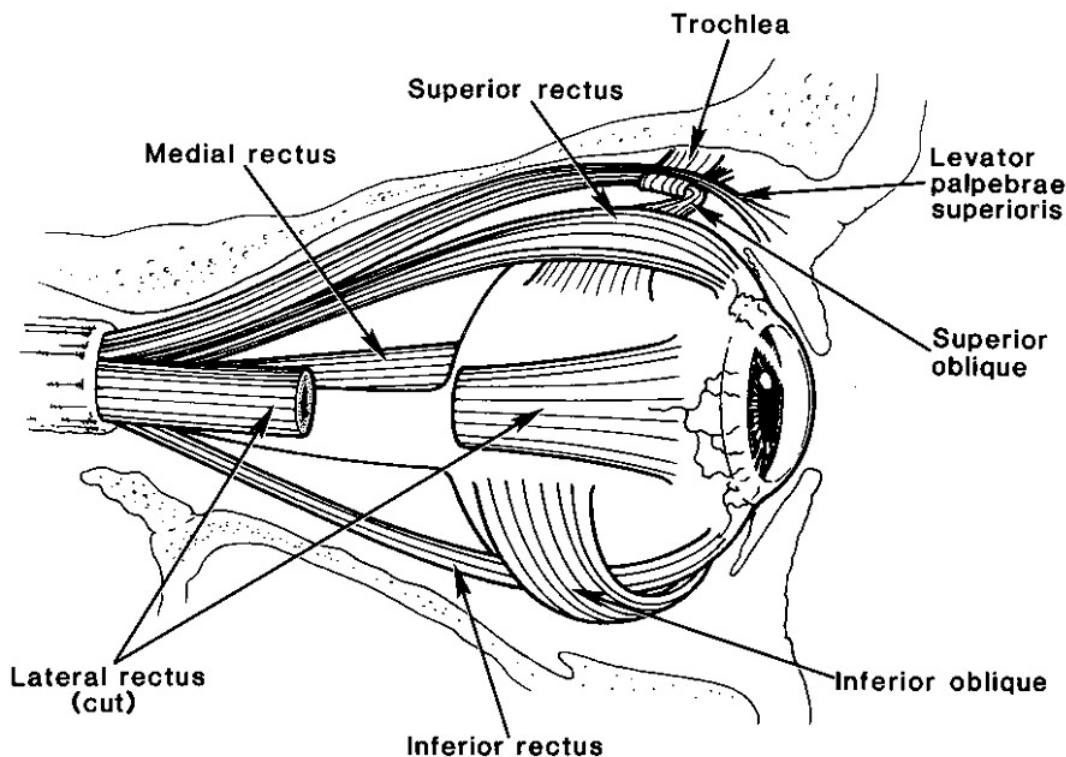
The eye is protected from exterior particles by the eyelids and lacrimal glands. The eyelids can close voluntarily whenever you’re in an area where debris can enter the eye. They are controlled by two muscles: the orbicularis oculi, which closes the eyelid, and the levator palpebrae superioris, which opens the eyelid.

The eyes involuntarily blink periodically to help keep the outer surface (the conjunctiva) lubricated with fluid (tears) from the lacrimal glands. If debris does enter the eye in spite of the protection from the eyelids, fine hairs (the eyelashes), trap the debris before it can cause serious problems.

### Movement of the eye

Movement of the eyeball itself is made possible by the six main muscles of the eye (figure 1-11). The following table identifies each muscle and their type of action. Take a few minutes to study this table with the figure to be sure you know where the muscles are and what they do to help you see.

Muscle	Action
Superior rectus	Rotates eye upward and toward the midline.
Inferior rectus	Rotates eye downward and toward the midline.
Medial rectus	Rotates eye toward the midline.
Lateral rectus	Rotates eye away from the midline.
Superior oblique	Rotates eye downward and away from the midline.
Inferior oblique	Rotates eye upward and away from the midline.



B2F1-03

Figure 1-11. Eye muscles.

### Receiving and transmitting light images

Vision is an instantaneous process through which light images that enter the eye are changed into electrical impulses and transmitted to the brain. The process begins with an adjustment made by the iris to regulate the amount of light that can enter the eye. For example, when a bright light is present, the iris constricts to make the pupil smaller so it will admit only a small amount of light. On the other hand, when the environment is dark, the iris dilates to make the pupil larger to admit as much light as possible. Then, the lens changes in thickness and shape to permit viewing objects according to how close they are to the eye. This action is called “accommodation.” For example, when you look at a



close object, the lens in your eye thickens and becomes convex in shape. When you look at a distant object, the ciliary muscles relax and the lens becomes thinner.

As images enter the lens, the rods and cones receive them in the retina. The rods are very sensitive to light and are largely responsible for viewing dimly lit images. Rods permit seeing a general image, while cones make viewing color images possible. Rods can only permit colorless vision. Cones are responsible for sharpening the view of an image. Various other characteristics of the retina help to define the depth, height, width, and distance of objects.

The various neurons that are midway along the length of the retina transmit impulses toward the optic nerve, which transmits them to the brain. At this point, the brain translates the impulses into visual images.

### **Anatomy and physiology of the ear**

This lesson covers the anatomy of the human ear and how the various structures of the ear work together to perform two important functions—hearing and balance. Let's first review the structures of the ear, which are located in one of three areas—external, middle, and inner ear (fig. 1-12).

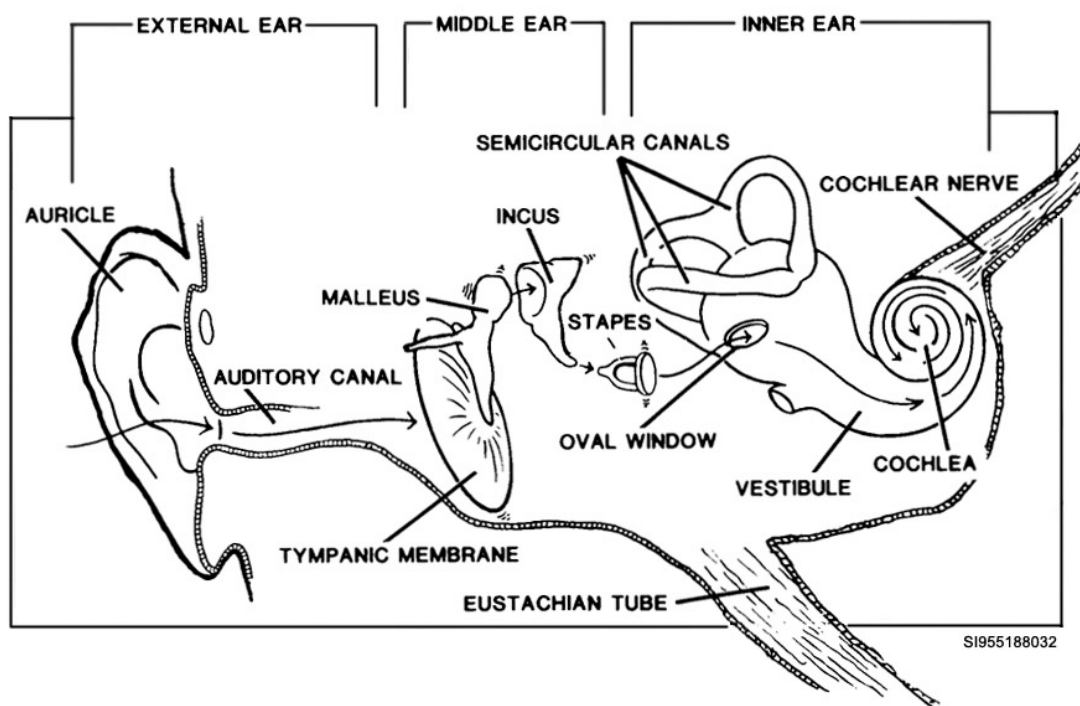


Figure 1-12. Ear.

#### **External ear**

The external ear has two parts. These parts are the auricle and the external auditory canal.

The auricle (also called the pinna) is the visible part of the ear. It is composed of cartilage, and is covered with skin. The pinna has various folds and curves that guide sound waves into the auditory canal.

The external auditory canal is a tube-like passageway that is approximately one inch long. It leads from the pinna to the middle ear. Small hairs line the opening of the canal, and many small ceruminous glands are located within the canal.

### *Middle ear*

The middle ear includes the tympanic cavity, the tympanic membrane, and the auditory ossicles. In addition, the eustachian tube is sometimes considered a part of the middle ear.

### *Tympanic cavity*

The tympanic cavity is a space within the temporal bone. It is filled with air, and serves as a dividing chamber between the external ear and the inner ear.

### *Tympanic membrane*

The tympanic membrane is also known as the “eardrum.” It is a small flap that is covered by a thin layer of skin on the outside and has a thin layer of mucous membrane on the inside. The eardrum is shaped like an oval and has a slight cone shape at one end that points toward the inner ear.

**NOTE:** The cone shape of the eardrum is maintained by the malleus, which is one of the three auditory bones.

### *Auditory ossicles*

The malleus, incus, and stapes are three tiny bones that are collectively known as the auditory ossicles. Each of these bones is attached to the wall of the tympanic cavity, and together they form a bridge from the eardrum to the inner ear. The stapes also is attached to a small opening in the wall of the tympanic cavity that opens to the inner ear. This opening is called the “oval window.”

### *Eustachian tube*

The eustachian tube is a small tube that connects the middle ear to the pharynx. It has a small flap-like valve that opens to the throat.

### *Inner ear*

The inner ear contains a system of chambers and tubes, which is called a “labyrinth.” There are various structures within this area that you should know about. Again, refer to figure 1–13, and identify each of these structures as you read the following descriptions.

### *Cochlea*

The cochlea resembles the shape of a coiled snail shell and is covered with a thin membrane. The inside of the cochlea is divided into two compartments. The upper compartment is connected to the oval window of the middle ear and extends to the center of the coiled cochlea. The lower compartment extends from the center of the cochlea to the round window, which is an opening in the wall of the inner ear.

### *Semicircular canals*

The inner ear has three semicircular canals. Each of these canals resembles a loop and extends outward from the area of the vestibule and back.

### *Vestibule*

The vestibule is a bony chamber that is located between the cochlea and the semicircular canals. This part of the inner ear contains various membranous structures.

### *Organ of Corti*

This highly sensitive part of the inner ear is located within the cochlea. It contains approximately 16,000 hearing receptor cells that are called “hair” cells because of the tiny hairlike projections that extend outward from them.

### **Receiving and interpreting sound waves**

The process of receiving and interpreting sound waves is so rapid that normal hearing is capable of detecting more than 20,000 sound vibrations per second. Sounds are produced by vibrations that

travel through the air in the form of sound waves. These sound waves are guided into the external auditory canal by the auricle (pinna). Once the vibrations enter the external auditory canal, they travel the entire length of the canal until they reach the eardrum.

Sound waves cause pressure changes in the canal that result in a back and forth movement of the eardrum. The malleus, one of the tiny bones in the middle ear, then moves in unison with the eardrum and stimulates the incus and stapes to move also. Movement of the stapes causes pressure to be applied against the oval window. This pressure stimulates the movement of fluid within the cochlea, which is in the inner ear. The fluid movement within the cochlea stimulates the hair cells to pick up the vibrations and they move and change with the frequencies of the vibrations.

The receptor cells in the organ of Corti then transmit the vibrations to the auditory nerve pathways, which lead to the auditory nerve. The auditory nerve then transmits them to the cerebrum. The brain then interprets the sound vibrations.

### Maintaining balance

Balance often is referred to as “equilibrium.” The physiological process of maintaining equilibrium for the body is divided into two categories, *static* equilibrium and *dynamic* equilibrium.

#### Static equilibrium

Static equilibrium involves determining the position of the head when no head or body movement is occurring. It is interpreted by the chambers of the vestibule. Small hairs within the vestibule project either horizontally or vertically, depending on the position of the head. The position of the hairs is detected by nerve fibers and sent as a message to the brain, where head position is interpreted instantly.

#### Dynamic equilibrium

Dynamic equilibrium involves the interpretation of head and body movement. This interpretation is made possible by the semicircular canals, which act somewhat like a gyroscope when determining the position of the head and body. Receptor cells transmit the positions through nerve pathways to the brain, where head and body positions are interpreted. The brain can then stimulate action by the skeletal muscles to prevent individuals from falling.

## 206. Anatomy and physiology of the nose

Though the nose is a part of the respiratory system, it serves an additional purpose by providing a means for *olfaction* (the sense of smell). This lesson addresses the anatomy of the nose, introduced earlier in this volume.

### Nasal cavity

The nasal cavity lies behind the externally visible nose (fig. 1-13). This cavity is divided into three passageways that make up the “nasal conchae.” These three passageways are the superior meatus, middle meatus and inferior meatus.

#### Olfactory receptors

The upper posterior portion of the nasal cavity is lined with olfactory receptors. These receptor cells are bipolar neurons that have tiny knob-like projections. These

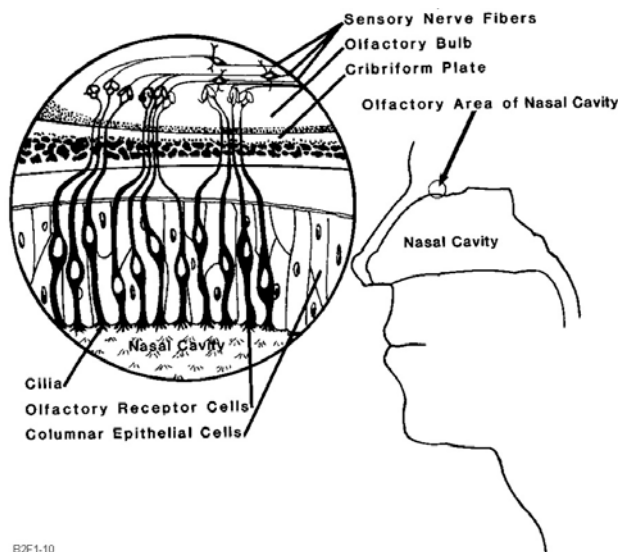


Figure 1-13. Nose.

projections are covered with fine, hair-like cilia that project into the nasal cavity.

### *Olfactory nerve pathways*

Olfactory nerves extend from the olfactory receptors to enlarged areas called “olfactory bulbs.” The pathways that extend beyond the olfactory bulbs are called “olfactory tracts.” Ultimately, the nerve pathways lead to a receiving area of the brain located anterior to the hypothalamus.

As you know, olfaction is the sense of smell. Although the design of the olfactory organs and pathways may seem relatively simple in comparison to the structure of the eye or ear, very little is understood regarding just how various odors are detected, distinguished and interpreted. Most experts agree that there are at least seven groups of odors that can be discerned by olfaction; and research indicates that any odor can be described as belonging to one of these primary odor groups or a combination of these groups. The following table identifies each of these seven primary odor groups.

Primary Odors	
<b>Group</b>	<b>Description</b>
Camphoraceous	Scent of camphor
Musky	Scent of musk
Floral	Scent of flowers
Pepperminty	Scent of the oil of peppermint
Ethereal	Scent of ether
Pungent	Scent of spices
Putrid	Scent of decaying meat

Three unique items of interest are associated with olfaction. First, detecting some odors is often difficult since the olfactory receptors are located very high in the nasal cavity. A person will often need to sniff forcefully to permit enough airflow to reach above the normal air pathway. Second, olfactory receptors rapidly adapt to the sensation of an odor. This means that approximately 50 percent of the intensity of an odor is lost within the first second following stimulation. After one minute, it is possible for the receptors to become completely insensitive to an odor. Third, the receptor neurons of the olfactory pathways are the only parts of the nervous system that are always in direct contact with the environment. This third fact makes it possible for damage to the olfactory neurons to occur. Damage to these neurons is irreversible when it occurs; thus, a person can lose some or even all of their sense of smell as exposure continues during the process of aging.

### *Nasal cavity*

The nasal cavity lies behind the externally visible nose. This cavity is divided into three passageways that make up the “nasal conchae.” These three passageways are the superior meatus, middle meatus and inferior meatus.

### *Olfactory receptors*

The upper posterior portion of the nasal cavity is lined with olfactory receptors. These receptor cells are bipolar neurons that have tiny knob-like projections. These projections are covered with fine, hair-like cilia that project into the nasal cavity.

### *Olfactory nerve pathways*

Olfactory nerves extend from the olfactory receptors to enlarged areas called “olfactory bulbs.” The pathways that extend beyond the olfactory bulbs are called “olfactory tracts.” Ultimately, the nerve pathways lead to a receiving area of the brain located anterior to the hypothalamus.

## Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

### 205. Eyes and ears

1. Where is the lacrimal gland located?
2. How many *extrinsic* muscles extend from the outer surface of the eye to the bones of the orbit?
3. Where is vitreous humor located?
4. What muscle causes the eye to rotate toward the midline?
5. What is “accommodation”?
6. What two actions occur in the lens when you look at a distant object?
7. What are the two external ear structures?
8. What is the system of chambers and tubes in the inner ear called?
9. Approximately how many hair cells are located in the organ of Corti?
10. How many vibrations per second can normal hearing detect?
11. What part of the ear does the pinna guide sound waves into?
12. What does *dynamic* equilibrium involve?

**206. Anatomy and physiology of the nose**

1. How many passageways are in the nasal conchae?
2. Where are the olfactory receptors located?
3. What are “olfactory tracts”?
4. How many primary odor groups can the nose detect?
5. Why are some odors difficult for us to detect?
6. What percent of odor intensity is lost within the first second after receptor stimulation?

---

**Answers to Self-Test Questions**

**201**

1. Standing upright, arms at side, palms facing forward.
2. Toward the head.
3. The eyes are superior to the chin.
4. Closer to a given point of origin.
5. The elbow is proximal to the wrist.
6. An imaginary line that passes lengthwise through a portion of the body or a bone.
7. Circumduction.
8. Plantar flexion.
9. Moving a body part toward the midline or medial plane.
10. Moving a body part forward, away from the middle of the body.

**202**

1. These abbreviations are the medical shorthand and are a quick, clear and concise way to communicate through documentation.
2. The Joint Commission (JC).
3. Four times a day.
4. Because of the high risk of being mixed up or mistaken for another abbreviation.
5. (1). G.  
(2). i.  
(3). F.  
(4). J.

- (5). D.
- (6). A.
- (7). K.
- (8). H.
- (9). L.
- (10). C.
- (11). B.
- (12). E.

**203**

- 1. Only in shape and size.
- 2. Cell membrane.
- 3. Cytoplasm.
- 4. Centrosomes.
- 5. Cell nucleus.
- 6. Begins when the cell is formed and ends when it completes reproduction.
- 7. Four.
- 8. Mitosis.
- 9. Metaphase.
- 10. Anaphase.

**204**

- 1. Epithelial, connective, muscle, nervous.
- 2. Throughout the body, covering all body surfaces (both inside and out). Also found in the glands.
- 3. Skeletal, smooth, cardiac.

**205**

- 1. Within the orbit on the side of the eye.
- 2. Six.
- 3. Within the vitreous body.
- 4. Medial rectus.
- 5. The ability of the lens to adjust its thickness and shape to focus on objects at various distances.
- 6. Ciliary muscles relax and the lens becomes thinner.
- 7. Auricle (or pinna) and external auditory canal.
- 8. Labyrinth.
- 9. 16,000.
- 10. 20,000.
- 11. External auditory canal.
- 12. Interpreting head and body movement.

**206**

- 1. Three.
- 2. In the upper posterior nasal cavity.
- 3. Pathways that extend beyond olfactory bulbs.
- 4. Seven.
- 5. Because olfactory receptors are located high in the nasal cavity.
- 6. 50.

**Do the unit review exercises before going to the next unit.**

## Unit Review Exercises

**Note to Student:** Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

**Do not return your answer sheet to AFCDA.**

1. (201) How does the anatomical lateral position differ from the term medial?
  - a. At the back of the body or body part.
  - b. Toward the back of the body or body part.
  - c. Away from the midline of the body or body part.
  - d. Toward the head or area of the body that is closer to the head.
2. (201) A line projecting at right angles to the plane of motion *best* describes which of the following body movements?
  - a. Circumduction.
  - b. Range of motion.
  - c. Longitudinal axis.
  - d. Axis of joint rotation.
3. (202) You are double-checking the doctor's orders before going into one of your patients, Mrs. Jones room. What would it mean for Mrs. Jones if the doctor's orders are written as NPO?
  - a. May walk around as desired.
  - b. Should increase her fluid intake.
  - c. May not have anything to eat or drink.
  - d. May not get out of bed without assistance.
4. (202) You have just completed screening a patient with an appointment for blurred vision in the right eye. How should you document this information correctly?
  - a. Patient complains of blurred vision-OD.
  - b. Patient complains of blurred vision-AD.
  - c. Patient complains of blurred vision-right eye.
  - d. The technician informs the provider but does not document.
5. (203) You would *not* find which of the following components in the cytoplasm of a cell?
  - a. Nucleus
  - b. Centrosomes.
  - c. Golgi apparatus.
  - d. Endoplasmic reticulum.
6. (203) The network of tubules that moves molecules within the cell is the
  - a. vesicle.
  - b. ribosome.
  - c. golgi apparatus.
  - d. endoplasmic reticulum.
7. (203) What part of the cell provides the *primary* source of cellular energy?
  - a. Ribosomes.
  - b. Lysosomes.
  - c. Peroxisomes.
  - d. Mitochondria.



8. (203) What part of the cell plays an important role in processing proteins within the cell and other areas of the body?
  - a. Ribosomes.
  - b. Centrosomes.
  - c. Cilia and flagella.
  - d. Endoplasmic reticulum.
9. (203) Which phase of mitosis would signify that the nucleus of the cell is actually dividing?
  - a. Anaphase.
  - b. Prophase.
  - c. Telophase.
  - d. Metaphase.
10. (203) In what part of the cell life cycle would the cell continue to grow until it divided again?
  - a. Mitosis.
  - b. Interphase.
  - c. Metabolism.
  - d. Cell differentiation.
11. (203) The complicated process responsible for the distinction of cell characteristics is known as
  - a. interphase.
  - b. metaphase.
  - c. cell differentiation.
  - d. cytoplasmic division.
12. (204) What type of tissue is found in the spinal cord?
  - a. Cardiac.
  - b. Smooth.
  - c. Skeletal.
  - d. Nervous.
13. (204) What type of tissue can change its shape?
  - a. Muscle.
  - b. Nervous.
  - c. Epithelial.
  - d. Connective.
14. (204) Because of its striated appearance, which tissue is similar to skeletal muscle tissue?
  - a. Nervous.
  - b. Epithelial.
  - c. Smooth muscle.
  - d. Cardiac muscle.
15. (205) Which muscle is attached to the eyelid?
  - a. Levator palpebrae superioris.
  - b. Superior oblique.
  - c. Anterior oblique.
  - d. Lateral rectus.
16. (205) Aqueous humor fills the space between the cornea and the
  - a. iris.
  - b. sclera.
  - c. macula.
  - d. conjunctiva.

17. (205) What part of the eye is largely responsible for viewing dimly lit images?
- a. Rods.
  - b. Cones.
  - c. Anterior portion of the iris.
  - d. Posterior portion of the iris.
18. (205) What nerve is the pathway to vision?
- a. Posterior.
  - b. Anterior.
  - c. Sclera.
  - d. Optic.
19. (205) The auditory ossicles are located in the
- a. cochlea.
  - b. inner ear.
  - c. middle ear.
  - d. semicircular canals.
20. (205) Movement of the stapes causes stimulation of fluid within the
- a. pinna.
  - b. cochlea.
  - c. malleus.
  - d. organ of Corti.
21. (205) What is the system of chambers and tubes within the inner ear called?
- a. Cochlea.
  - b. Labyrinth.
  - c. Vestibule.
  - d. Semicircular canal.
22. (206) Which of the following is a nasal air passageway?
- a. Olfactory bulb.
  - b. Middle meatus.
  - c. Anterior meatus.
  - d. Olfactory receptor.
23. (206) Odors are described as belonging to which of these groups?
- a. seven primary odors, or a combination of at least two of them.
  - b. six primary odors, or a combination of at least two of them.
  - c. five primary odors, or a combination of at least two of them.
  - d. four primary odors, or a combination of at least two of them.
24. (206) What part of the nasal cavity does the superior meatus, middle meatus and inferior meatus make up?
- a. nasal conchae.
  - b. cribriform plate.
  - c. nerve pathways.
  - d. olfactory receptors.

## Unit 2. Systematic Anatomy

<b>2–1. Anatomy and Physiology of the Integumentary System .....</b>	<b>2–1</b>
207. Anatomy of the integumentary system .....	2–1
208. Physiology of the integumentary system .....	2–5
<b>2–2. Anatomy and Physiology of the Musculoskeletal System .....</b>	<b>2–6</b>
209. Skeletal system .....	2–6
210. Muscular system .....	2–15
211. Physiology of the musculoskeletal system .....	2–17
<b>2-3. Anatomy and Physiology of the Circulatory System .....</b>	<b>2–23</b>
212. Anatomy of the circulatory system .....	2–24
213. Physiology of circulation .....	2–29
<b>2-4. Lymphatic System .....</b>	<b>2–31</b>
214. Anatomy of the lymphatic system .....	2–31
215. Physiology of the lymphatic system .....	2–33
<b>2-5. Anatomy and Physiology of the Respiratory System .....</b>	<b>2–34</b>
216. Anatomy of the respiratory system .....	2–34
217. Physiology of respiration .....	2–37
<b>2-6. Anatomy and Physiology of the Nervous System .....</b>	<b>2–39</b>
218. Anatomy of the nervous system .....	2–39
219. Physiology of the peripheral nervous system .....	2–45

**T**he integumentary system encompasses the entire human body. This system provides a body covering for protection and it regulates body temperature. Characteristics that determine some of a person's physical appearance also can be attributed to the integumentary system.

### 2–1. Anatomy and Physiology of the Integumentary System

In this section, you will learn about both the anatomical and the physiological functions of the integumentary system.

#### 207. Anatomy of the integumentary system

The organs of the integumentary system fall into one of two categories, skin and skin appendages. In this lesson, you will first learn about the organs that are considered to be part of the skin. Then you will move on to study the organs known as skin appendages.

##### Skin

The skin is one of the largest organs in the body. It consists of three layers of tissue (fig. 2–1). The two main layers of tissue are called the *epidermis* and the *dermis*. The third underlying layer of tissue, which serves as a connector to internal body structures, is called the *subcutaneous layer*.

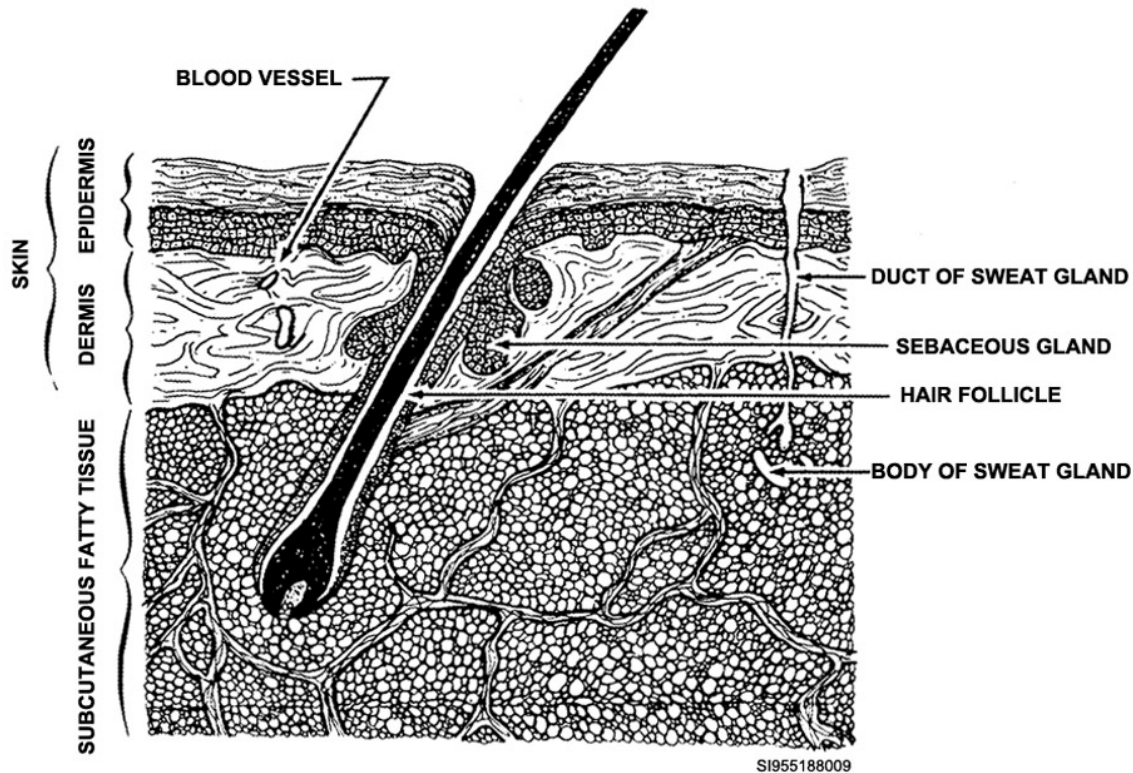


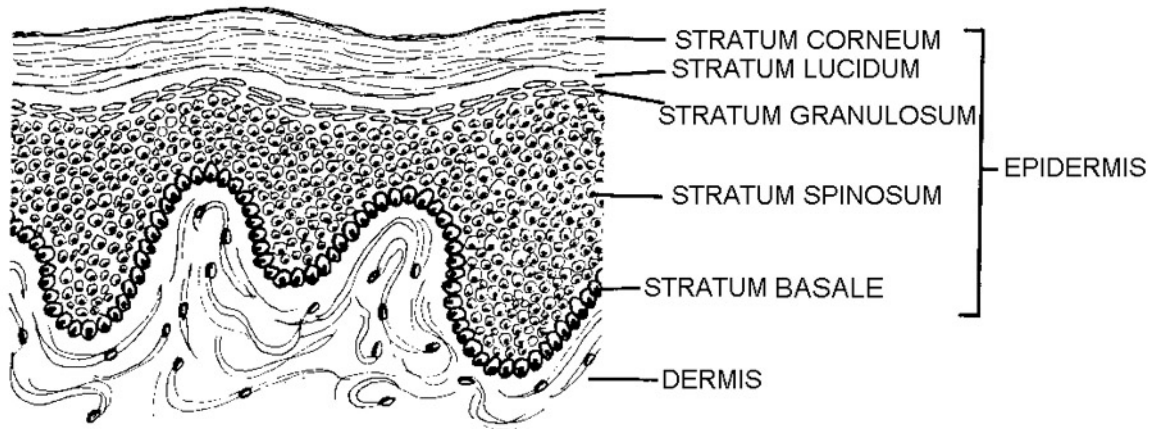
Figure 2-1. Three layers of skin tissue.

### *Epidermis*

The outer layer of the skin is the epidermis. The epidermis lacks blood vessels; however, the blood vessels of the dermis nourish the deeper layer of the epidermis. The epidermis also contains very few nerve endings.

The epidermis contains both living and dead cells. In most body areas, the epidermis contains three cellular layers. In the palms of the hands and soles of the feet, however, four layers can be found: stratum corneum, stratum granulosum, stratum spinosum, and stratum basale (figure 2-2).

Stratum corneum is the outermost layer of the epidermis, and contains mostly dead cells. These dead cells are constantly flaking off as they are replaced by nourished cells that push toward the surface from the inner layers. Stratum granulosum is the second layer of epidermis, which is beneath the stratum corneum. It contains only three to five layers of cells. In body areas where the epidermis contains only three layers, the stratum granulosum is missing. Stratum spinosum is the third layer of epidermis contains many layers of cells. Stratum basale is the fourth and deepest layer of the epidermis, also referred to as the “basal cell layer.”

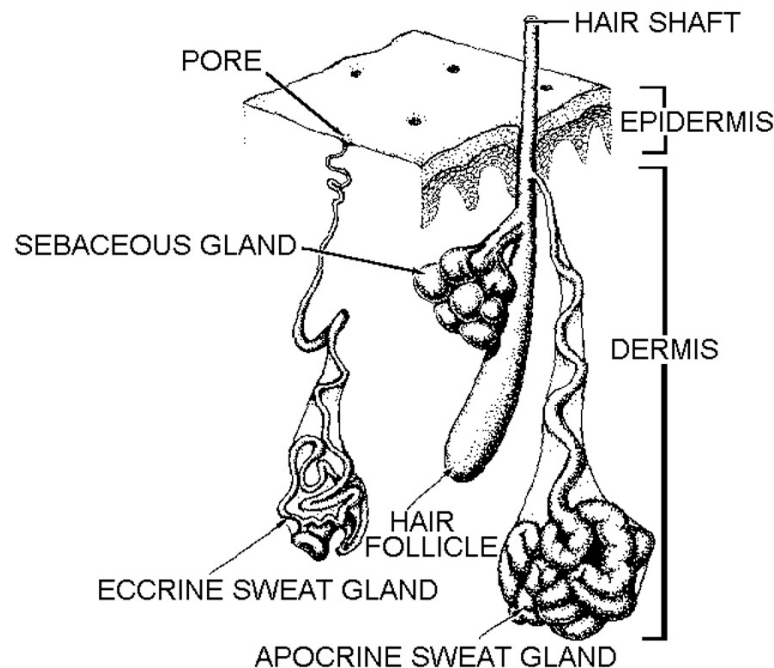


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Figure 2-2. Layers of the Epidermis.

### *Dermis*

The dermis is composed of connective tissue. This layer provides toughness and elasticity to the skin. The thickness of the dermis varies depending on the body area. Blood vessels, nerves, sweat glands, sebaceous glands and hair follicles can all be found in the dermis (fig.2-3).



B1F1-21

Figure 2-3. Dermis.

### *Subcutaneous layer*

Beneath the epidermis and dermis, the two main layers of the skin, lies the subcutaneous layer. This layer consists mainly of connective and adipose (fatty) tissue. Like the dermis, the thickness of the subcutaneous layer varies depending on the body area. The amount of adipose tissue also varies depending on an individual's nutritional status. The major blood vessels that support the integumentary system are located in the subcutaneous layer.

### Skin appendages

The skin has additional features called appendages. The four appendages are the hair follicles, nails, sweat glands and sebaceous glands.

#### Hair follicles

Hair is located on all surfaces of the skin with the exception of the palms of the hands, soles of the feet, lips and various reproductive organ surfaces. The amount of hair also varies depending on the body area. Some body regions normally contain very pronounced amounts of hair, while other areas (such as the anterior surface of the arms, the forehead and the posterior surface of the hands and feet) usually contain very fine amounts.

Hair development begins below the surface of the skin and extends into the dermis. The hair roots are nourished by blood vessels within the dermis. Hair shafts are composed mostly of dead epidermal cells. The shaft pushes upward through the epidermis and to the exterior skin surface.

#### Nails

Nails are located on the tips of the fingers and toes. Each nail consists of a nail plate and a nail bed (fig. 2-4). The plate is the visible exterior of the nail and the bed is the skin surface area that the plate lies on top of. The nail grows outward from the white area at the base called the *lunula*.

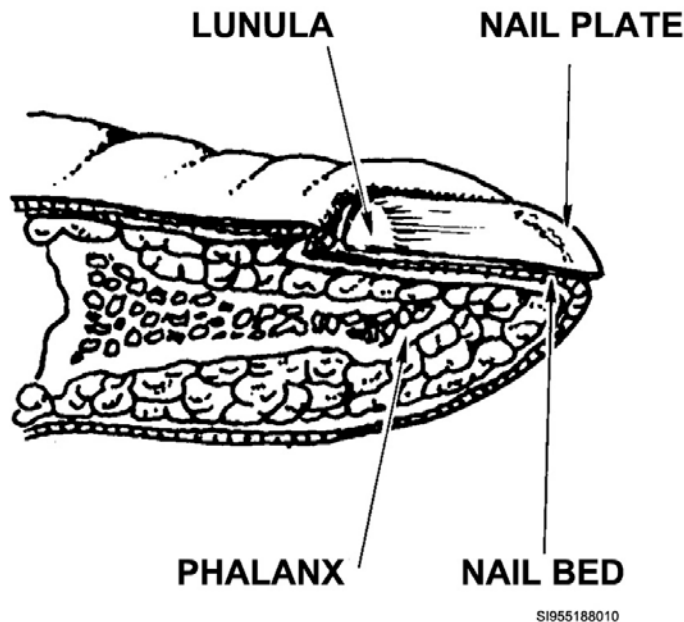


Figure 2-4. Nail.

#### Sweat glands

Sweat glands are located throughout the integumentary system; however, they are most prominent in the palms of the hands and soles of the feet. Each gland originates as a small coil in either the deeper portion of the dermis or the superficial layer of the subcutaneous tissue. Two main types of sweat glands can be found in the system—apocrine glands and eccrine glands.

Apocrine *glands* are usually connected to hair follicles and are stimulated by emotional stress. These types of sweat glands are also referred to as scent glands, as they typically produce an odor. Apocrine glands normally do not begin to function until a person becomes sexually mature at puberty. *Eccrine glands* are not connected to hair follicles. These glands extend to the outer skin surface through small openings in the epidermis called pores. Eccrine glands are stimulated by an elevation in body temperature and are most prominent on the back, neck and forehead.

### **Sebaceous glands**

Sebaceous glands are sometimes referred to as oil glands. They are located in all body areas except the palms and soles. Sebaceous glands are usually connected to hair follicles; however, they open directly to the skin surface in areas such as the outer corners of the mouth, the lips and on the surface of exterior reproductive organs. These glands secrete an oily substance called *sebum* directly into the hair follicles. The sebum keeps the hair and skin surface soft and virtually waterproof.

## **208. Physiology of the integumentary system**

The integumentary system provides three main physiological functions. This lesson discusses these functions, which are body temperature regulation, protection and external physical characteristics.

### **Body temperature regulation**

A primary function of the integumentary system is to regulate internal body temperature. The integumentary system works with the circulatory system to perform this function. Blood vessels dilate to permit an increase in blood flow to the body surface when external temperatures are high. This also stimulates an increase in sweating, which helps cool the body through evaporation. Lower external temperatures result in a constriction of vessels, enabling the body to retain heat.

### **Protection**

As a covering for the entire body, the skin provides protection in two main ways. The first way that the skin provides protection is by protecting against external damaging factors. The admission of bacteria and other foreign matter directly into the body is normally prevented by an intact skin surface. The skin also helps guard internal organs from injury. Additionally, the nerve endings in the skin serve to warn of factors that can be dangerous to a person, such as excessive heat, cold, pressure or pain. The *second* way skin provides protection is that it keeps the body from losing excessive internal water content.

### **External physical characteristics**

The external physical appearance of an individual is greatly attributed to the integumentary system. The most notable of these traits is skin color. The deepest layer of the epidermis contains cells known as *melanocytes*. Melanocytes produce a substance called *melanin*. The melanin serves two purposes—pigmentation (color) of the skin and protection against damaging ultraviolet rays of the sun. The ultraviolet ray protection is made possible by the melanin's ability to absorb light energy. Other skin traits that contribute to external physical characteristics include the amount of adipose tissue, hair amount and color and the strength and condition of the dermis. As elasticity and strength diminish with aging, the appearance of the skin tends to become more wrinkled.

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## **Self-Test Questions**

After you complete these questions, you may check your answers at the end of the unit.

### **207. Anatomy of the integumentary system**

1. What is the outermost layer of the epidermis?
2. What layer of the skin contains blood vessels, sweat glands, and hair follicles?
3. Hair shafts are composed mainly of what type of cells?



4. What type of sweat gland is usually connected to hair follicles?

5. What type of glands secrete sebum?

### **208. Physiology of the integumentary system**

1. What is one function of the integumentary system?
2. When external temperatures are high, what do blood vessels in the skin do? Why?
3. What substance is produced in the deepest layer of the epidermis to protect the skin against damage caused by ultraviolet rays from the sun?
4. How does aging affect the skin?

## **2-2. Anatomy and Physiology of the Musculoskeletal System**

The musculoskeletal system serves as the body's frame. It is actually a combination of two systems—the skeletal system and the muscular system. These two are discussed as a collective system because of their close relationship. This section addresses the anatomy of the entire musculoskeletal system. You will first read about the structure of the skeletal and muscular systems. Then, you will learn how these two systems work together to provide support and movement for the entire body.

### **209. Skeletal system**

The skeletal system includes all of the bones and joints of the body. In this lesson, you will learn about bone composition, classifications and terminology. Also, you will read about the actual skeletal structure of the body.

#### **Bone composition**

The main outermost portion of bones is composed of a tough tissue membrane called the *periosteum* (fig. 2-5). Beneath the outer layer lies the main portion of the entire bone. This area is referred to as *compact bone*. Compact bone is the strong portion of the bone that does not bend. The ends of the bones are covered with a layer of cartilage called *articular cartilage*. Bone ends contain very little compact bone. Instead, they mainly are composed of a spongy substance called *cancellous bone*.

Beneath the compact and cancellous bone is a hollow area called the *medullary cavity* (or medullary canal). This cavity is lined with a thin layer of cells called the *endosteum*; and it is filled with a soft substance called *marrow*. Nerves and blood vessels are also located within the medullary cavity.



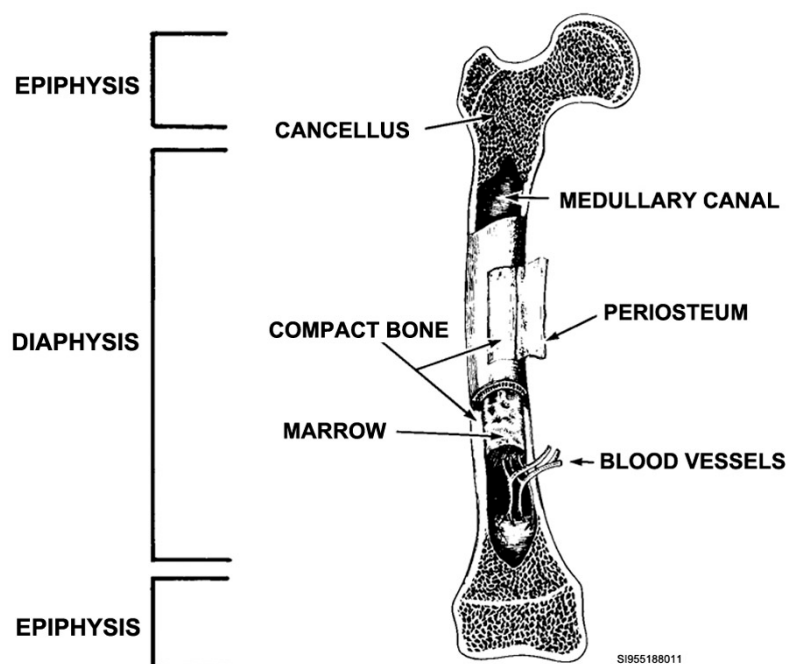


Figure 2-5. Bone composition.

### Bone classifications

There are four main classifications used to identify the bones of the body (fig.2-6):

1. Long bones have a central body called the *diaphysis*. The ends of long bones expand outward. This portion of the bone is called the *epiphysis*.
2. Short bones are compact and are approximately just as long as they are wide.
3. Flat bones are plate like and have a broad surface.
4. Irregular bones are found in various shapes and sizes. They are almost always connected to other bones.

A fifth classification, *round* or *sesamoid*, is used to describe only a few bones of the body. Sesamoid bones are small bones that are usually located within tendons where pressure is frequently applied. Most of the sesamoid bones lie near joints. The kneecap is an example of a round bone even though it is often triangular in appearance.

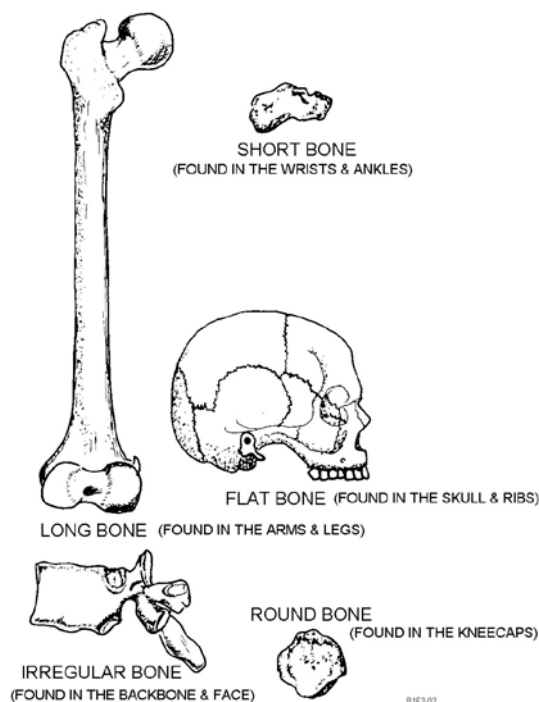


Figure 2-6. Bone classification.

### Bone terminology

Various terms are used to describe bone characteristics. A list of these common terms is included in the following table:

Term	Definition
<b>Articulate</b>	The joining of two or more bones.
<b>Condyle</b>	Rounded bone end that normally joins with another bone.
<b>Epicondyle</b>	A projection that extends beyond a condyle.
<b>Fissure</b>	A groove in a bone surface.
<b>Fontanel</b>	Soft spot between skull bones of infants that is covered with a membrane layer.
<b>Foramen</b>	An opening through a bone that serves as a passageway for blood vessels, nerves and/or ligaments.
<b>Fossa</b>	A deep depression in a bone.
<b>Joint</b>	A moveable location where two or more bones are connected.
<b>Process</b>	A projection that extends outward from a bone.
<b>Sinus</b>	A bone cavity.
<b>Suture</b>	The line where two bone surfaces are joined.
<b>Trochanter</b>	A large process of a bone.
<b>Tubercle</b>	A small, knoblike bone process.
<b>Tuberosity</b>	A medium-sized knoblike bone process.

### Skeletal structure of the body

The human body has an average of 206 bones. In areas where tendons are located, some people have more bones where other people have less. The entire skeleton is divided into two areas: the axial skeleton and the appendicular skeleton.

#### Axial skeleton

The axial skeleton contains the bones that support the head, neck and torso. The bones of the axial skeleton are found in one of four areas: the skull, hyoid, vertebral column and thoracic cage.

#### Skull

The cranium and facial bones make up the skull (fig. 2-7). There are 28 bones in the skull. Eight of them are interlocked along lines called *sutures* to make up the cranium. Thirteen bones unite to form the facial structure; six small bones are in the ear; and one bone, the mandible, is the moveable skull bone that is connected to the cranium by ligaments.

#### Hyoid bone

The hyoid bone is located between the mandible and larynx in the neck. It is not

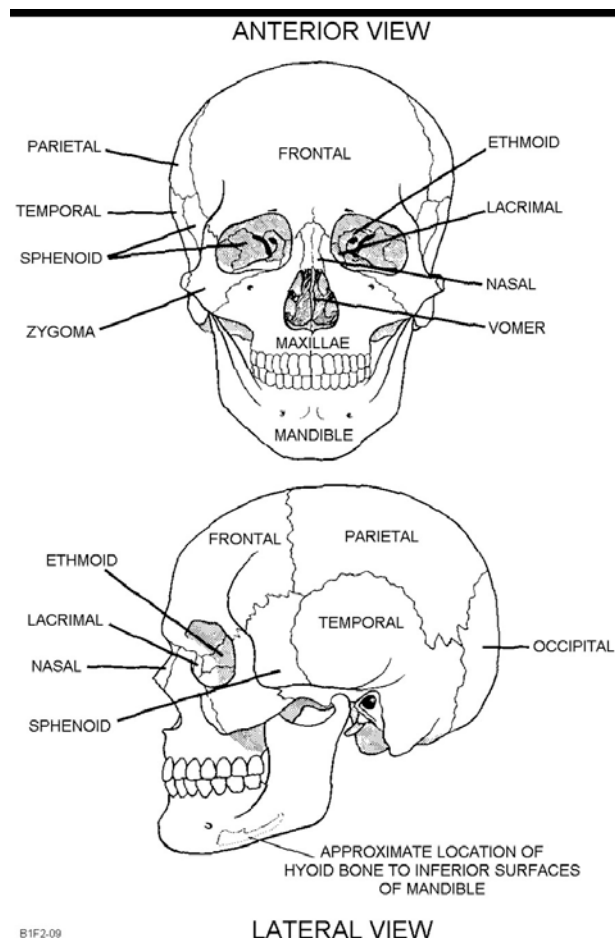


Figure 2-7. Skull.

attached to any other bone, but is held in position by muscles and ligaments.

### Vertebral column

The vertebral column (spine) is composed of 26 separate, irregular bones that are joined together by cartilaginous disks (fig. 2-8). The vertebral column is split into five separate regions: *cervical*, *thoracic*, *lumbar*, *sacrum* and *coccyx*. The cervical, thoracic and lumbar areas are composed of vertebrae that are attached to each other. At the distal end of the lumbar vertebrae, several bones are fused into a single structure called the “sacrum.” Attached to the sacrum is a final projection called the “coccyx” (tailbone).

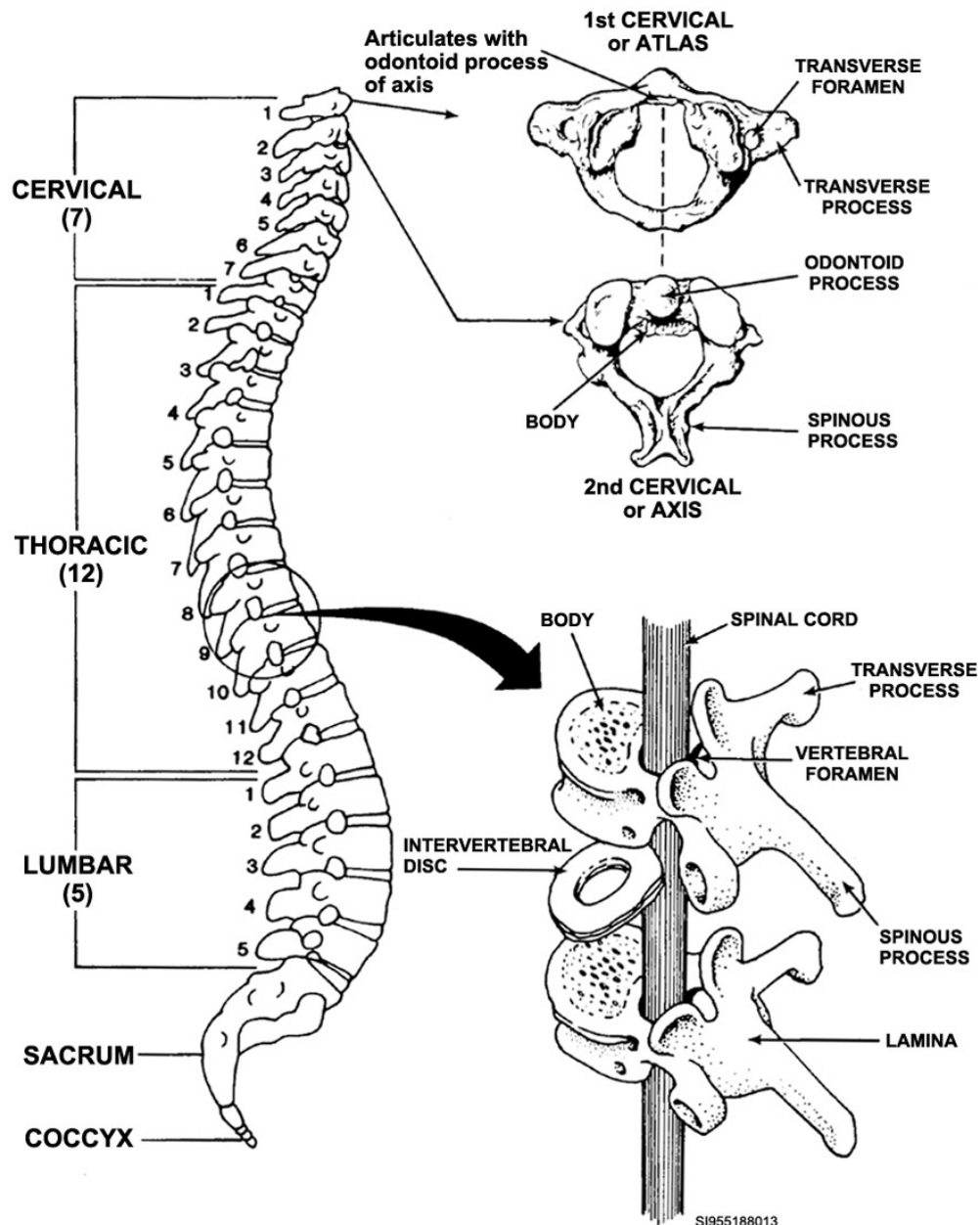


Figure 2-8. Vertebral Column.

### Thoracic cage

The chest, sides and upper back are enclosed by the thoracic cage (fig. 2-9). This protective structure consists of 12 pairs of ribs and the sternum. The ribs are flat bones. The first seven pairs attach

directly to the sternum. The next three pairs do not attach directly to the sternum, but rather, these three pairs are attached to the seventh rib on each side. The final two pairs of ribs are sometimes called *floating ribs* since their distal ends hang free in the thoracic cavity. The sternum or breastbone has a small inferior tip called the *xiphoid process*.

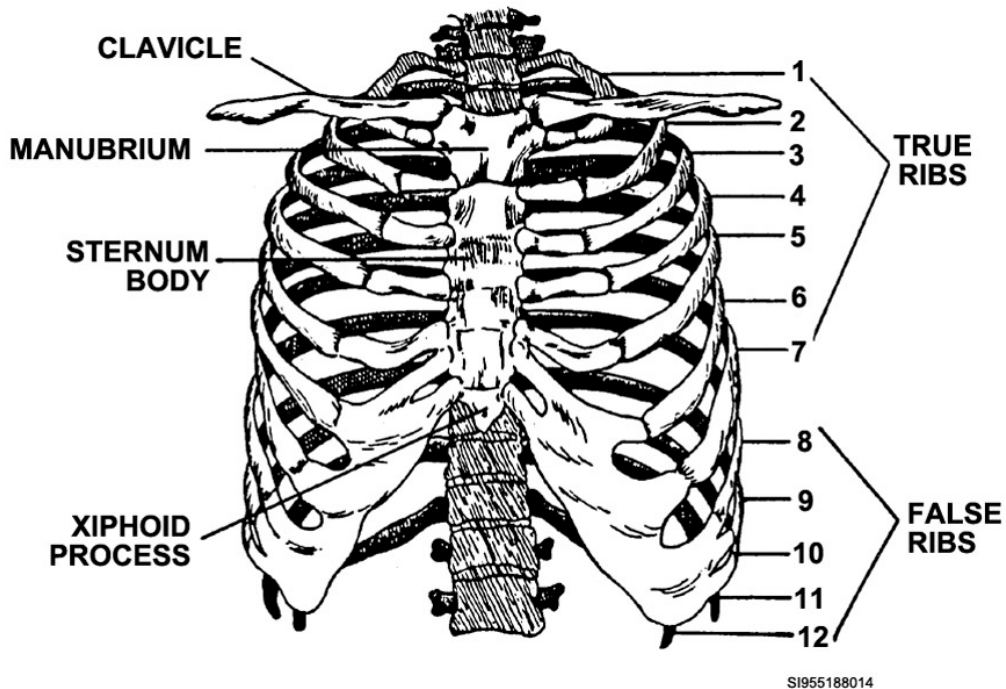


Figure 2-9. Thoracic cage.

### Appendicular skeleton

The second main division of the skeletal system consists of the bones of the appendicular skeleton. The appendicular skeleton includes the bones of the upper and lower extremities, as well as the bones that join the limbs to the axial skeleton.

### Upper extremities

The upper bone of each arm is the humerus (fig. 2-10). Two bones lie parallel to each other in the lower arm. The radius is the lateral bone and the ulna is the medial bone. The humerus, radius and ulna all join at the midpoint of the arm to form the elbow. Distal to the radius and ulna are the short bones of the wrist, hand and fingers. There are eight carpal bones that compose the wrist. The metacarpals are the bones of the hand and the phalanges are the bones of the fingers (figure 2-11).

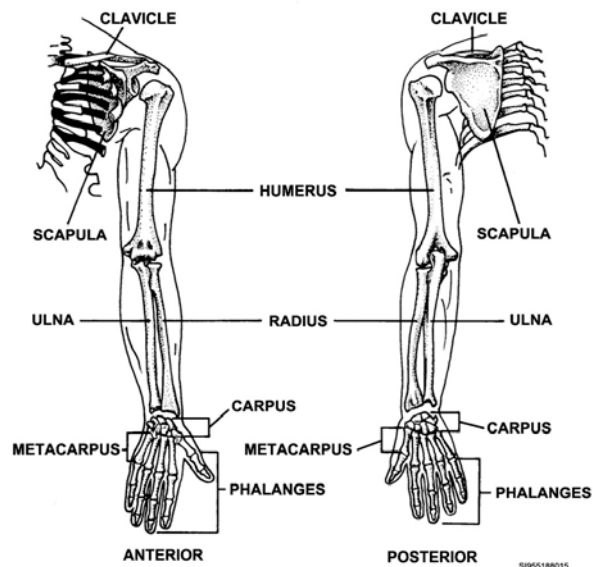
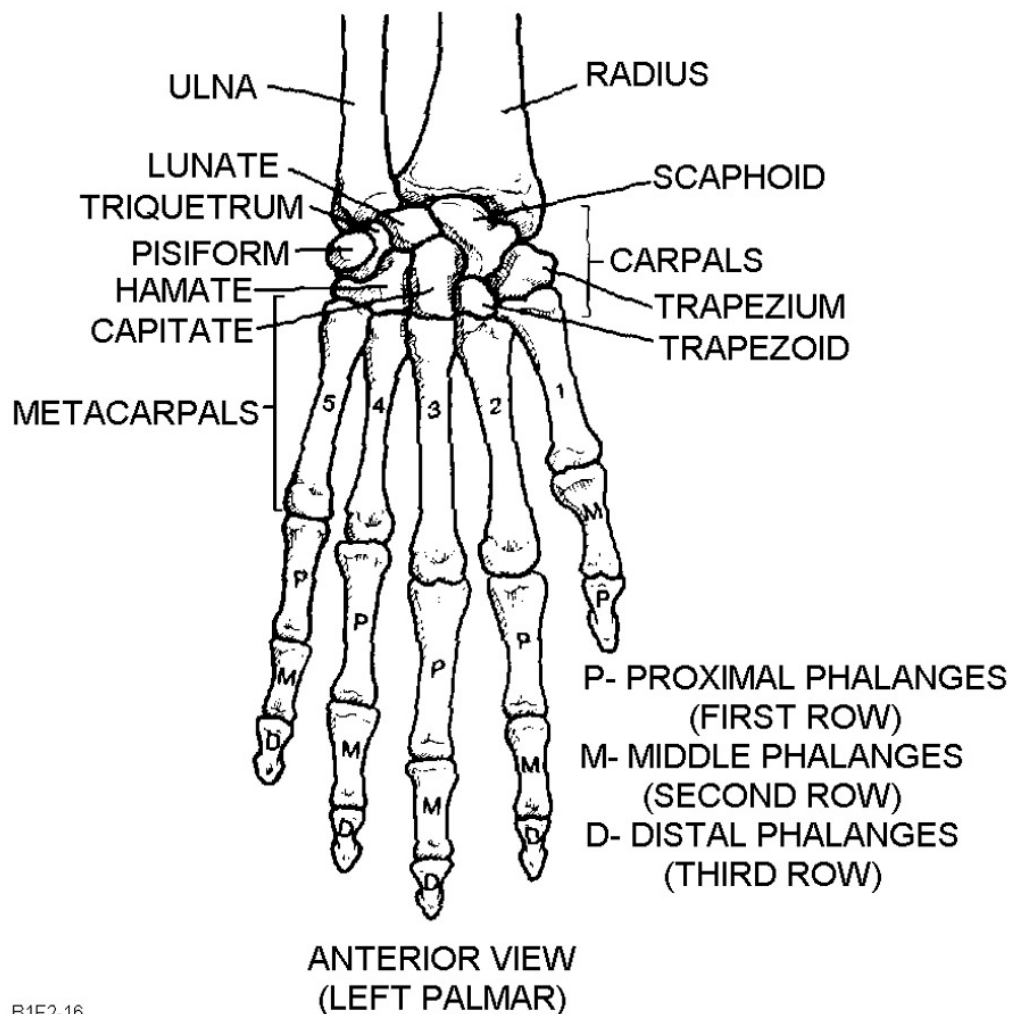


Figure 2-10. Upper Extremity.



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Figure 2-11. Bones of the hand.

### *Pectoral girdle*

The arms are connected to the axial skeleton by the pectoral girdle. This girdle includes the scapula (flat bones referred to as shoulder blades) and the clavicle or collarbone.

### *Lower extremities*

The legs contain three long bones (fig. 2-12). The femur is the upper leg bone—the largest bone in the body. The two lower leg bones are the tibia and fibula. The tibia (shinbone) is the larger of the two and lies anterior to the smaller fibula. The three leg bones join at the midpoint of the leg to form the knee joint. A triangular-shaped bone, called the *patella*, lies over the anterior portion of the knee joint to form the kneecap. Seven short bones, called *tarsals*, join together to form the ankle. The metatarsals are the short bones of the foot and, like the fingers, phalanges are the bones of the toes (figure 2-13).

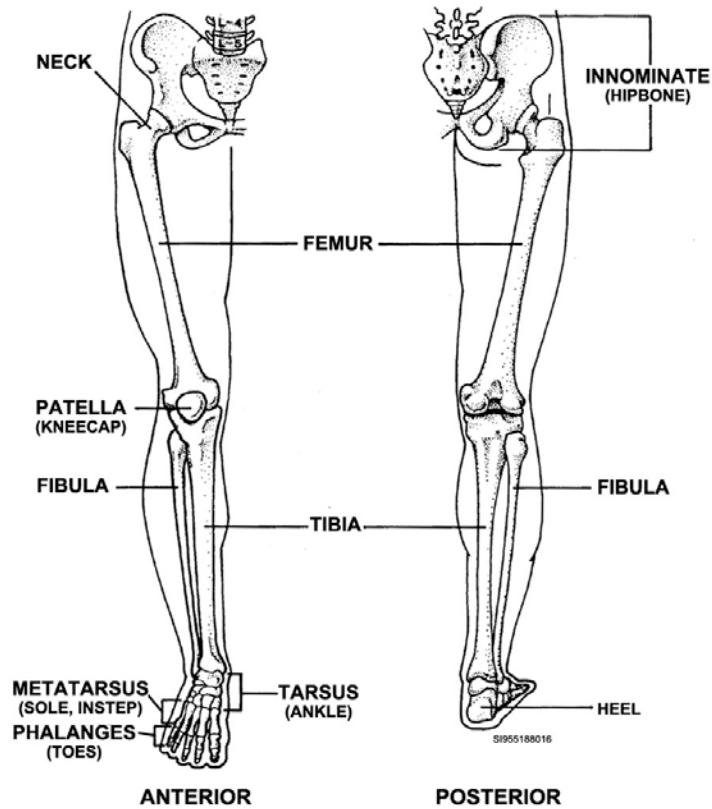


Figure 2-12. Lower Extremity.

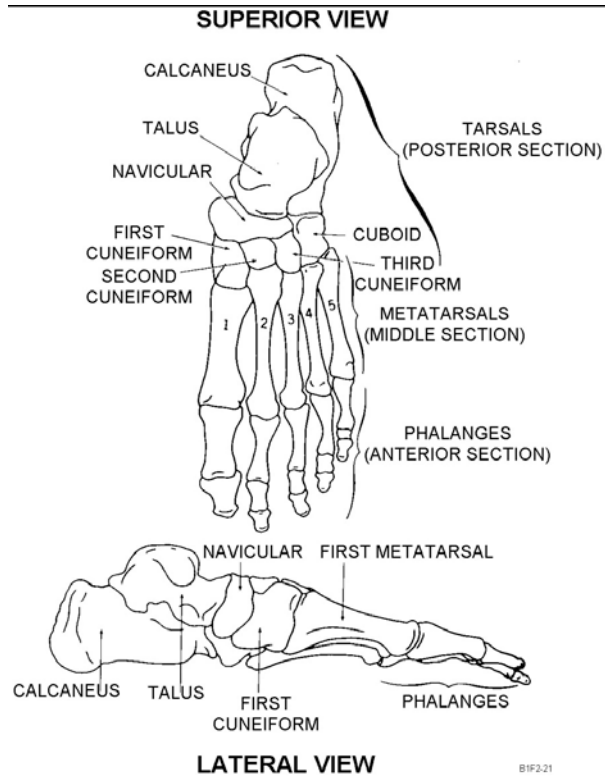


Figure 2-13. Bones of the feet.



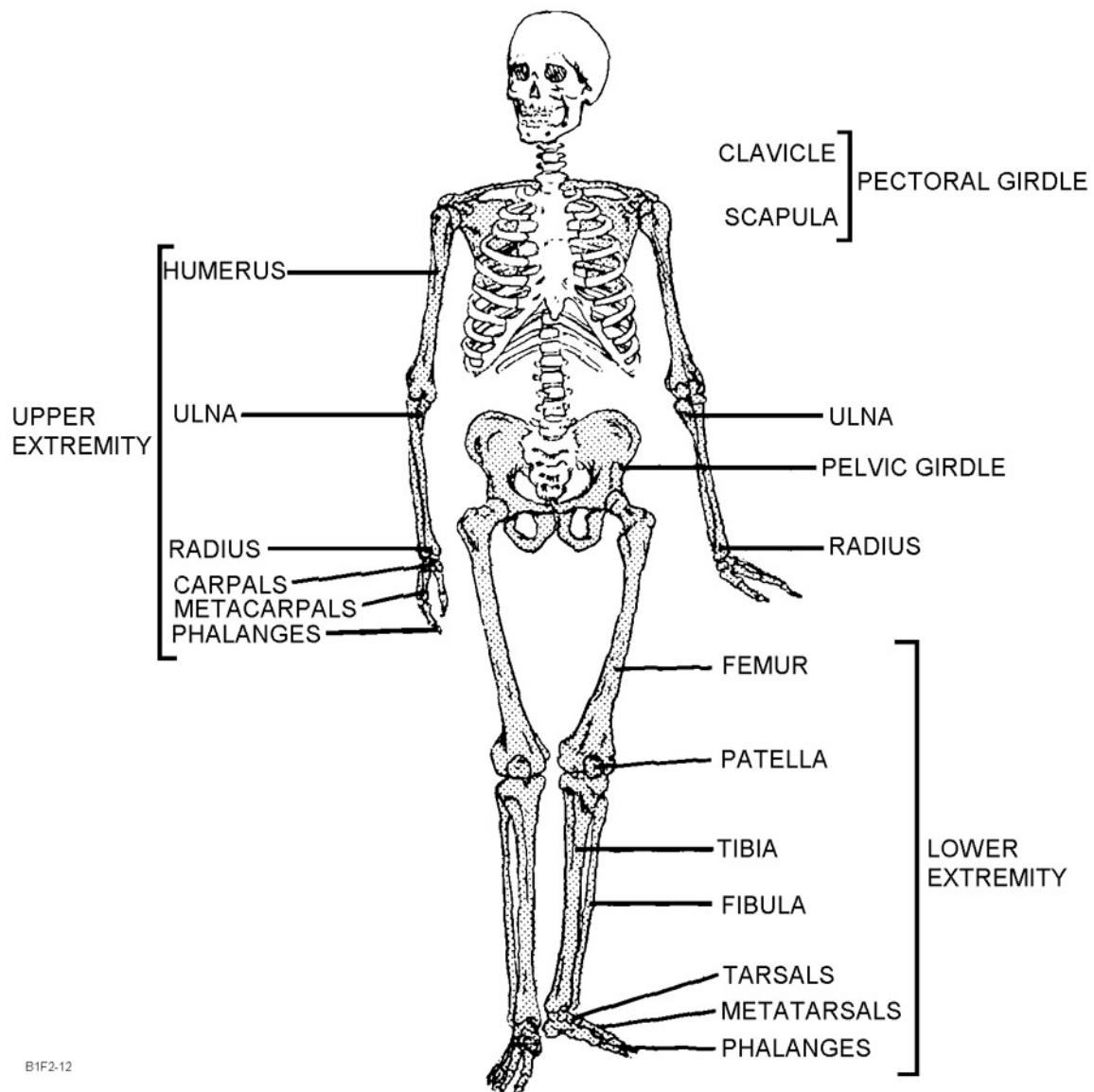
### Pelvic girdle

The legs are connected to the axial skeleton by the pelvic girdle. This girdle contains two flat coxal bones that join to form the pelvis. Each coxal bone has three fused parts: the *ilium*, *ischium* and *pubis*. The following tables contain lists of each of the bones in the human body (fig. 2-14):

Axial Skeleton			
Area	Division	Bone	Number
Skull	Cranial	Frontal	1
		Parietal	2
		Occipital	1
		Temporal	2
		Sphenoid	1
		Ethmoid	1
	Facial	Maxilla	2
		Palatine	2
		Zygomatic	2
		Lacrimal	2
		Nasal	2
		Vomer	1
		Inferior nasal concha	2
	Middle ear	Malleus	2
		Incus	2
		Stapes	2
	Lower jaw	Mandible	1
Neck	n/a	Hyoid	1
Vertebral column	Cervical	Cervical vertebrae	7
	Thoracic	Thoracic vertebrae	12
	Lumbar	Lumbar vertebrae	5
	Sacrum	Sacrum	1
	Coccyx	Coccyx	1
Thoracic cage	n/a	Ribs	24
	n/a	Sternum	1

Appendicular Skeleton			
Area	Division	Bone	Number
Upper extremities	Upper arm	Humerus	2
	Lower arm	Radius	2
		Ulna	2
	Wrist	Carpals	16
	Hand	Metacarpals	10
	Fingers	Phalanges	28
Pectoral girdle	Shoulder blades	Scapula	2
	Collarbone	Clavicle	2

Appendicular Skeleton			
Area	Division	Bone	Number
Lower extremities	Upper leg	Femur	2
	Kneecap	Patella	2
	Lower leg	Tibia	2
		Fibula	2
	Ankle	Tarsals	14
	Foot	Metatarsals	10
	Toes	Phalanges	28
Pelvic girdle	Pelvis	Coxal	2



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Figure 2-14. Bones of the body.



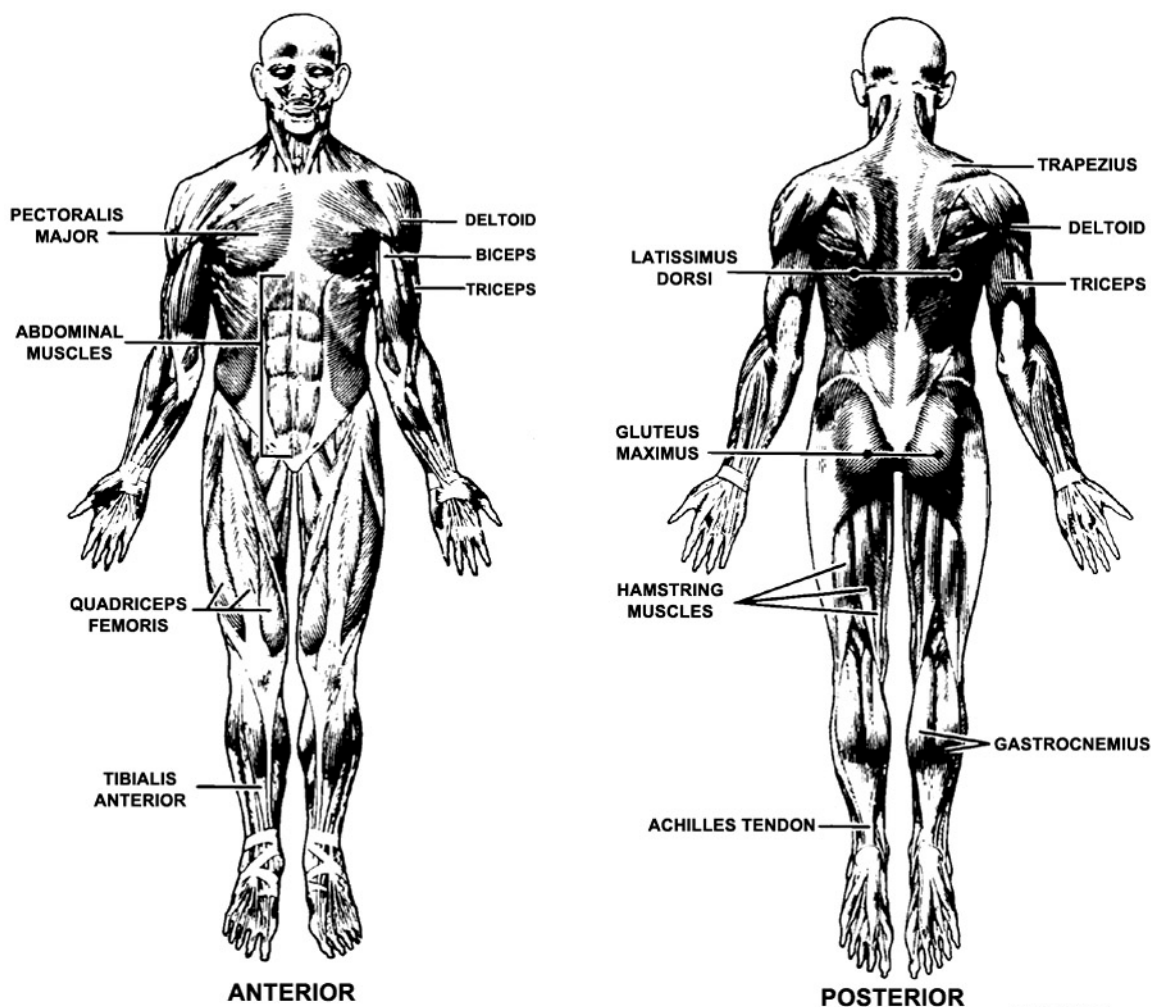
## 210. Muscular system

The muscles of the body work with the skeletal system to provide movement and support. The body contains more than 500 muscles, some of which are under voluntary control, while some are controlled involuntarily. There are three types of muscles: *skeletal*, *smooth* and *cardiac*.

### Skeletal muscles

Skeletal muscles are voluntary muscles composed of various layers of tissue. This type of muscle is called striated, due to its string-like appearance. The outermost layer that surrounds the actual muscle and attaches it to bone surfaces is called the *fascia*. Where skeletal muscles are attached to bones, the fascia extends outward to form a cord-like attachment called a *tendon*. Tendon fibers connect to the periosteum of bones. In some locations, fibrous sheets called *aponeuroses*, serve to attach muscles to each other.

Beneath the fascia lies the outer surface of the muscle itself. This layer is called the *epimysium*. Below this layer is the *perimysium*, which separates the actual muscle into small sections called *fascicles*. The fascicles are covered with a thin layer called the *endomysium*. Figure 2-15 shows both of the major anterior and posterior muscle groups of the body and figure 2-16 details the major muscles of the face.



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Figure 2-15. Major Muscles group.

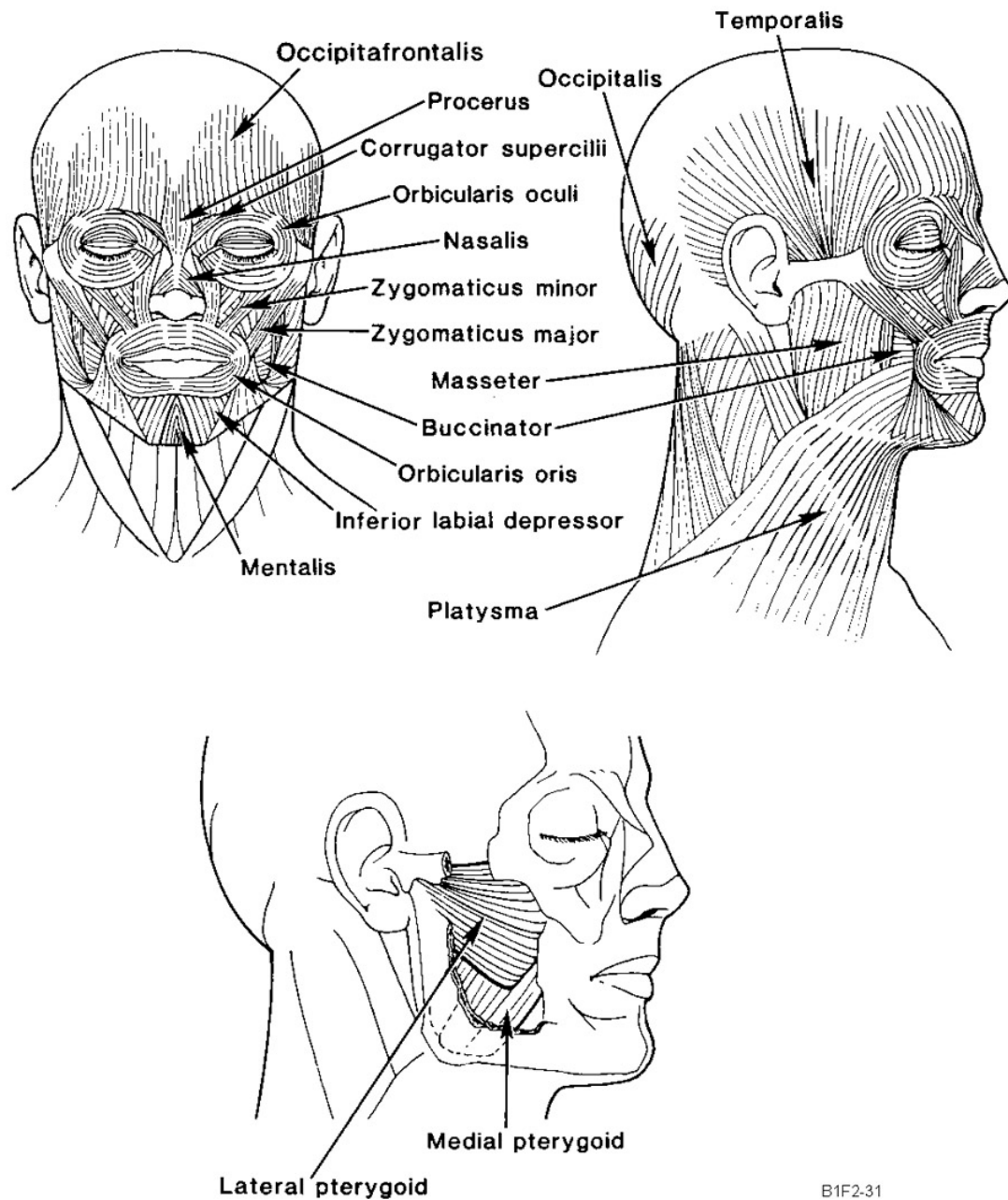


Figure 2-16. Facial muscles.

### Smooth muscles

The smooth muscles of the body have a different structure than skeletal muscles. This type of muscle is found in the walls of both hollow and visceral organs. Smooth muscles are under involuntary control. There are two major types of smooth muscles: *multiunit* and *visceral*.

#### *Multiunit smooth muscles*

This type of smooth muscle is found in the walls of blood vessels and in the irises of the eyes. Multiunit smooth muscles are constructed in separate fibers instead of sheets.

### Visceral smooth muscles

Visceral muscles are sheets of cells that lie very close to each other. This type of muscle is the more common of the two smooth muscle types and can be found in the walls of hollow organs, such as the stomach, bladder, intestines and uterus.

### Cardiac muscle

Cardiac muscle is only found in the heart. Like skeletal muscle, it's basically striated. The structure of cardiac muscle permits the unique action necessary for heart function.

## 211. Physiology of the musculoskeletal system

The bones and muscles of the body work to perform important human body functions. These physiological functions include support for the entire body, movement, protection of vital organs, heat production and blood cell production.

### Support

Bones provide a framework for the body. The entire body is supported in a manner that permits weightbearing, due to the structure of the musculoskeletal system.

### Movement

In addition to support, the musculoskeletal system provides movement to the human body. Body movement is possible because of two factors: bone joints and muscle action.

### Joints

The body has three classifications of joints, each named according to the type of tissue that the joint contains. These classifications are *fibrous*, *cartilaginous* and *synovial joints*. There are three types of fibrous joints, two types of cartilaginous joints and six types of synovial joints. The following tables provide information on the first two classifications: fibrous and cartilaginous joints.

Fibrous Joints		
Type	Characteristics	Examples
Syndesmosis	Minimal to no movement. Bones are joined by a thin layer of connective tissue.	Distal end of the tibia and fibula.
Suture	No movement.	Only where flat bones of the skull unite.
Gomphosis	Cone-shaped bony process that is "plugged into" a bone socket.	Root of tooth embedded in a socket in the jaw.

Cartilaginous Joints		
Type	Characteristics	Examples
Synchondrosis	Bones united by a band of cartilage. Temporary joint that disappears with the growth process. Cartilage eventually converts into bone.	Some long bones in persons until approximately age 25 at the oldest. Union of the sternum and first rib.
Symphysis	Limited movement. Pad of fibrocartilage between bones.	Symphysis pubis joint that joins the pubic bones. Intervertebral disks that separate spinal vertebrae.

Most joints of the body are synovial joints. A synovial joint has a more complex structure than fibrous or cartilaginous joints.

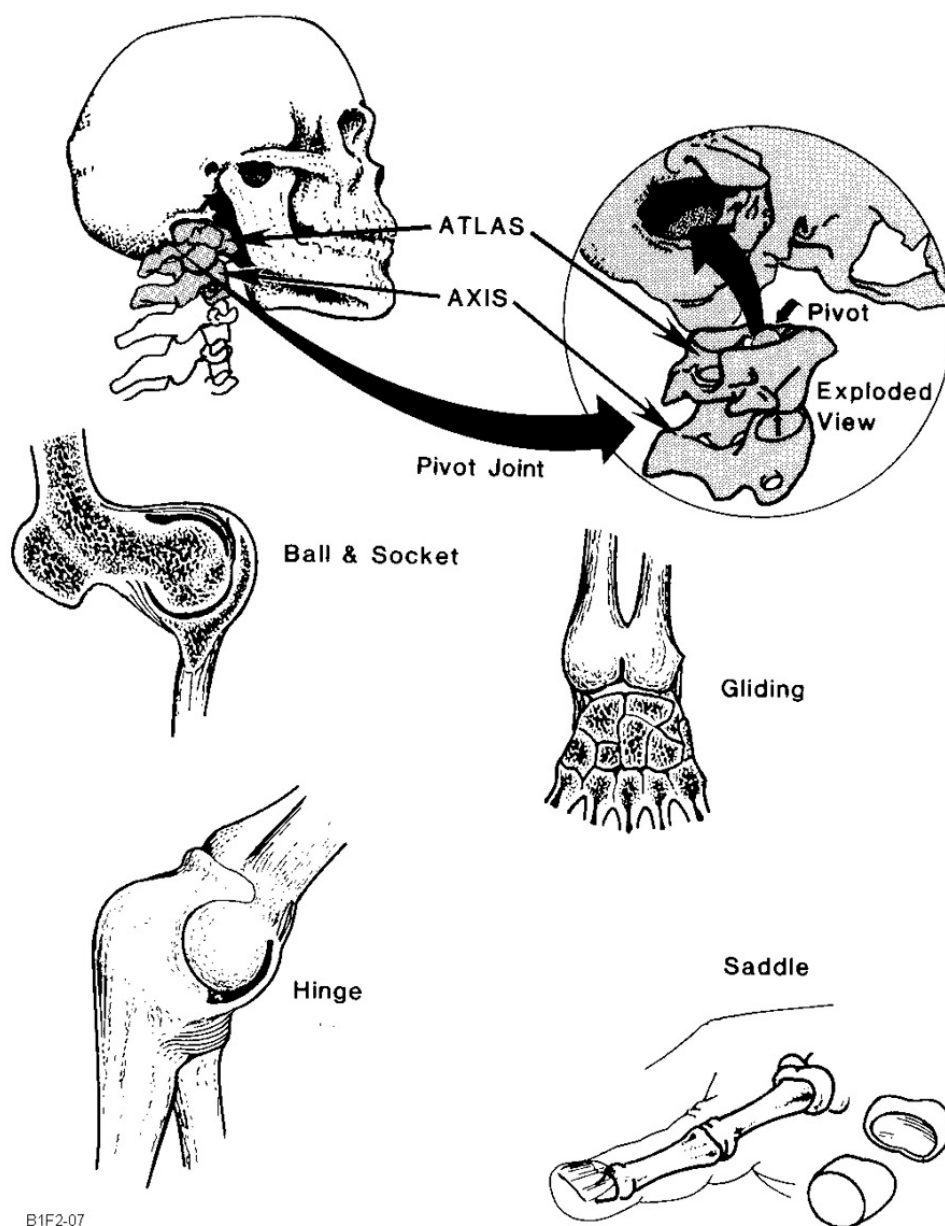
The ends of the bones connected by a synovial joint are covered with a thin layer called *articular cartilage*. This cartilage acts to prevent wear and excessive friction during movement. Two layers of connective tissue called the joint capsule hold the bones together. The outer layer encloses the entire joint. The inner layer called the *synovial membrane* is a very thin membrane lining that secretes a clear fluid into the joint called *synovial fluid*. The fluid acts as both a joint lubricant and as a nutrient supplier for the cartilage within the joint. The following table provides information on the six types of synovial joints found in the body (figure 2-17 through 2-22).

Synovial Joints		
Type	Characteristics	Examples
Ball and socket	Ball-shaped end of one bone fits into the socket-shaped end of another bone. Rotational movement in all directions is possible.	Shoulders Hips
Hinge	Rounded convex surface of one bone end fits into the concave end of another bone. Movement in one direction only is possible.	Elbows Fingers Toes
Pivot	Cylinder-shaped end of one bone fits inside the ring-shaped end of another bone. Rotational movement.	Proximal ends of the radius and ulna. Neck (turning the head from side-to-side).
Gliding	Bone surfaces that are either almost flat or slightly curved connect with each other. Sliding and twisting movement is possible.	Wrists Ankles
Condylloid	Oval-shaped end of one bone fits inside the curved end of another bone. Possible to move in most directions except rotational.	Finger knuckles
Saddle	Combined concave and convex (wavy) bone ends are joined. Varieties of movements are possible.	Thumb where it joins with the hand

### **Muscle action**

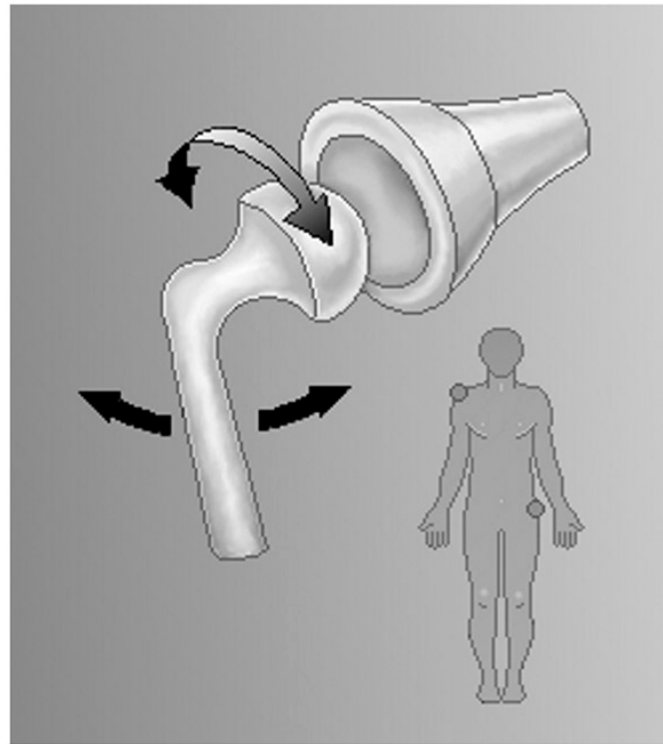
Muscles play a vital role in body movement through their ability to contract and relax.

Neurotransmitters of the nervous system stimulate muscle action. As mentioned previously, the action can be of either a voluntary or involuntary nature.



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Figure 2-17. Types of joints.



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Figure 2-18. Ball and socket joint.

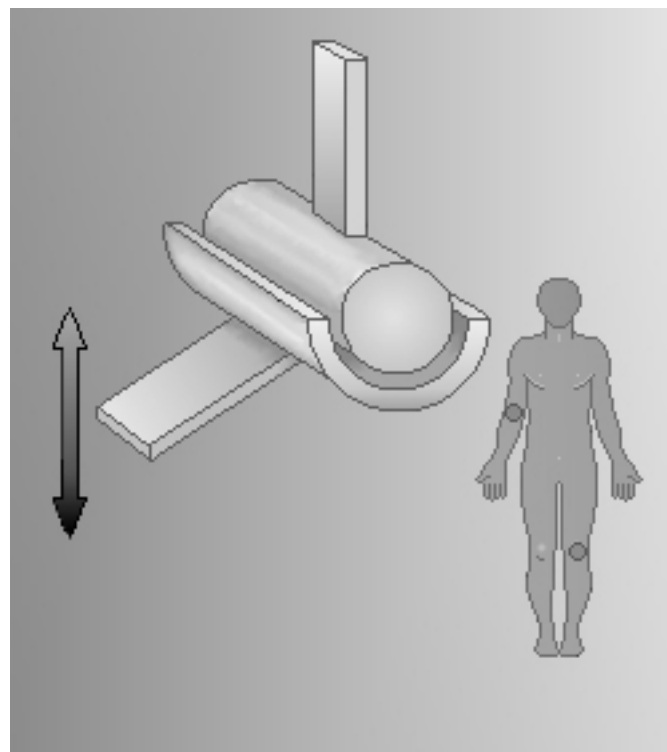
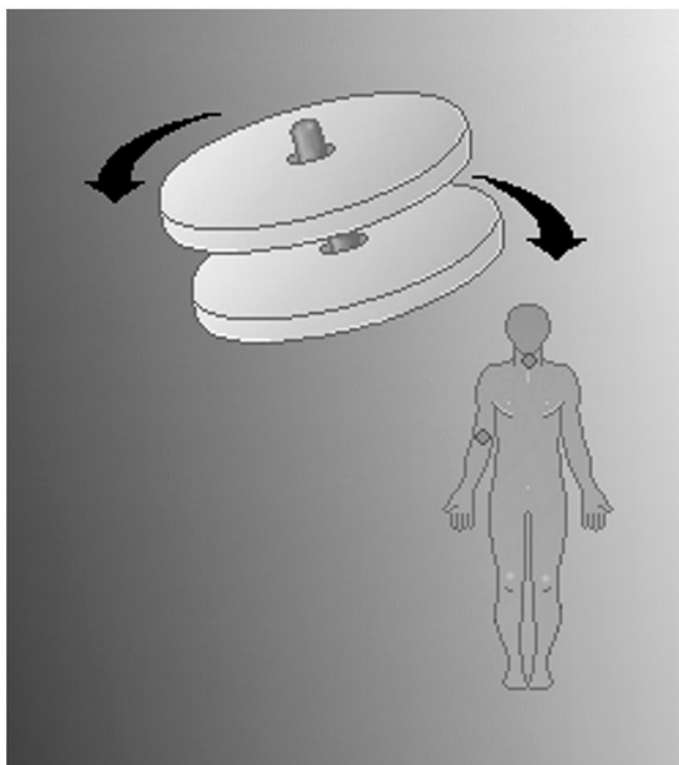
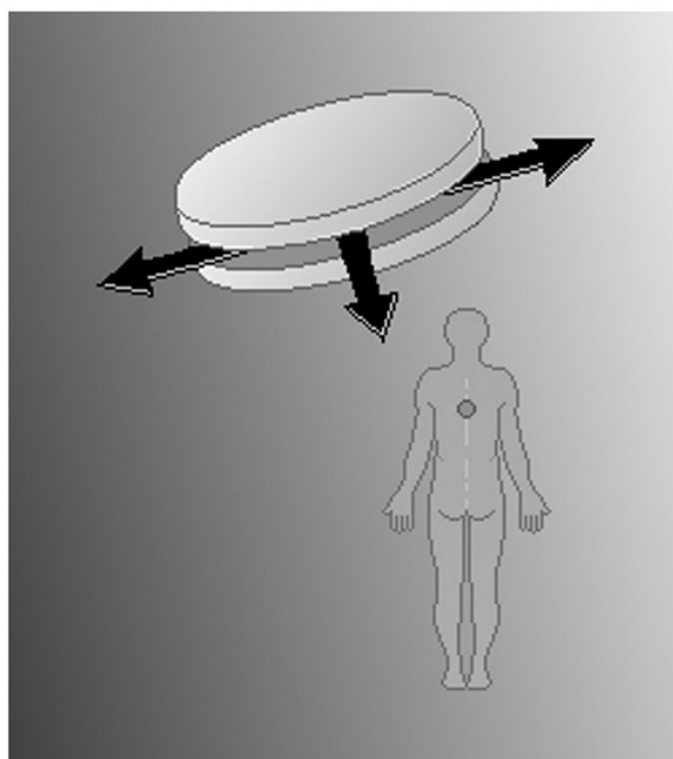


Figure 2-19. Hinge joint.



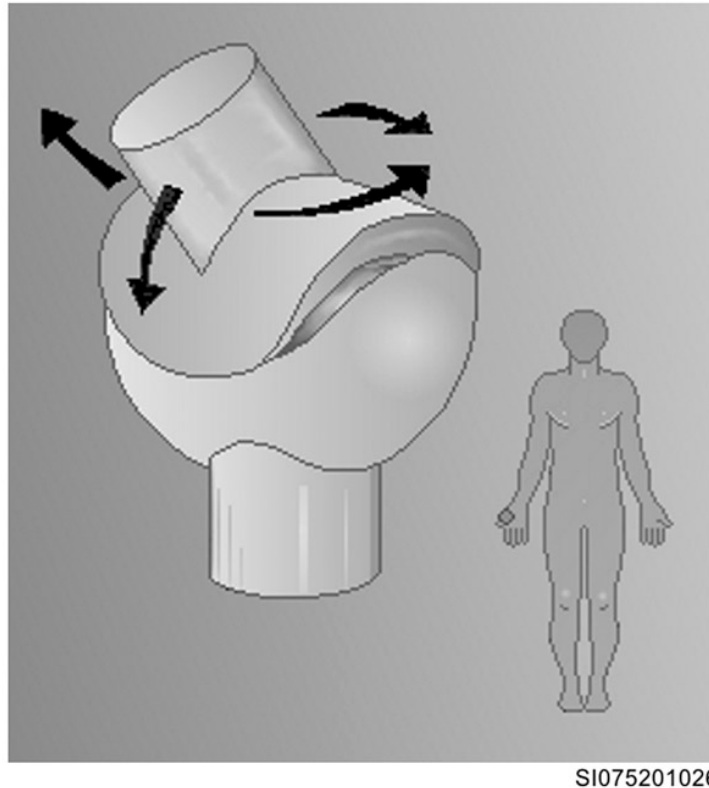
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Figure 2-20. Pivot joint.



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Figure 2-21. Gliding joint.



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Figure 2-22. Saddle joint.

### Protection

The vital organs of the body are protected by the musculoskeletal system, particularly by the bones. Examples include the skull, which protects the brain; the thoracic cage, which protects organs within the chest and upper abdomen; the vertebral column, which protects the spinal cord; and the pelvic bones, which protect lower abdominal structures. Additionally, the bones of the extremities protect the blood vessels and nerves found in the arms and legs.

### Heat production

Muscles serve a major physiological purpose in the production and release of excessive body heat. This is possible, due to the large content of muscle tissue in the body. When muscles are active, heat is released. An example of this action is the shivering that occurs when a person is very cold. Excessive heat is released when the hypothalamus in the brain detects an excessive internal body temperature. This occurs by a stimulus that causes muscles within the walls of blood vessels to relax, thereby making the release of heat to the outside of the body possible.

### Blood cell production

The process of blood cell formation is referred to as *hematopoiesis*. The bones of the skeletal system play an important role in blood cell production. A soft mass of tissue called *marrow* is found within the medullary cavities of some bones. Marrow is essential to the production of new blood cells. There are two types of marrow: red and yellow. Red marrow serves to assist in the formation of erythrocytes, leukocytes and thrombocytes in infants and children. This type of marrow is red because of the hemoglobin content of the erythrocytes.

As a person ages, much of the red marrow is gradually replaced by yellow marrow. Yellow marrow serves mostly as a fat storage tissue and does not play a major role in blood cell production. Instead, as a person ages, the process of blood cell production is gradually transferred to the liver and spleen.



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## Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

### 209. Skeletal system

1. What is the outermost portion of a bone called?
2. What is the main portion of a bone called?
3. What is a condyle?

### 210. Muscular system

1. How many muscles are in the body?
2. What is the outer surface of a muscle called?
3. What type of muscle is found in the walls of blood vessels?

### 211. Physiology of the musculoskeletal system

1. What type of joint is a suture?
2. What type of joint is a condyloid?
3. What is "hematopoiesis"?

## 2-3. Anatomy and Physiology of the Circulatory System

The circulatory system is one of the most vital systems for sustaining life. The major functions of this system are to transport oxygen and nutrients to all parts of the body and to provide a means for the removal of waste products. It is a constantly working system that can never stop functioning if it is to support life. Closely related to the circulatory system is the lymphatic system. This unit focuses on the circulatory system and its relationship with the lymphatic system.

It is important that everyone in the medical field has knowledge of the components of the circulatory system and how it functions to sustain life. In the next couple of lessons we will discuss the heart,

blood and blood vessels. After reading these lessons, perhaps you will feel compelled to learn more about the heart and how it affects all of the other systems in the human body.

## **212. Anatomy of the circulatory system**

This lesson focuses on the three main components of the circulatory system: heart, blood vessels and blood. Together, the heart and blood vessels are sometimes referred to as the cardiovascular system. The heart (fig. 2-23) is a hollow, muscular organ that lies to the left side of the center of the chest in an area of the thorax known as the *mediastinum*. The lungs are located lateral to the heart; and the sternum, ribs and thoracic vertebrae provide protection to the heart.

### **Heart structure**

Three layers make up the structure of the heart:

1. The outer layer is the *pericardium*, a thin sac covering the heart muscle.
2. The second layer is the *myocardium*, which is the thick, muscular portion of the heart.
3. The *endocardium* is the thin membrane that lines the inner surface of the heart muscle.

The heart is divided into two upper and two lower chambers. The two upper chambers are referred to as the *atria*; and the two lower chambers are the *ventricles*. Since the function of the left side of the heart is different than that of the right side, the atria and ventricles are referred to separately as the right atrium, right ventricle, left atrium and left ventricle. The right and left sides of the heart are divided by a wall called the *septum*.

Within the chambers of the heart are four valves that ensure a constant one-way flow of blood. The valve between the left atrium and left ventricle is the *mitral (bicuspid) valve*. This valve is made of two flaps, or cusps—hence the name bicuspid. The valve between the right atrium and right ventricle is called the *tricuspid valve*. This valve is composed of three flaps. A third valve called the *aortic valve* is located between the left ventricle and the aorta. The fourth valve leads from the right ventricle to the pulmonary artery. This valve is called the *pulmonary valve*.

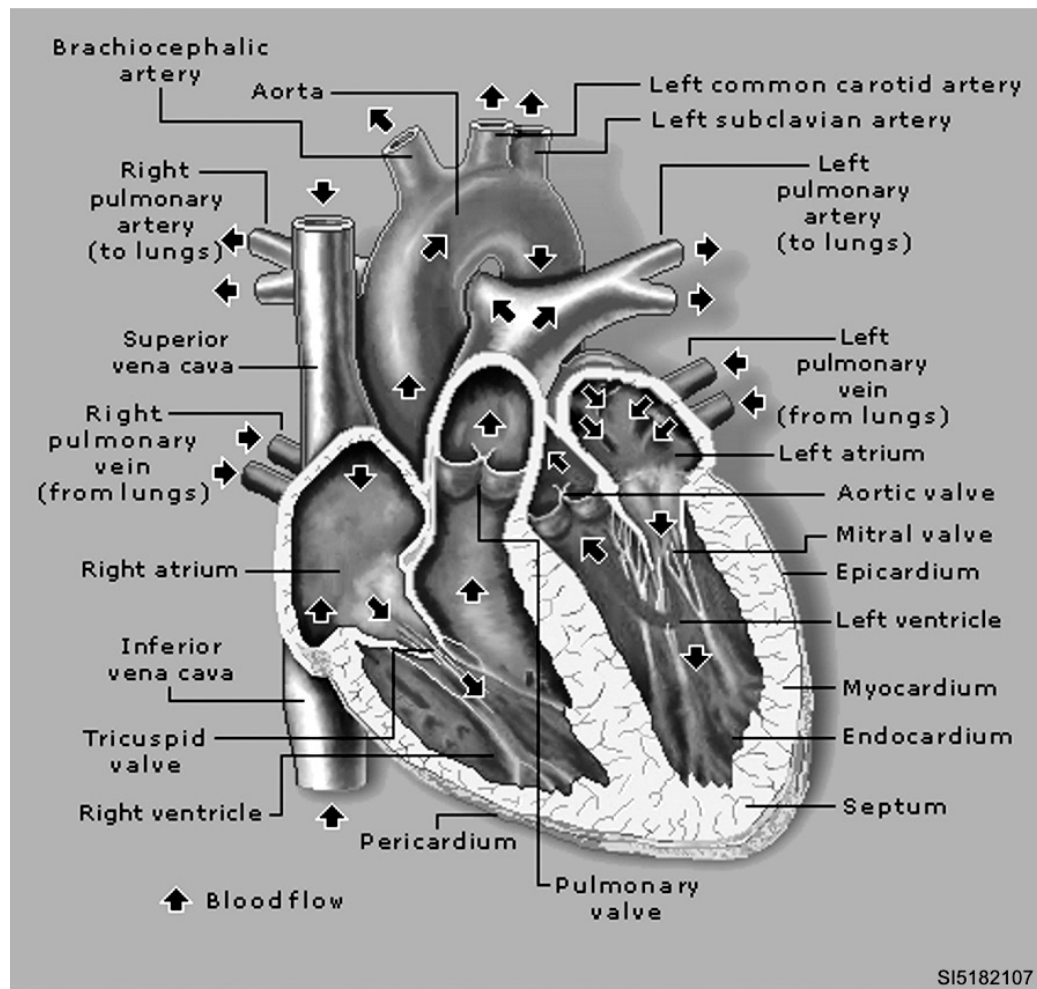


Figure 2-23. Heart.

### Blood vessels

Blood vessels are hollow pathways for blood to travel through. Vessels are divided into three types: arteries, capillaries and veins. Arteries are further divided into arterioles and veins are further divided into venules.

### Arteries

Arteries are elastic vessels that are strong enough to maintain blood under a relatively high pressure. The aorta is the largest artery in the body. It extends from the left ventricle of the heart and branches into the body's main arteries. The major arteries branch into smaller vessels called arterioles, which connect to capillaries (fig. 2-24).

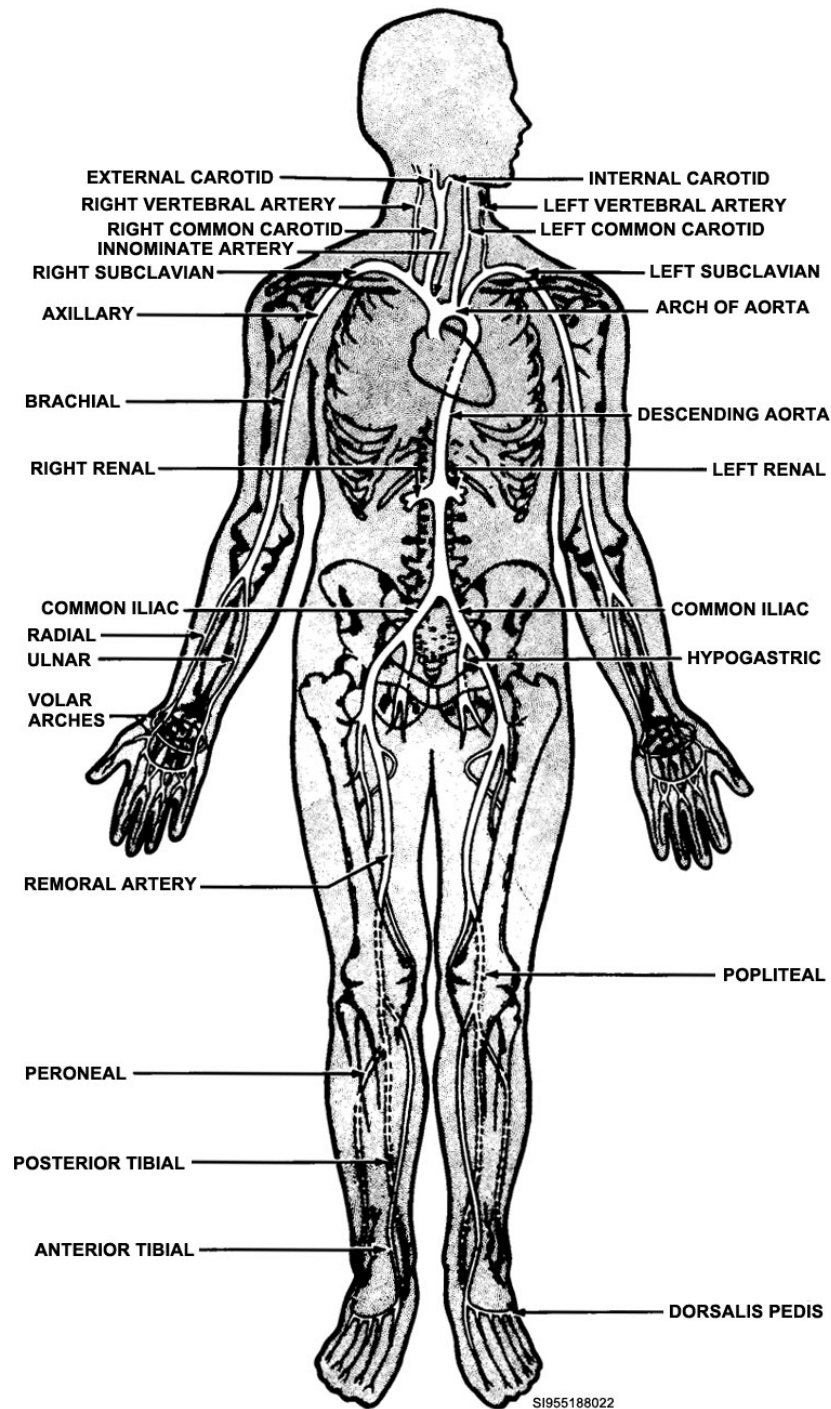


Figure 2-24. Arteries.

### Capillaries

Capillaries are the smallest blood vessels. They are composed of a very thin membrane that permits the exchange of nutrients and waste products with the body's cells. Capillaries then join with venules, where the pathway back to the heart begins.

## Veins

The construction of veins is similar to that of the arteries, with the exception that they are not as strong in elasticity. The two largest veins in the body are the *superior vena cava* and the *inferior vena cava*, both of which connect to the right atrium. Venules are the smallest branches of the major veins. They carry blood from the capillaries to the veins (fig. 2-25).

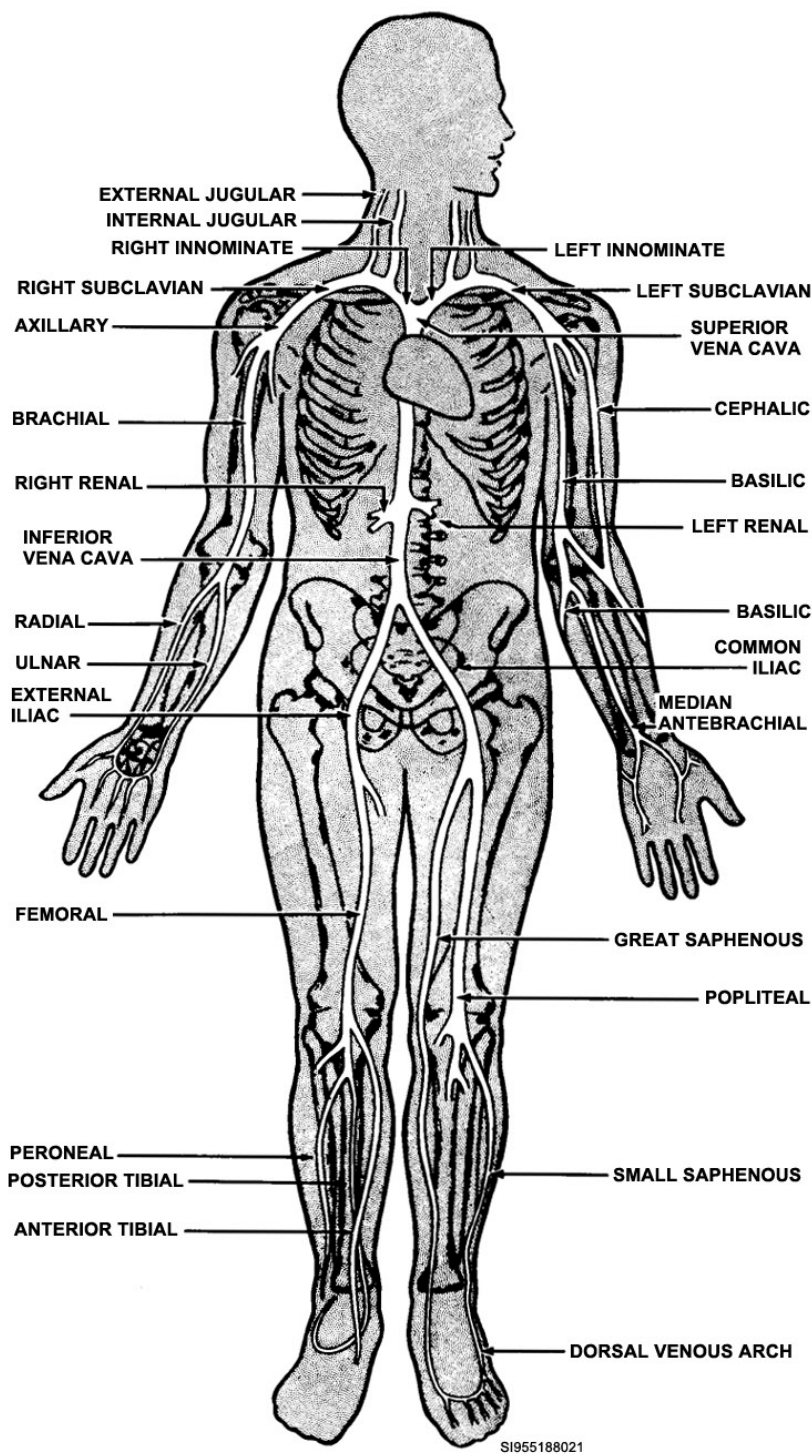


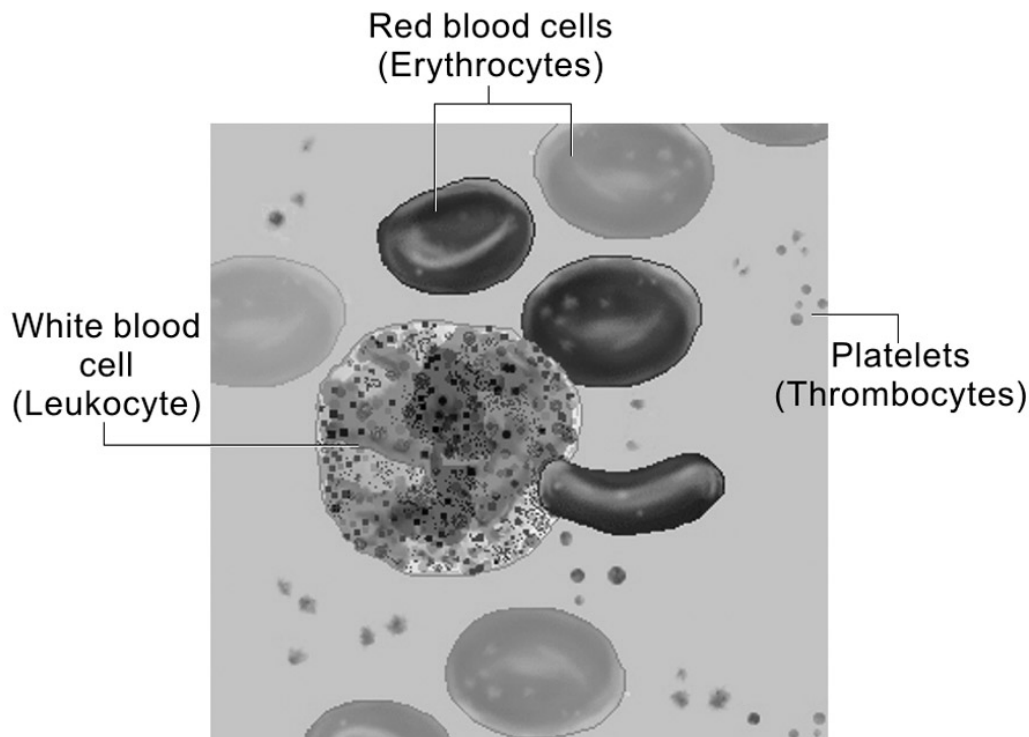
Figure 2-25. Veins.



## Blood

Adults have approximately 5 liters of blood in their body. This whole blood contains red blood cells (RBC), white blood cells (WBC), platelets and plasma (figure 2-26). In a blood sample, 55 percent of the sample is plasma and the other 45 percent is blood cells. The percentage of cells is called the hematocrit or packed cell volume. Ninety-nine percent of these cells are RBCs, while the remaining one percent is WBCs and platelets.

Blood components	Description
Red blood cells (erythrocytes)	RBCs contain a substance called hemoglobin. Hemoglobin is the portion of the blood that contains oxygen and gives the blood its red color. Approximately one million new RBCs are produced by the bone marrow every second. They live for three to four months. As the RBCs become old, the liver and spleen destroy them.
White blood cells (leukocytes)	These are colorless cells that protect the body against infection. When an infectious agent invades the body, WBCs reproduce very rapidly to combat the infection. This is why a high WBC count detected in a blood test is a good indication of the presence of some type of infection. WBCs are also produced by the bone marrow. They live for about nine days.
Platelets (thrombocytes)	Platelets are responsible for the blood's clotting action. They are produced by the bone marrow and live for approximately four days.
Plasma	Plasma is the sticky liquid portion of the blood, which consists mostly of water. The function of the plasma is to transport the blood cells throughout the circulatory system. Plasma also carries other nutrients and chemical substances throughout the body and transports waste products.



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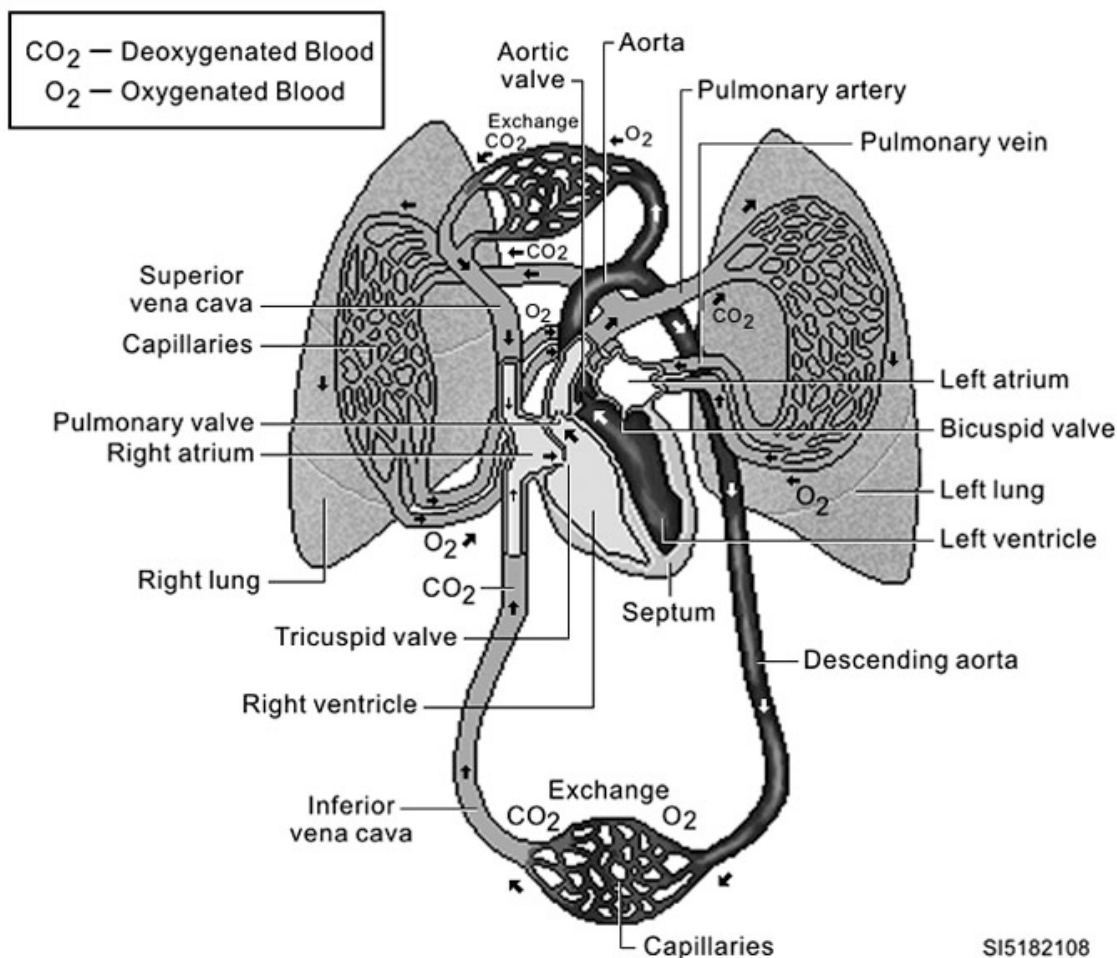
Figure 2-26. Blood cells.

### 213. Physiology of circulation

Now that you know something about the structure of the circulatory system, let's look at the actual physiological process of circulation. The action of the heart is fundamental to the process of circulation. Both atria are receiving chambers and both ventricles are pumping chambers. The brain stimulates the electrical action of the heart, which results in a constant pumping activity. Blood automatically enters the atria each time that blood is pumped out of the heart by the ventricles. The blood flows throughout the entire circulatory system as a result of the pressure that the pumping activity generates.

Blood pressure is referred to in two separate measurements. The pressure that blood exerts against the walls of the arteries during the pumping (systole) action of the heart is called the *systolic blood pressure*. When the heart muscle rests between each contraction (diastole), the pressure that remains in the system is known as the *diastolic blood pressure*. Arterial walls are controlled by nervous stimulation that permits changes in the diameter of the vessels to accommodate the blood volume and pressure within them.

Take a few minutes to carefully study figure 2-27. The arrows identify the direction of blood-flow. Use this figure to read and study the "Path of Circulation" to learn how the components of the circulatory system work to keep us going.



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Figure 2-27. Circulation of the blood.

**Path of Circulation**

1. The contracting (pumping) action of the left ventricle forces oxygen-rich blood out of the left ventricle through the aortic valve.
2. Blood enters the aorta.
3. The aorta branches into the major arteries that carry the blood toward all areas of the body.
4. The major arteries carry the blood to smaller arterioles.
5. Arterioles lead to capillaries.
6. Oxygen and nutrient-rich blood is passed from the capillaries into all of the cells of the body.
7. While the oxygenated blood is being dispersed, waste products, including carbon dioxide, are exchanged and picked up from the cells by the capillaries.
8. The journey of the oxygen-depleted blood now begins its journey back toward the heart and lungs from the capillaries.
9. The capillaries pass the blood to the many venules in the system.
10. The venules transport the blood to the major veins of the body.
11. The veins all join with one of the two major veins, the *superior vena cava* (which returns blood from the upper body) and the *inferior vena cava* (which returns blood from the lower body).
12. The superior and inferior vena cava enter the heart's right atrium.
13. Blood passes from the right atrium through the tricuspid valve into the right ventricle. At this point, the blood must now make a journey to the lungs in order to replenish its oxygen supply and remove the waste products.
14. The pumping action of the right ventricle forces the blood through the pulmonary valve and into the pulmonary artery.
15. Blood travels through the pulmonary artery to the lungs. The pulmonary artery is the only artery in the body that carries deoxygenated blood. It is called an artery because it is transporting blood away from the heart.
16. In the alveoli of the lungs, capillaries exchange the waste products contained in the blood for a new supply of oxygen.
17. Blood then travels back toward the heart through the pulmonary vein. The pulmonary vein is the only vein in the body that carries oxygenated blood. It is called a vein because it transports blood to the heart.
18. The pulmonary vein returns the blood to the left atrium.
19. Blood is passed from the left atrium through the mitral valve and back into the left ventricle.

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**Self-Test Questions**

After you complete these questions, you may check your answers at the end of the unit.

**212. Anatomy of the circulatory system**

1. The heart is located in what area of the thorax?
2. What valve is between the left atrium and left ventricle?
3. What are the two largest veins in the body?

**213. Physiology of circulation**

1. Map the route of circulating blood as it leaves the left ventricle by numbering the following 17 circulatory system areas in order:
  - a. \_\_\_\_ left atrium.



- b. \_\_\_\_ Right atrium.
- c. \_\_\_\_ Right ventricle.
- d. \_\_\_\_ Aortic valve.
- e. \_\_\_\_ Mitral valve.
- f. \_\_\_\_ Tricuspid valve.
- g. \_\_\_\_ Pulmonary valve.
- h. \_\_\_\_ Pulmonary artery.
- i. \_\_\_\_ Pulmonary vein.
- j. \_\_\_\_ Major arteries.
- k. \_\_\_\_ Major veins.
- l. \_\_\_\_ Arterioles.
- m. \_\_\_\_ Venules.
- n. \_\_\_\_ Capillaries.
- o. \_\_\_\_ Aorta.
- p. \_\_\_\_ Superior and inferior vena cava.
- q. \_\_\_\_ Lungs.

## **2-4. Lymphatic System**

The lymphatic system works closely with the circulatory system to circulate body fluids. This section addresses the anatomy and physiology of the lymphatic system.

### **214. Anatomy of the lymphatic system**

The lymphatic system consists of two functions: (1) to help maintain a proper fluid balance by removing excess fluid from the interstitial spaces that exist between cells and within most body tissues, and (2) to help defend the body against infection. The components of the lymphatic system include lymphatic capillaries, lymphatic vessels, lymph nodes, lymphatic trunks, collecting ducts, the thymus and the spleen. In this lesson, you will briefly review descriptions and functions of each of these components (figure 2-28).

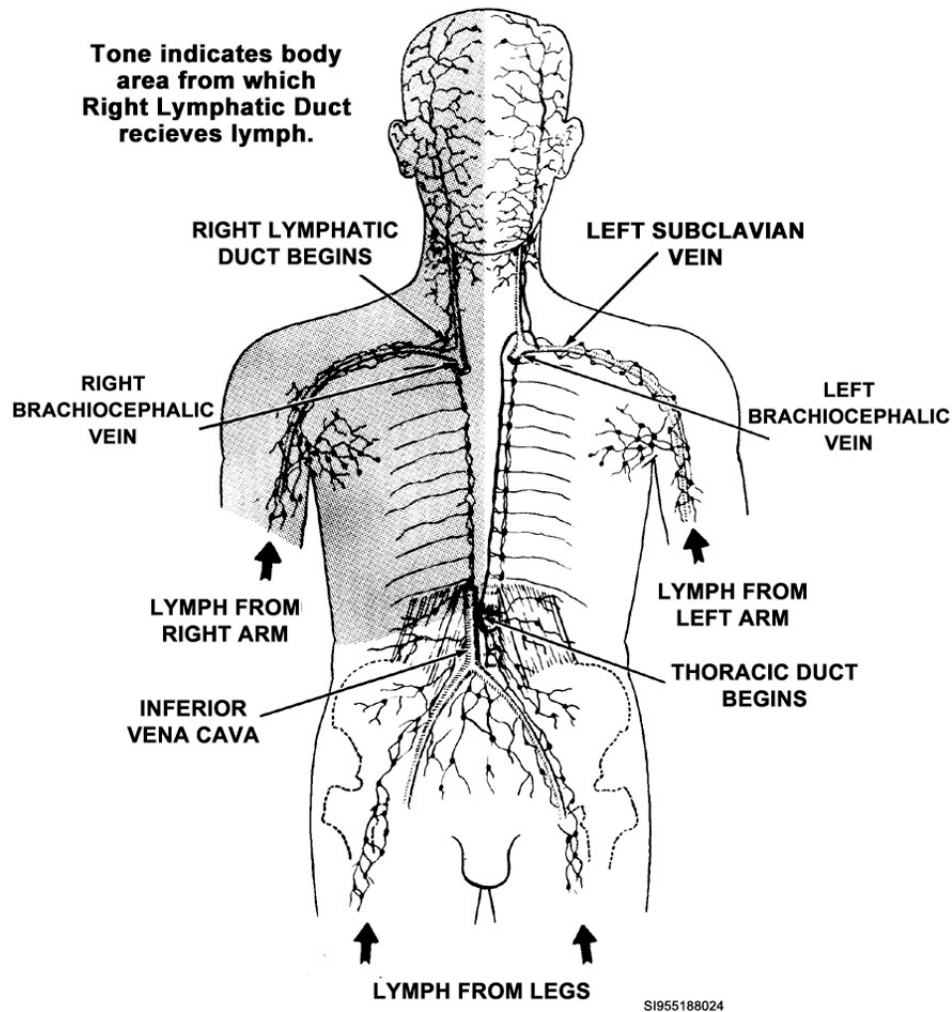


Figure 2-28. Lymphatic system.

### Lymphatic capillaries

Lymphatic capillaries run parallel to the capillaries of the circulatory system. They are microscopic tubes that extend into the spaces within the body tissues (interstitial spaces). Like blood capillaries, lymphatic capillaries have a thin membrane wall.

### Lymphatic vessels

Lymphatic capillaries merge and form lymphatic vessels. These vessels are similar to the veins in structure.

### Lymph nodes

The larger lymphatic vessels lead to special organs called lymph nodes. Lymph nodes act as the filters of the lymphatic system. The vessels that lead into the node are called *afferent lymphatic vessels*. The vessels that lead out of the node are known as *efferent lymphatic vessels*.

### Lymphatic trunks

After lymphatic vessels pass through the lymph nodes, they merge to form larger vessels known as lymphatic trunks. Each of these trunks is named according to the body region that it serves.

### Collecting ducts

All of the lymphatic trunks join to form one of the two collecting ducts in the body. These two ducts are the thoracic duct and the right lymphatic duct. The thoracic duct joins with the left subclavian vein. The right lymphatic duct joins with the right subclavian vein. The merging of these two ducts with the left and right subclavian veins is what ties the lymphatic system to the circulatory system.

### Thymus

The thymus is a lymphatic organ with a function closely related to that of the lymph nodes. It is located in the mediastinum, anterior to the aorta and posterior to the sternum. The thymus extends from the base of the neck to the pericardium.

### Spleen

Like the thymus, the spleen is a specialized organ of the lymphatic system with a function similar to that of the lymph nodes. The spleen is the largest lymphatic organ. It is located in the upper left quadrant of the abdomen, inferior to the diaphragm and posterior to the stomach.

## 215. Physiology of the lymphatic system

This lesson focuses on how the lymphatic system removes excess fluid from the body tissues and helps defend the body against infection.

### Excess fluid removal

Excess fluid from the body tissues enters the lymphatic capillaries. Once the fluid is inside the capillaries, it is known as *lymph*. The lymph then travels through the lymphatic vessels to the various lymph nodes. Lymph then is transported through the lymphatic trunk to one of the two collecting ducts. Lymph from the thoracic duct empties into the left subclavian vein. Lymph from the right lymphatic duct empties into the right subclavian vein. The lymph now becomes part of the blood plasma within the circulatory system, just before it enters the right atrium.

### Defense against infection

The lymph nodes contain two infection-fighting organisms called *lymphocytes* and *macrophages*. As the lymph is filtered in the nodes, the lymphocytes attack any bacterial cells and viruses that may be present. The macrophages surround and destroy foreign substances, damaged cells and cellular debris.

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## Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

### 214. Anatomy of the lymphatic system

1. What are the two functions of the lymphatic system?
2. After passing through the lymph nodes, lymphatic vessels merge to form what component of the lymphatic system?
3. What vein is joined to the thoracic duct?

### 215. Physiology of the lymphatic system

1. Into which vein does all lymph eventually empty?
2. What are macrophages?
3. What is the function of lymphocytes?

## 2-5. Anatomy and Physiology of the Respiratory System

Oxygen is required to support the metabolic processes that sustain life. Carbon dioxide is a waste product of the metabolism. Respiration is the term used to describe the entire process involved in the exchange of these two gases. Various organs and structures are involved in the process of respiration and together they make up the respiratory system. This unit presents the anatomy and physiology of the respiratory system.

The respiratory system includes all organs involved in the exchange of gases (oxygen and carbon dioxide). The process of respiration involves inhalation of oxygen and exhalation of carbon dioxide. It also includes the exchange of these gases at the cellular level.

The human body requires a constant exchange of these gases, in order to sustain life. To understand the *physiology* of respiration, a thorough comprehension of the *anatomy* of the respiratory system must first be explored. This knowledge is also vital, in order to provide effective medical care for patients with various pulmonary disorders.

### 216. Anatomy of the respiratory system

This lesson provides an overview of the major organs and structures involved in respiration. The respiratory system is divided into three major sections: the upper respiratory system, the lower respiratory system, and accessory structures.

#### The upper respiratory system

Organs considered a part of the upper respiratory system include the nose, pharynx and larynx (fig.2-29).

##### *Nose*

The nose is a framework of bone and cartilage that has an external covering of skin. The two external openings are the *nostrils*. The nostrils join to form the nasal cavity, which is divided into two parts by the *nasal septum* and separated from the mouth by the *palate*. Bones of the skull and face form the roof of the nasal cavity, which is lined with a mucous membrane and hair-like structures called “cilia.”

##### *Pharynx*

The *pharynx* or throat is the passageway between the nose and the larynx. It consists of three parts: the nasopharynx, oropharynx and laryngopharynx. The *nasopharynx* is the superior portion of the pharynx and contains the two eustachian tubes that connect to the middle ears. The mucous membrane that lines the pharynx extends continuously to the eustachian tubes. The nasopharynx also contains a mass of lymphoid tissue called the adenoids. The function of the adenoids is a matter of debate in the medical field and they are often surgically removed as a result of childhood infections. The *oropharynx* is located directly posterior to the mouth and contains the *tonsils*. The only known

function of the tonsils is the formation of lymphocytes. The tonsils often become infected, resulting in a condition known as tonsillitis. A tonsillectomy is the surgical removal of the tonsils. The *laryngopharynx* contains an anterior opening into the larynx and a posterior opening into the esophagus.

### **Larynx**

The larynx or “voice box” lies in the middle of the neck, between the base of the tongue and the trachea. It is the passageway from the pharynx to the trachea. The larynx is a triangular, cartilaginous structure that is composed of nine cartilages that are joined by ligaments. These nine cartilages include three single cartilages and three paired cartilages. The largest of these cartilages is the thyroid cartilage, which is butterfly-shaped and forms a large prominence known as the Adam’s apple.

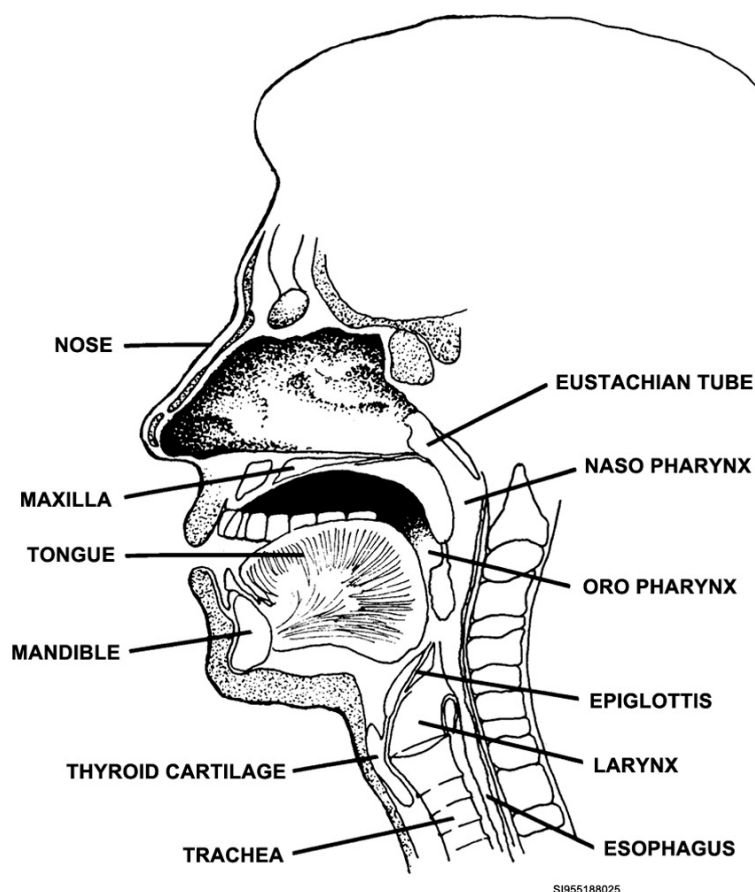


Figure 2-29. Upper Respiratory System.

### **The lower respiratory system**

The lower respiratory system consists of the trachea, bronchi, alveoli and lungs (fig. 2-30). Refer to this figure as you read the descriptions of these parts of the lower respiratory system.

### **Trachea**

The trachea or windpipe is located anterior to the esophagus. It extends from the larynx and terminates at the point at which it divides into the right and left bronchi. It is a cylindrical tube that is composed of 16 to 20 C-shaped cartilage rings that are lined with cilia and a mucous membrane. The cartilage rings add strength to the trachea to prevent it from collapsing.

### *Bronchi*

The trachea branches off into two main passageways known as the bronchi. The right bronchus extends into the right lung; the left bronchus extends into the left lung. Each bronchus is further divided inside the lungs into smaller passages leading to each lobe within the lungs. Once inside the lobes, the bronchus then branches into smaller parts called bronchioles. The bronchioles lead to the alveoli.

### *Alveoli*

The alveoli are the air sacs of the lungs. They connect to the many capillaries of the circulatory system within the lungs.

### *Lungs*

The lungs are the primary organs of respiration. They are located inside the thoracic (chest) cavity and are enclosed in a protective lining called the pleura. The right lung contains three lobes and the left lung contains two lobes. The lungs are soft and spongy and constantly change shape to facilitate breathing.

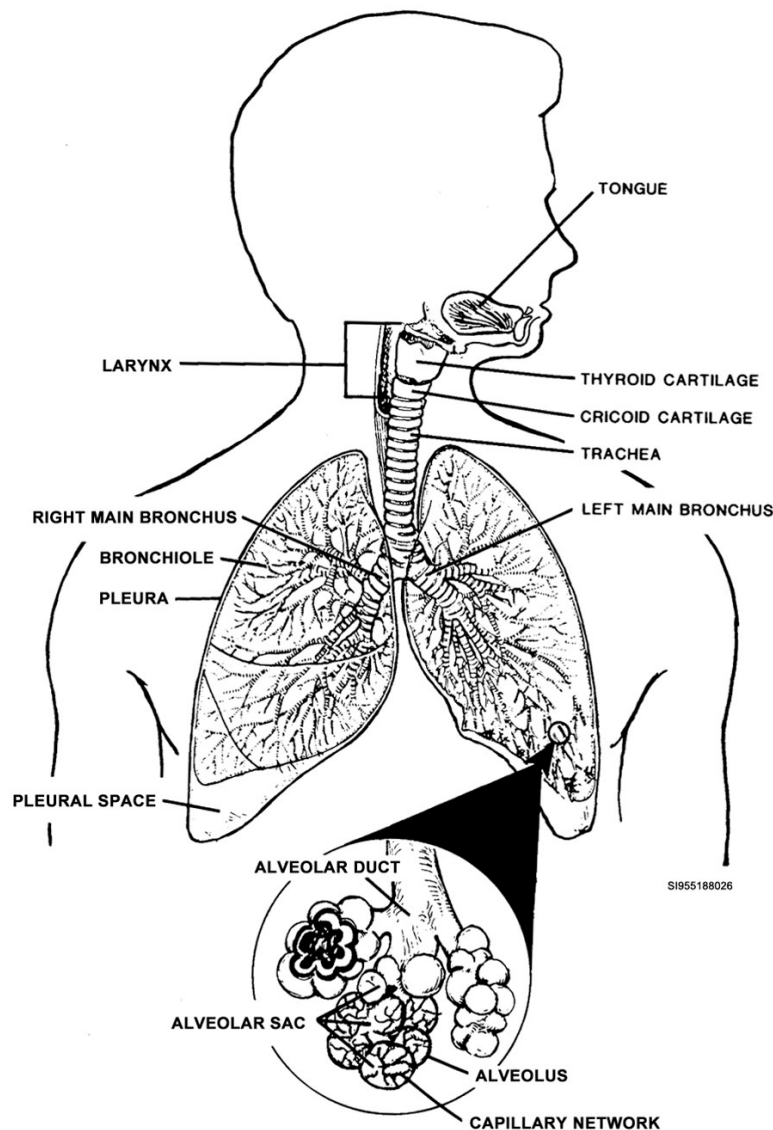


Figure 2-30. Lower Respiratory System.

### Accessories of the respiratory system

Three main accessories that assist the respiratory system are the pleurae, diaphragm and intercostal muscles.

#### *Pleurae*

The pleurae are protective membrane linings. The pleurae consist of two layers; one layer is attached to each lung and the second layer is attached to the thoracic wall. The space in between the two layers is filled with pleural fluid. This fluid acts as a lubricant for the lungs to prevent irritation during respiration.

#### *Diaphragm*

The diaphragm is the main muscle of respiration and is located inferior to the lungs.

#### *Intercostal muscles*

Intercostal muscles are located between the ribs. Together with the diaphragm, they assist the process of respiration.

### 217. Physiology of respiration

All of the organs of the upper and lower respiratory system, as well as the accessory structures, combine to permit the process of respiration to take place. Nerve impulses, muscular activity and mechanical pressure changes work together as they are influenced by chemical changes in the blood.

#### **Inhalation**

Although it is possible to voluntarily control your breathing (such as: by holding your breath or by purposely breathing fast or slow), respiration is normally an involuntary act that is controlled by the nervous system. The primary stimulus for breathing is the brain's need to eliminate carbon dioxide from the body. The need for oxygen is secondary to this. Most people breathe, due to the primary stimulus; however, in cases of certain pulmonary disorders, the stimulus to breathe is often the need for oxygen. This is important to remember, because administering too much oxygen to a patient with this condition could lead to a partial or complete respiratory shutdown.

A group of nerve cells in the brain stimulates the process of thoracic muscle action by sending impulses through two sets of nerves—*phrenic* and *intercostal*. The phrenic nerves control the action of the diaphragm and the intercostal nerves control the action of the intercostal muscles. The muscles of respiration must initiate a mechanical action to permit inhalation. The diaphragm and intercostal muscles contract to become smaller. This creates additional room inside the thoracic cavity for the lungs to expand as they fill with air. The diaphragm moves downward as it contracts, while intercostal muscular contraction permits the ribs to move forward and slightly upward. All of this activity results in a decrease in intrathoracic pressure. When pressure in the intrathoracic space (the space between the outer surface of the lungs and the internal lining of the thorax) decreases; atmospheric pressure outside of the body forces air into the lungs through the passages of the respiratory system. Air then enters the upper respiratory system through the nose.

Air enters the nose through the nostrils. As it passes through the nasal cavity, it is warmed and moisturized through contact with the mucous membrane. The cilia in the nasal cavity cause a wavelike motion that directs foreign matter toward the pharynx. The foreign matter is then either expelled through the mouth or swallowed.

As the air passes through the trachea, the cilia and mucous membrane lining, help to trap additional foreign matter. The wave-like motion of the cilia causes foreign matter to be moved upward toward the pharynx, where it can be expelled from the body by coughing.

Once the air enters the lungs through the bronchi, it passes through the network of bronchioles and eventually into the alveoli. Although the lungs can hold approximately 6.0 liters of air when filled to capacity, only 0.5 liter of this amount enters and leaves the lungs with each natural respiration. This is



called *tidal air*. The maximum amount of air that can be taken in (over and above the tidal air) and expelled by the strongest possible expiratory effort after the tidal air has been allowed to escape naturally is called the *expiratory reserve*. The sum of the tidal air and the expiratory reserve is called the *vital capacity*. Any amount of air remaining in the lungs after the strongest possible expiration is known as the *residual air*.

The exchange of oxygen and carbon dioxide between the respiratory and circulatory systems takes place once the air has reached the alveoli. The alveoli are covered with pulmonary capillaries. Once the exchange of gases between the alveoli and the pulmonary capillaries occurs, the circulatory system transports the oxygen to all parts of the body for cellular perfusion.

### **Exhalation**

The process of exhalation begins where the process of inhalation ends—in the alveoli. Since the muscles of respiration have to decrease in size during inhalation, it is obvious that the opposite must be true for exhalation to occur. The diaphragm and intercostal muscles relax, thereby increasing in size. As these muscles get larger, pressure is exerted against the lungs and air is forced out. The path of exhalation follows the same passages used during inhalation. Once the carbon dioxide has been expelled from the body, the respiratory process repeats itself.

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## **Self-Test Questions**

After you complete these questions, you may check your answers at the end of the unit.

### **216. Anatomy of the respiratory system**

1. To what part of the circulatory system do the alveoli connect directly?
2. What is the main function of the pleurae? How many layers do the pleurae have?
3. How many lobes does the right lung have?
4. Where are intercostal muscles?

### **217. Physiology of respiration**

1. What is the *primary* stimulus to breathe?
2. What controls the action of the diaphragm?
3. When filled to capacity, approximately how much air can the lungs hold?



## 2-6. Anatomy and Physiology of the Nervous System

The nervous system is responsible for directing all body systems and functions. This unit presents the anatomy and physiology of the nervous system. All of the body's stimulus-response action is coordinated and regulated by the nervous system. It is a highly organized system that helps the body to adjust to both internal and external factors. Think of the nervous system as the ultimate communication system. In this section, you will first briefly review the components that comprise the *anatomy* of the nervous system. Then, you will study the physiology of this system.

### 218. Anatomy of the nervous system

There are two main divisions of the nervous system: the central nervous system (CNS) and the peripheral nervous system (PNS). Both of these main divisions are further subdivided; and all of the subdivisions work together to permit proper functioning of the nervous system as a whole.

The nervous system is composed mainly of neural tissue. This tissue contains two basic types of cells: neurons (nerve cells) and neuroglia (which are often referred to as just "glia"). Neuroglia cells are basically responsible for nourishing neurons, as well as for assisting in determination of the specific function each neuron is to perform. The small spaces between the neurons are called the *synapses*. Molecules known as "neurotransmitters" carry messages between neurons in the synapses.

Although there are many other microscopic parts within the structure of the nervous system, this lesson focuses on the primary component, the neuron.

#### Neurons

Neurons vary in size and shape, but have certain features in common. These features include a cell body and tubular processes filled with cytoplasm that transmit nerve impulses to or from the cell body. Each neuron contains a *soma* (cell body), dendrites and axons (fig. 2-31). Axons carry impulses away from the soma; dendrites carry impulses to the soma.

Protection of the neurons is essential. The axon of each neuron is surrounded by layers of cell membranes that are filled with the lipoprotein myelin. This protective coating is known as the "myelin sheath." Some neurons have an additional thin layer of membrane surrounding the myelin sheath. This additional layer of membrane is known as the "neurilemmal sheath."

There are three types of neurons. Each of these types of neurons is described briefly in the following table. Also refer to figure 2-32.

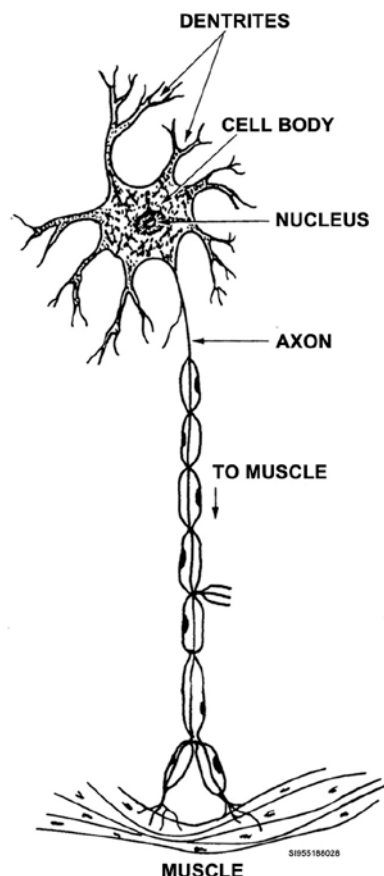
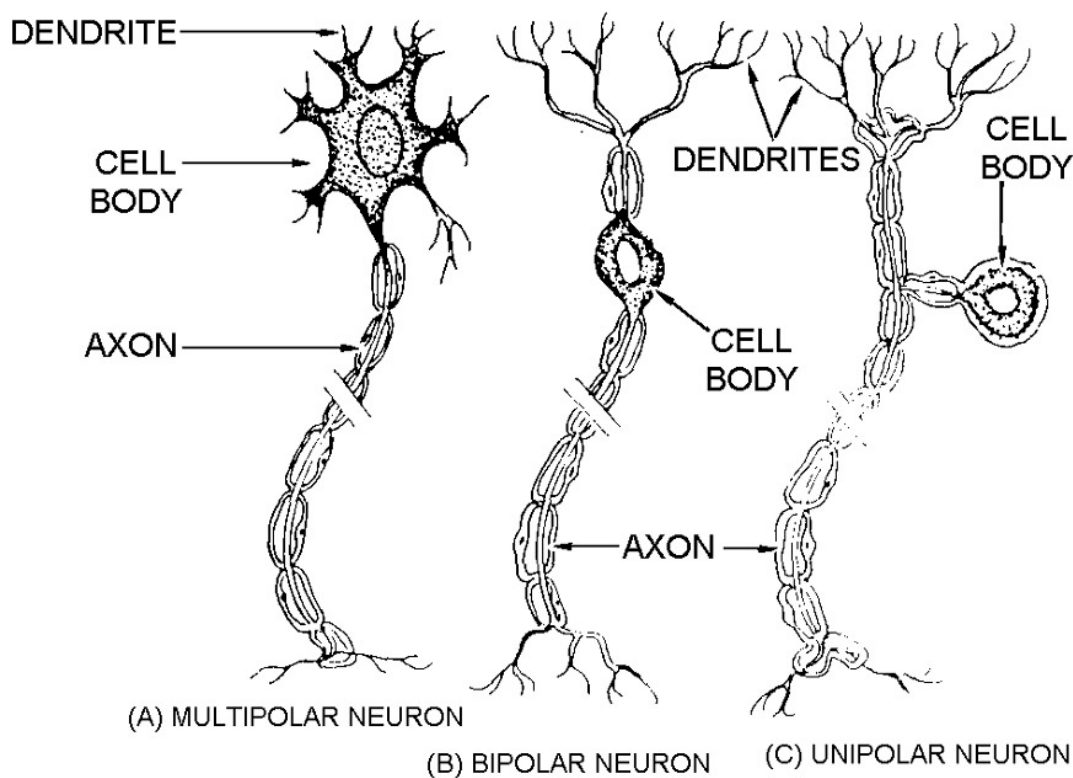


Figure 2-31. Nerve cell.

Neuron Type	Description
<b>Bipolar</b>	Has one axon extending from one end of the soma and one dendrite extending from the other end. Bipolar neurons are found in the eyes, nose and ears.
<b>Unipolar</b>	Has a single fiber that extends from the soma. The fiber then branches into an axon and a dendrite a short distance away from the soma. Most unipolar neurons originate in masses of nerve tissue called <i>ganglia</i> , which are located outside the brain and spinal cord.
<b>Multipolar</b>	Has one axon and many dendrites that extend from the soma. Multipolar neurons are the most common type found in the brain and spinal cord.



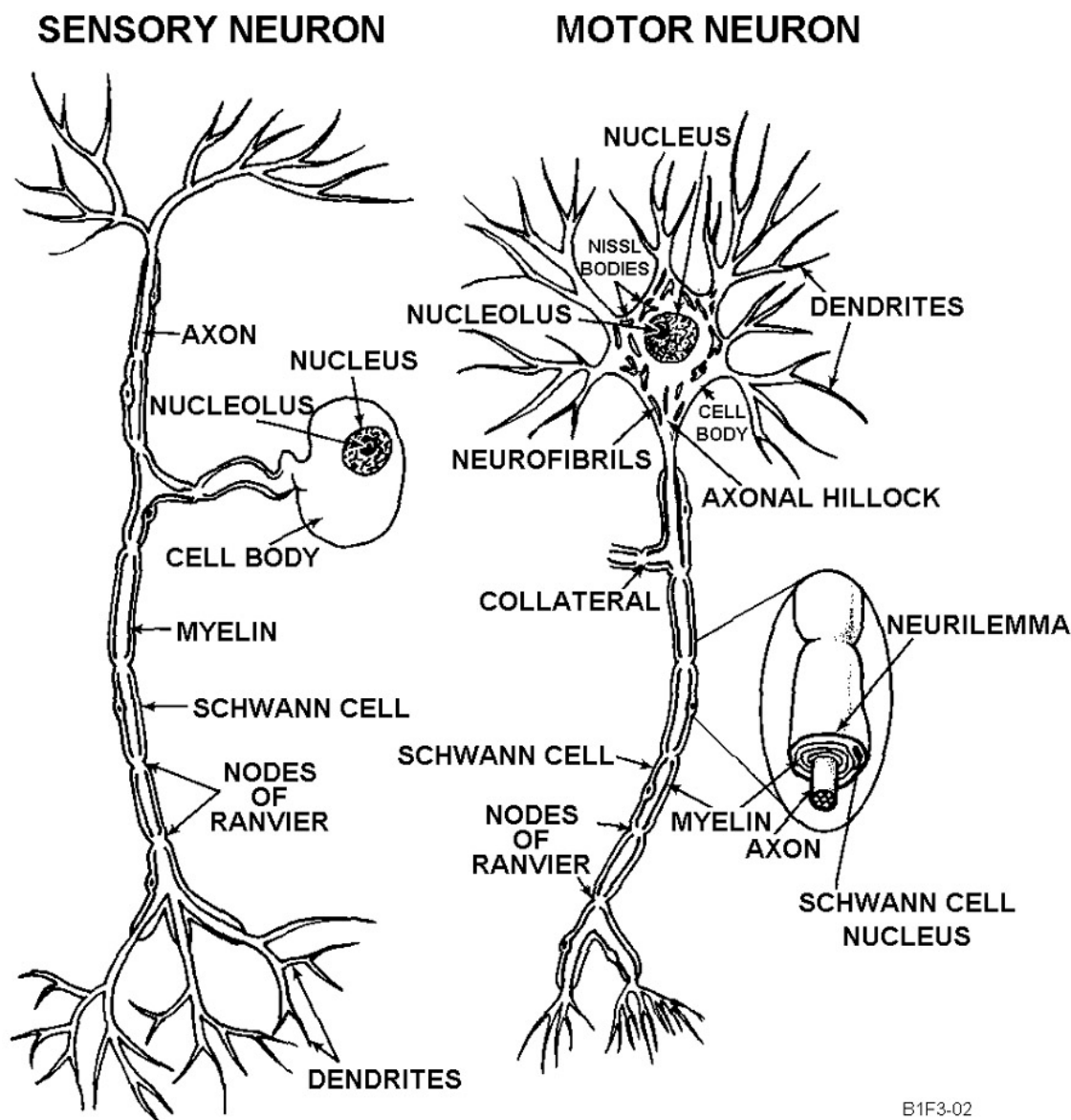
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Figure 2-32. Types of Neurons.

In addition to classification by type, neurons are classified by their *function*, as identified in the following table. Also refer to figure 2-33.

Neuron Function	Description
<b>Sensory</b>	Sometimes referred to as <i>afferent</i> neurons, they conduct impulses from peripheral body locations to the brain or spinal cord. Most are unipolar neurons, some are bipolar.
<b>Interneuron</b>	Also known as <i>association</i> or <i>internuncial</i> neurons, transmit impulses within the brain or spinal cord. Interneurons are all of the multipolar type.
<b>Motor</b>	Also known as an <i>efferent</i> neuron, conducts impulses from the brain or spinal cord out to peripheral muscles and glands

Neuron Function	Description
	in the body. Motor neurons are also of the multipolar type.



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Figure 2-33. Classification of neuron.

### Nervous system

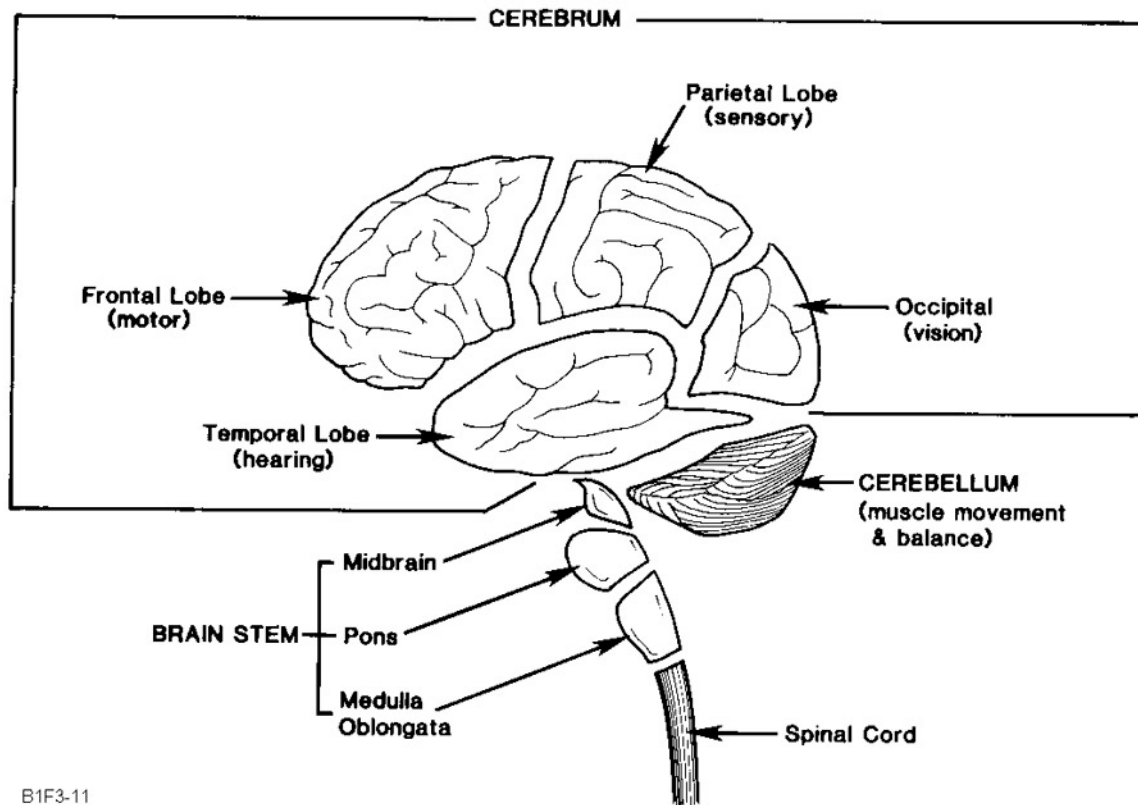
The nervous system is functionally divided into two subsystems. Although these two subsystems perform different functions, they are closely related and work together to make the entire nervous system function properly.

### Central nervous system (CNS)

This subsystem of the nervous system consists of the brain and the spinal cord. The brain lies within the cranium and the spinal cord lies within the vertebral column.

## Brain

The brain receives and interprets impulses that result from stimuli and sends out responses for the body's reaction. The brain (fig. 2-34) consists of a large mass of nerve tissue and it has three major parts: the cerebrum, cerebellum and the brain stem.



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Figure 2-34. Brain.

The *cerebrum* is the largest part of the brain. It is the center of intelligence and personality. The cerebrum is divided into two sections—the right and left hemispheres. Each hemisphere is divided into lobes that are named after the cranial bones, to which they attach. This table identifies each lobe and its function.

Lobe	Function
Frontal	A motor area.
Parietal	A sensory area.
Occipital	The center for vision.
Temporal	The center for hearing.

The interior of the cerebrum is responsible for storing knowledge (memory) and interpreting sensations. The interior of the cerebrum contains bundles of axons and nerve tracts that are covered with myelin sheaths, which give it its white color.

The gray outer layer of the cerebrum, known as the cortex, governs all conscious functions. Masses of nerve tissue give the cortex its characteristic gray appearance. Because of this coloration, it is often referred to as the “gray matter.”

The cerebellum is the second largest part of the brain. It is located below the cerebrum, in the lower posterior part of the cranial cavity. Its primary functions are to control the activities of the brain itself and to coordinate muscular movements and body equilibrium.

The third major part of the brain is called the brain stem. It is located where the spinal cord connects to the base of the brain. The brain stem consists of three parts: the midbrain, pons and medulla oblongata. The following table provides a brief description of each of these parts.

Brain Stem Part	Description
<b>Midbrain</b>	The superior portion of the brain stem; responsible for reflex control.
<b>Pons</b>	The middle part of the brain stem; serves as a connecting bridge to the cerebellum. It also is the point of exit for cranial nerves and assists in regulating respiration.
<b>Medulla oblongata</b>	The inferior portion of the brain stem that connects directly to the spinal cord. It is the center for control of respiration, heartbeat and blood pressure. In addition, any reflex actions, such as sneezing, coughing and peristalsis are also controlled by the medulla oblongata.

### *Spinal cord*

In infants, the length of the spinal cord extends the entire length of the vertebral column. As a person grows, the vertebral column grows more rapidly than the cord. Therefore, the spinal cord in an adult extends only to the second lumbar vertebrae. The cord exits the skull through an opening called the *foramen magnum*.

### *Protection of the CNS*

Both the brain and the spinal cord are protected by the *meninges*. The meninges are divided into three layers:

1. Dura mater is the outer layer, which lies against the skull and also against the vertebrae. It consists mainly of tough, white fibrous connective tissue and contains many blood vessels and nerves.
2. Arachnoid mater is the thin, center layer. It is a web-like membrane that does not contain any blood vessels.
3. Pia mater is the innermost layer that attaches directly to the surfaces of the brain and spinal cord. It contains nerves, as well as blood vessels that nourish the cells of the brain and spinal cord.

The CNS is further protected by the cerebrospinal fluid (CSF), contained within the meninges. The CSF is a clear, watery fluid that acts as a shock absorber for the CNS. The fluid is located in a space called the *arachnoid space*, which is between the arachnoid mater and pia mater.

### *Peripheral nervous system*

The second subsystem of the nervous system is known as the “peripheral nervous system.” It involves all of the major nerves that branch out from the central nervous system.

### *Cranial nerves*

The cranial nerves extend from the brain, controlling functions that are sensory or motor or a combination of the two. There are 12 pairs of cranial nerves. Each of the cranial nerves can be referred to either by number or by name. Take a few minutes to study the following table, which identifies and describes each of the pairs of cranial nerves. Also refer to figure 2-35.

Cranial Nerve	Nerve Number	Description
Olfactory	First	Responsible for conveying the sensation of smell from the mucosa of the nose to the olfactory center of the brain.

Cranial Nerve	Nerve Number	Description
Optic	Second	Related to vision. These nerves convey the sensation of sight from the receptor cells in the retina to the visual area in the posterior occipital lobe of the cerebrum.
Oculomotor	Third	Control movement of eye muscles. These nerves also control the constricting and dilating of the iris.
Trigeminal	Fourth	Include the ophthalmic, maxillary and mandibular nerve. They play a role in control of both the eye and the oral cavity.
Trochlear	Fifth	Control of the superior oblique muscles of the eye.
Abducent	Sixth	Control the lateral rectus muscles of the eye.
Facial	Seventh	Control the muscles of the face that affect facial expression.
Acoustic	Eighth	A combination of two nerve roots—the cochlear and the vestibular. The cochlear root is concerned with hearing; the vestibular root aids in the control of equilibrium (balance).
Glossopharyngeal	Ninth	Control the tongue and pharynx. They convey taste sensations from the tongue to the cerebrum.
Vagus	Tenth	Extend through the neck to the pharynx, larynx, trachea and esophagus. They also are widely distributed in the thoracic and abdominal viscera. Vagus nerves influence heart rate, breathing, speech and swallowing.
Spinal accessory	Eleventh	Control the muscles of the neck—the trapezius and the sternocleidomastoideus.
Hypoglossal	Twelfth	Control the muscles of the tongue.

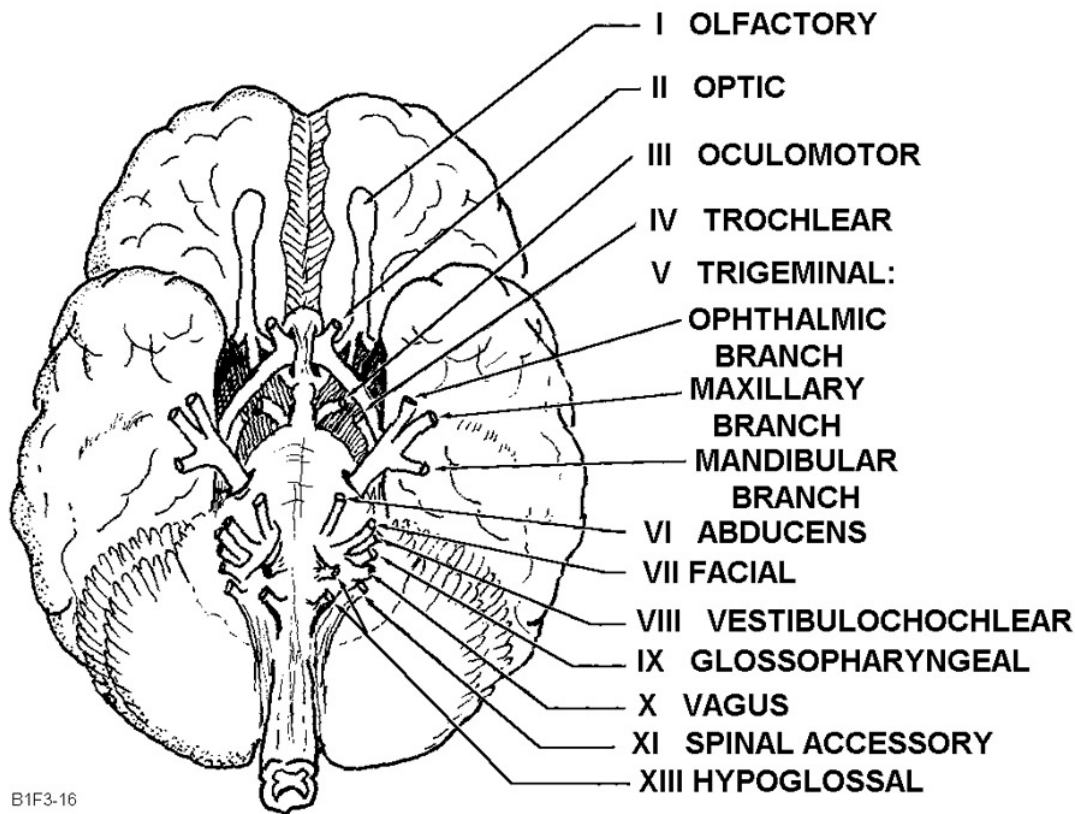


Figure 2-35. Cranial nerves.

### Spinal nerves

There are 31 pairs of spinal nerves that extend from the spinal cord, through an opening in the vertebrae known as the intervertebral foramina, and to the body. These 31 pairs of spinal nerves are divided into five areas: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal. The names of these areas correspond to the section of the vertebral column that is located nearby.

In some regions of the body, spinal nerves interlace to form a large intersection of nerves. Each of these intersections is known as a *plexus*. The four major plexuses are the *cervical*, *brachial*, *lumbar* and *sacral* regions.

## 219. Physiology of the peripheral nervous system

The transmitting of impulses between the body and the brain is the obvious purpose of the nervous system. It's important that you understand that, aside from the obvious, the peripheral nervous system is subdivided according to the functions it performs. The two functional divisions of the peripheral nervous system are the *somatic* nervous system and the *autonomic* nervous system.

### Somatic nervous system

The somatic nervous system includes all nerves that are involved in voluntary (or conscious) body movement. The somatic nervous system is responsible for all coordinated body activities.

### Autonomic nervous system

This system includes nerves that are responsible for involuntary (or unconscious) body functions. As the name implies, functions controlled by the autonomic nervous system occur automatically. Examples of functions controlled by the autonomic nervous system include heart rate, breathing and glandular secretions.

Because of the variations in involuntary body functions, the autonomic nervous system is further divided into two functional subdivisions that act in apposition to each other. These functional subdivisions are the *sympathetic* nervous system and the *parasympathetic* nervous system.

### Sympathetic nervous system

This subdivision of the autonomic nervous system is responsible for speeding up body functions. It is usually activated in situations of extreme emotion that require an immediate response. Sometimes referred to as the “fight-or-flight reaction,” the sympathetic nervous system causes the body to hurry, gain strength, stamina and so forth, when it is most needed. As a result of this reaction, the body will eventually need to rest or return to normal.

### Parasympathetic nervous system

Returning the body to “normal” condition is the role of the parasympathetic nervous system. This system is designed to prevent extensive overworking of the body. Just like the paramedic who comes to the assistance of those in an emergency, the parasympathetic nervous system acts when necessary to restore the body back to normal.

The parasympathetic nervous system can be stimulated to act either when the sympathetic nervous system has been activated too long or when the body is consciously caused to relax on its own. When someone faints from exhaustion, often times it is, due to the work of the parasympathetic nervous system.

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## Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

### 218. Anatomy of the nervous system

1. What are the two *main* divisions of the nervous system?

2. What are the three types of neurons?
3. Where is the motor area of the cerebrum located?
4. What is the name of the third cranial nerve?

### **219. Physiology of the nervous system**

1. What type of movements does the somatic nervous system control?
2. What part of the nervous system automatically causes body functions to speed up?
3. What part of the nervous system automatically causes body functions to return to normal?

---

## **Answers to Self-Test Questions**

### **207**

1. Stratum corneum.
2. Dermis.
3. Dead epidermal cells.
4. Apocrine.
5. Sebaceous.

### **208**

1. One of the following: body temperature regulation, protection, and external physical characteristics.
2. Dilate. To permit increase in blood-flow and stimulate sweating.
3. Melanin.
4. Decreases skin elasticity.

### **209**

1. Periosteum.
2. Compact bone.
3. A rounded bone end that normally joins with another bone.

### **210**

1. More than 500.
2. Epimysium.
3. Multiunit.



**211**

1. Fibrous.
2. Synovial.
3. Blood cell formation.

**212**

1. Mediastinum.
2. Mitral (or bicuspid).
3. Superior and inferior vena cava.

**213**

1. a. 16.
  - b. 9.
  - c. 11.
  - d. 1.
  - e. 17.
  - f. 10.
  - g. 12.
  - h. 13.
  - i. 15.
  - j. 3.
  - k. 7.
  - l. 4.
  - m. 6.
  - n. 5.
  - o. 2.
  - p. 8.
  - q. 14.

**214**

1. Maintain proper fluid balance and defend against infection.
2. Lymphatic trunks.
3. Left subclavian vein.

**215**

1. One of the two subclavian veins.
2. Infection-fighting organisms in lymph.
3. To fight infection.

**216**

1. Capillaries.
2. To protect the lungs. Two.
3. Three.
4. Between the ribs.

**217**

1. The need to eliminate carbon dioxide from the body.
2. Phrenic nerves.
3. Six liters.

**218**

1. CNS and PNS.
2. Bipolar, unipolar, and multipolar.
3. Frontal lobe.
4. Oculomotor nerve.

**219**

1. Voluntary.
2. Sympathetic.
3. Parasympathetic.

**Do the unit review exercises before going to the next unit.**

---

### Unit Review Exercises

**Note to Student:** Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to a Field Scoring Answer Sheet.

**Do not return your answer sheet to AFCDA.**

25. (207) The layer of the epidermis that is next to the deepest layer is the
  - a. stratum basale.
  - b. stratum corneum.
  - c. stratum spinosum.
  - d. stratum granulosum.
26. (207) Which glands play a role in keeping the hair and skin soft and waterproof?
  - a. Sebaceous.
  - b. Apocrine .
  - c. Eccrine.
  - d. Sweat.
27. (207) The nail grows outward from the white area at the base called the
  - a. nail plate.
  - b. dermis.
  - c. lunula.
  - d. nail bed.
28. (207) What substance is secreted by the sebaceous gland?
  - a. Sebum.
  - b. Sweat.
  - c. Follicle.
  - d. Adipose.
29. (208) Pigmentation is attributed to
  - a. melanin.
  - b. dermal cells.
  - c. subcutaneous cells.
  - d. sebaceous gland secretions.

30. (208) What substance does melanocyte produce?
- a. Sebum.
  - b. Melanin.
  - c. Adipose.
  - d. Pigmentation.
31. (209) Where would you find very little compact bone in the skeletal system?
- a. Bone ends.
  - b. Sesamoid bones.
  - c. Medullary canal.
  - d. Outermost portion of the bone.
32. (209) Where are nerves and blood vessels contained in the bone?
- a. Articular.
  - b. Periosteum.
  - c. Cancellous bone.
  - d. Medullary cavity.
33. (209) What bones are usually located within tendons where pressure is frequently applied?
- a. Long.
  - b. Short.
  - c. Irregular.
  - d. Sesamoid.
34. (209) What is the name of the triangular shaped bone that lies over the anterior portion of the knee joint?
- a. Patella.
  - b. Fibula.
  - c. Femur.
  - d. Tibia.
35. (210) The epimysium is located beneath the
- a. fascia.
  - b. fascicles.
  - c. perimysium.
  - d. endomysium.
36. (210) What type of muscle is skeletal muscle?
- a. Voluntary; striated.
  - b. Voluntary; non striated.
  - c. Involuntary; striated.
  - d. Involuntary; non striated.
37. (210) The muscle layer that lies just below the epimysium is the
- a. fascia.
  - b. tendon.
  - c. perimysium.
  - d. endomysium.
38. (210) What attaches skeletal muscles to the bone?
- a. Tendons.
  - b. Ligaments.
  - c. Aponeuroses.
  - d. Visceral muscles.

39. (211) What type of joint joins the distal end of the tibia and fibula?
- Condylod.
  - Gomphosis.
  - Syndesmosis.
  - Synchondrosis.
40. (211) What type of joint connects the sternum and first rib?
- Condylod.
  - Gomphosis.
  - Syndesmosis.
  - Synchondrosis.
41. (211) What fluid acts as a joint lubricant and a nutrient supplier for cartilage within the joint?
- Gomphosis.
  - Synovial.
  - Mucosal.
  - Blood.
42. (212) The valve that leads from the right atrium to the right ventricle is the
- aortic valve.
  - mitral valve.
  - tricuspid valve.
  - pulmonary valve.
43. (212) What is the term for the muscular portion of the heart?
- Septum.
  - Pericardium.
  - Myocardium.
  - Endocardium.
44. (212) What is the valve between the left atrium and left ventricle?
- Aortic.
  - Mitral.
  - Tricuspid.
  - Pulmonary.
45. (212) What cells are responsible for the clotting action in blood?
- Plasma.
  - Platelets.
  - Leukocytes.
  - Erythrocytes.
46. (213) The pressure in the blood vessels when the heart is at rest between contractions is the
- pulse pressure.
  - residual pressure.
  - systolic blood pressure.
  - diastolic blood pressure.
47. (213) What vein returns blood back to the heart from the lower body?
- Capillaries.
  - Pulmonary vein.
  - Superior vena cava.
  - Inferior vena cava.

- 
- 
48. (213) What is the only vein that carries oxygenated blood?
- a. Aorta.
  - b. Pulmonary.
  - c. Superior vena cava.
  - d. Inferior vena cave.
49. (214) What is the purpose of the lymphatic system?
- a. Removes excess fluid and assist in blood clotting.
  - b. Removes waste products and assist in blood clotting.
  - c. Defends the body against infection and remove excess fluid.
  - d. Defends the body against infection and remove waste products.
50. (214) Vessels that lead out of the lymph nodes are called
- a. lymphatic ducts.
  - b. lymphatic capillaries.
  - c. afferent lymphatic vessels.
  - d. efferent lymphatic vessels.
51. (214) What is the largest lymphatic organ?
- a. Heart.
  - b. Spleen.
  - c. Thymus.
  - d. Right lymphatic duct.
52. (214) Lymph is transported through the lymphatic trunk directly to the
- a. spleen.
  - b. the thymus.
  - c. collecting duct.
  - d. left subclavian vein.
53. (214) What special organs do the larger lymphatic vessels lead to?
- a. lymph fluids.
  - b. lymph nodes.
  - c. lymphatic trunks.
  - d. lymphatic capillaries.
54. (214) What part of the lymph system acts as the filter?
- a. Capillaries.
  - b. Vessels.
  - c. Nodes.
  - d. Ducts.
55. (214) What lymphatic organ is located in the mediastinum between the aorta and sternum?
- a. Heart.
  - b. Thymus.
  - c. Thoracic cage.
  - d. Parotid gland.
56. (215) Where does lymph from the right lymphatic duct empty?
- a. Aorta.
  - b. Left ventricle.
  - c. Left subclavian vein.
  - d. Right subclavian vein.

57. (215) Once excess fluid from the body tissue enters lymphatic capillaries, it is known as
- blood.
  - lymph.
  - plasma.
  - body fluid.
58. (216) The larynx is composed of how many cartilages?
- Two single cartilages.
  - Three single cartilages.
  - Two single and two paired cartilages.
  - Three single and three paired cartilages.
59. (216) What part of the lower respiratory system does air travel to and from the lungs through a cylindrical tube composed of cartilage?
- Larynx.
  - Trachea.
  - Pharynx.
  - Esophagus.
60. (217) During *inhalation*, the intercostal muscular contraction permits the ribs to move
- back and slightly upward.
  - back and slightly downward.
  - forward and slightly upward.
  - forward and slightly downward.
61. (217) The amount of air that enters and leaves the lungs with each natural respiration is known as
- tidal air.
  - residual air.
  - vital capacity.
  - expiratory reserve.
62. (218) The small spaces between neurons are called the
- axons.
  - synapses.
  - nerve cells.
  - trigger zones.
63. (218) What type of neuron has one axon extending from one end of the soma and one dendrite extending from the other?
- Bipolar.
  - Sensory.
  - Interneuron.
  - Multipolar.
64. (218) The part of the brain stem that connects to the spinal cord is the
- pons.
  - midbrain.
  - cerebrum.
  - medulla oblongata.
65. (218) What are the three *major* parts of the brain?
- Cerebrum, cerebellum and parietal.
  - Cerebellum, frontal and brain stem.
  - Cerebrum, cerebellum and brain stem.
  - Temporal, cerebrum and medulla oblongata.

- 
- 
66. (218) What is the function of the interior of the cerebrum?
- a. Storing knowledge.
  - b. Control of the brain.
  - c. Control of vision and hearing.
  - d. Coordination of muscle movement.
67. (218) What is the name of the large intersection of interlaced spinal nerves?
- a. trigeminal.
  - b. autonomic.
  - c. brachial.
  - d. plexus.
68. (218) What cranial nerve is responsible for the sensation of sight?
- a. Optic.
  - b. Facial.
  - c. Trigeminal.
  - d. Oculomotor.
69. (218) What cranial nerve conveys taste?
- a. Vagus.
  - b. Hypoglossal.
  - c. Spinal accessory.
  - d. Glossopharyngeal.
70. (219) The "fight-or-flight" reaction is controlled by the
- a. cerebrum.
  - b. meninges.
  - c. sympathetic nervous system.
  - d. parasympathetic nervous system.
71. (219) The parasympathetic nervous system is designed to
- a. provide pain relief.
  - b. provide additional energy.
  - c. prevent extensive overworking of the body.
  - d. prevent prolonged relaxation of body systems.

## **Student Notes**



## Unit 3. Other Systems of the Human Body

<b>3-1. Anatomy and Physiology of the Digestive System .....</b>	<b>3-1</b>
220. Anatomy of the digestive system.....	3-1
221. Physiology of digestion .....	3-8
<b>3-2. Anatomy and Physiology of the Urinary System.....</b>	<b>3-9</b>
222. Anatomy of the urinary system.....	3-9
223. Physiology of the urinary system.....	3-12
<b>3-3. Anatomy and Physiology of the Reproductive and Edocrine Systems.....</b>	<b>3-13</b>
224. Male reproductive system.....	3-13
225. Female reproductive system .....	3-15
226. Endocrine system.....	3-18

**T**he human body is a complex organization that uses systems that work side by side to help humans function. This unit addresses the more major systems in the the human body. This unit focuses on the digestive system, the urinary system, the male and female reproductive systems, and the edocrine system.

### 3-1. Anatomy and Physiology of the Digestive System

The digestive system is composed of organs that process the body's nutritional needs through the mechanical and chemical breakdown of food products. It also distributes nutrients to the body and assists in the elimination of waste products.

#### 220. Anatomy of the digestive system

The entire digestive system can be divided into two main areas. These areas are the alimentary canal and the accessory organs. In this lesson, you will first learn the location of organs in the abdomen. Then you will study the anatomical structure of the alimentary canal.

#### Location of organs in the abdomen

To make identifying the location of various organs easier, the abdomen is divided into four quadrants:

1. Right upper quadrant (RUQ).
2. Left upper quadrant (LUQ).
3. Right lower quadrant (RLQ).
4. Right lower quadrant (RLQ).

Some organs cross over into more than one of the quadrants. The following table identifies the location of organs that serve a function in the digestive system:

Right Upper Quadrant	Left Upper Quadrant
Largest portion of the liver	Small portion of the liver
Gallbladder	Stomach
Portion of the pancreas	Portion of the pancreas
Portion of the transverse colon	Portion of the transverse colon
Portion of the small intestine	Portion of the small intestine
Right Lower Quadrant	Left Lower Quadrant
Cecum	Descending colon
Appendix	Sigmoid colon
Ascending colon	Portion of the small intestine
Portion of the small intestine	

**NOTE:** A thin membrane called the peritoneum lines the abdominal cavity and covers most of the organs within it.

### **Alimentary canal**

The alimentary canal is a muscular tube that is approximately 30 feet long (fig. 3-1). It begins at the mouth; extends through the pharynx, esophagus, stomach, small intestine and large intestine; and terminates at the anus. The wall of the alimentary canal is composed of four layers: serous, muscular, submucosa, and mucous membrane. Serous is the outer covering of the tube. It is composed of epithelial and connective tissues. This layer helps secretions to occur. It also keeps the tube lubricated so organs in the abdominal cavity can slide easily against each other. The second layer is the muscular, which consists of two coats of smooth muscle tissue. This layer is responsible for the movement of substances in the alimentary canal. The submucosa, the third layer, contains blood vessels, nerves, glands and lymphatic vessels. The mucous membrane is the inner lining of the tube. This layer assists in both the absorption and secretion digestive processes.

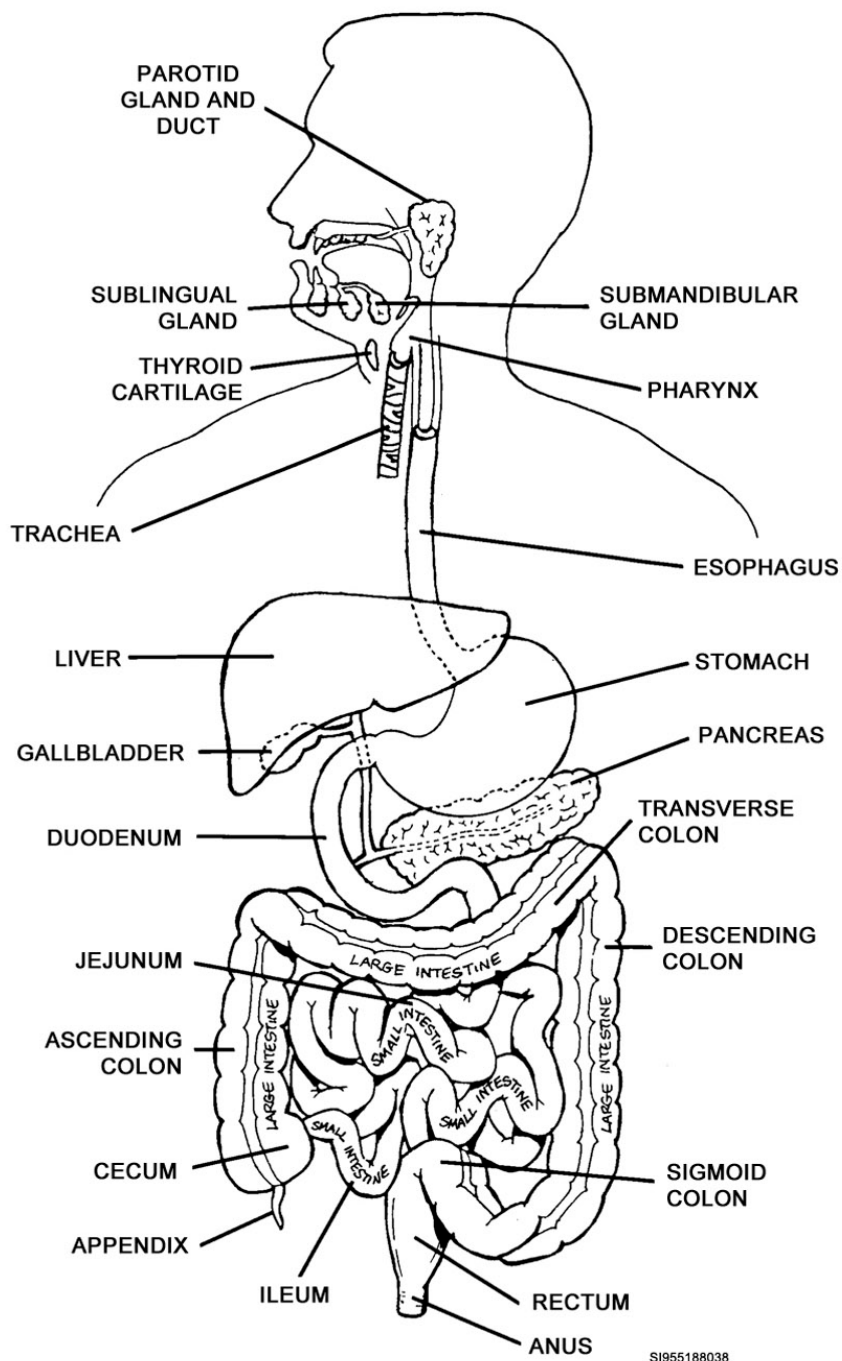


Figure 3-1. Digestive System

### Mouth

The mouth receives food and begins the process of digestion (figure 3-2). Within the mouth are the teeth, tongue, palate, cheeks and lips. The space within the mouth between the palate (roof of the mouth) and tongue is called the *oral cavity*. An additional space, located between the cheeks and teeth, is known as the *vestibule*. Included in the mouth are many small salivary glands located in the tongue, palate and cheeks.

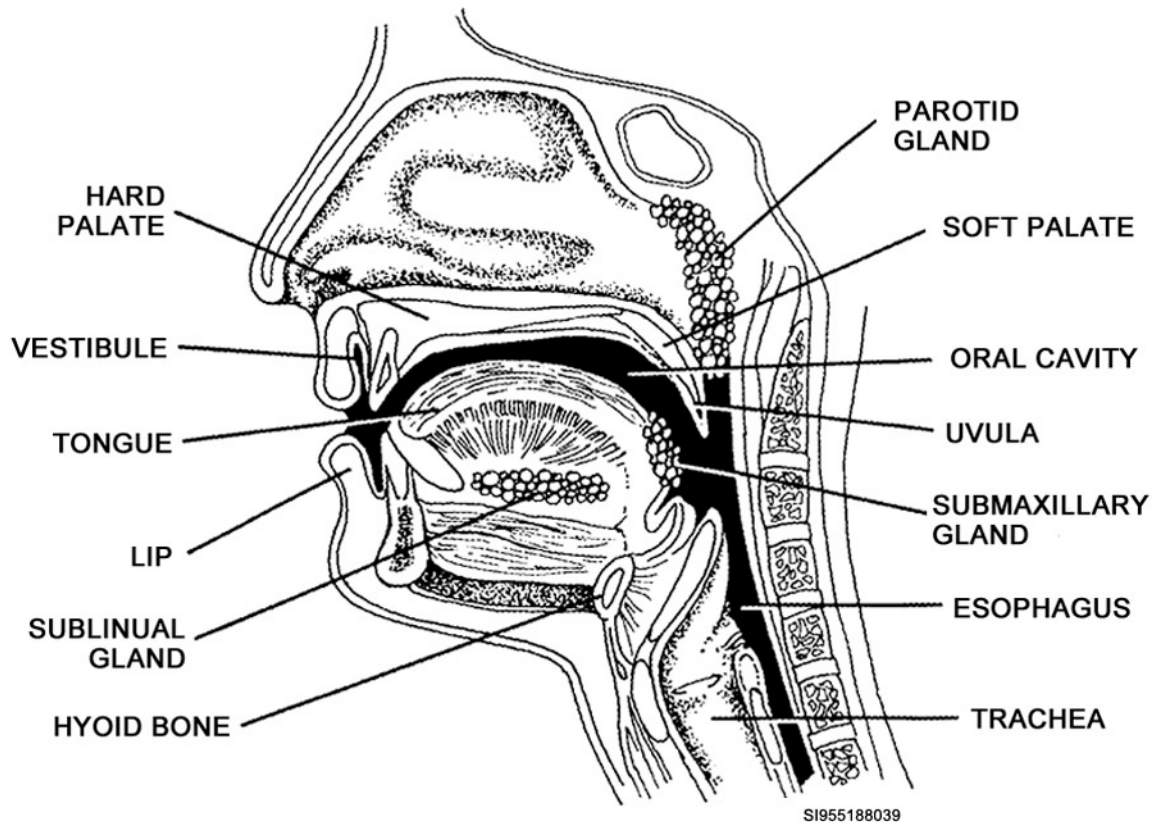


Figure 3-2. Oral cavity

### Teeth

The teeth develop within sockets located in both the mandible (lower jaw) and maxilla (upper jaw). Humans have two sets of teeth that develop during their lifetime. The first set, known as the primary (or deciduous) teeth, erupt at regular intervals between the ages of six months and four years. There are twenty deciduous teeth (ten in the mandible and ten in the maxilla). These teeth usually erupt in the following order, from the jaw midline toward the lateral sides:

Teeth	Number
Central incisors	4
Lateral incisors	4
Cuspids (canine teeth)	4
Second molars	4
Total	20

The deciduous teeth are usually lost in the same order they first appeared. As the secondary (permanent) teeth develop, they push the deciduous teeth out of their sockets (figure 3-3 and 3-4). There are 32 permanent teeth (16 in each jaw). These teeth are listed in the following table.

Teeth	Number
Central incisors	4
Lateral incisors	4
Cuspids	4
First bicuspid	4
Second bicuspid	4

First molars	4
Second molars	4
Third molars	4
Total	32

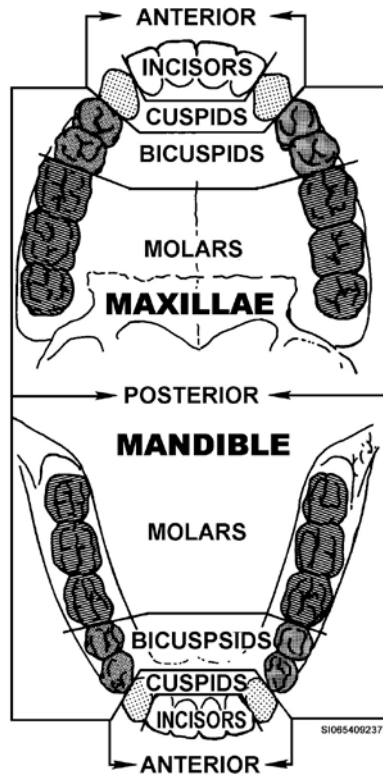


Figure 3-3. Teeth

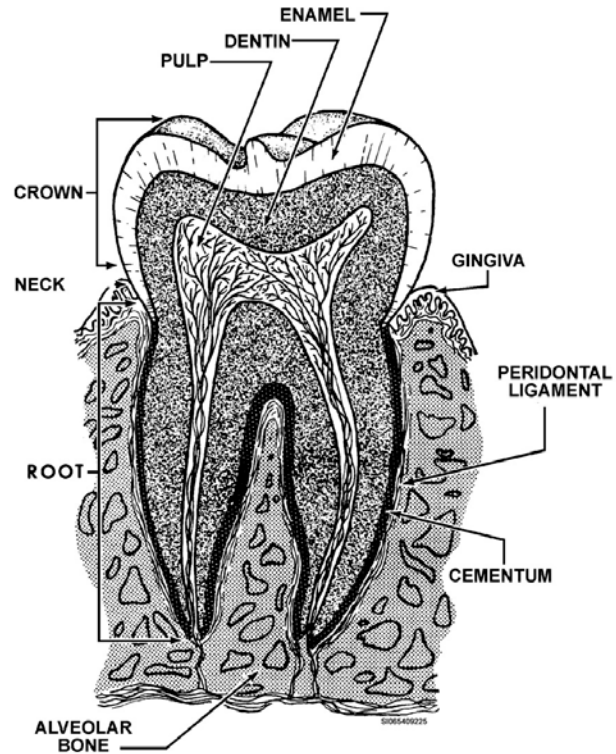


Figure 3-4. Anatomy of a tooth.

### *Tongue*

The tongue is a large muscular structure located on the floor of the mouth and occupies most of the oral cavity (figure 3-5). It is made up of intrinsic and extrinsic skeletal muscles. Intrinsic muscles are located completely (origin and insertion) within the tongue. The intrinsic muscle fibers run in all directions and enable the tongue to change size and shape. Extrinsic muscles originate in the mandible, temporal and hyoid bones and they insert in the tongue. They enable the tongue to move up, down or sideways within the mouth. The tongue is attached to the floor of the mouth by a fold of mucous membrane called the frenulum. The tongue is covered by a mucous membrane, which has little projections called papillae along its superior surface. The papillae provide friction that helps to hold food on the tongue. They also contain taste buds that stimulate the salivary and gastric glands.

The tongue is an important structure for both speech and digestion. It moves the food around, mixes it with saliva during chewing, and helps with swallowing by pushing the food back toward the pharynx. It helps with speech by altering the sounds as they come out through the pharynx.

### Pharynx

The pharynx is a cavity located posterior to the mouth. It serves as a passageway from the mouth to the esophagus. It is divided into three parts: nasopharynx, oropharynx, and laryngopharynx. The nasopharynx is above the palate and provides a passageway for air during respiration. The eustachian tube from the middle ear passes through the nasopharynx and connects with the pharynx. The oropharynx is behind the palate and extends downward toward the epiglottis. It functions as a passageway for both food and air. The laryngopharynx is below the oropharynx and extends from the epiglottis to the larynx, where it joins with the esophagus.

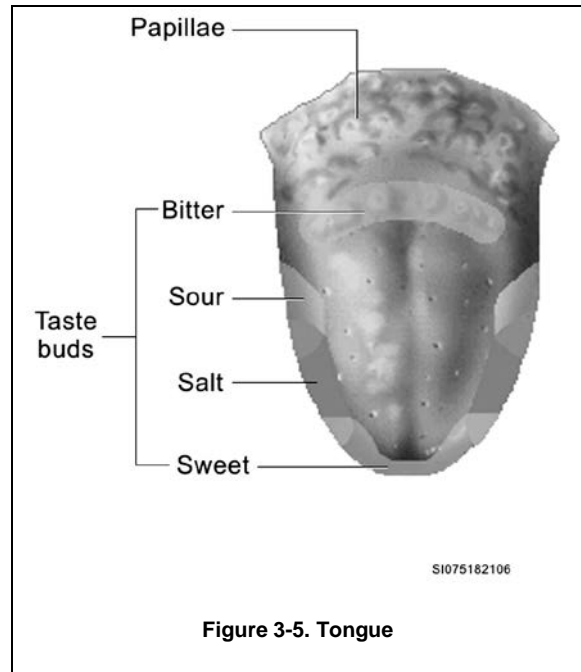


Figure 3-5. Tongue

### Esophagus

This organ is a straight, muscular tube that is approximately 10 inches long. It extends from the pharynx to the stomach and is located *posterior* to the trachea. A portion of the esophagus penetrates the diaphragm through an opening called the *esophageal hiatus*.

### Stomach

The stomach is a hollow, muscular organ that is approximately 10–12 inches long; and it can hold 1 liter (or more) of contents. The stomach is located below the diaphragm in the upper left quadrant of the abdominal cavity. The inner lining of the stomach contains many small openings called *gastric pits*, which are actually the open ends of many tubular gastric glands.

The stomach consists of four specific regions: the cardiac, fundic, body, and pyloric. Cardiac region is near the esophagus. At the point where the esophagus joins with the stomach there is a muscular valve known as the cardiac sphincter. Fundic region extends in a balloon-like manner above the cardiac region. This region is a temporary storage area for food and sometimes it fills with swallowed air. This swallowed air creates a gastric air bubble, which is often used as a landmark for abdominal x-rays. Body region is the main part of the stomach. It is located between the fundic and pyloric regions. Pyloric region becomes narrow and joins with the small intestine. A muscular valve, called the pyloric sphincter, is located between the pyloric region and the small intestine.

### Small intestine

The small intestine is a tubular organ that is approximately 18 to 20 feet long. It extends from the pyloric sphincter to the large intestine and it coils throughout most of the abdominal cavity. Throughout the inner lining of the small intestine there are tiny projections called villi. The small intestine is divided into three separate portions:

1. Duodenum is the shortest portion of the small intestine. It joins with the pyloric sphincter and then extends into the jejunum.
2. Jejunum is the middle portion.
3. Ileum connects to the large intestine through a valve known as the *ileocecal valve*.



### Large intestine

The large intestine is simply larger in diameter than the small intestine. It is approximately 5 feet long and has four portions: the cecum, colon, rectum, and anal. Cecum connects with the ileocecal valve of the small intestine. One end of the cecum extends downward to a closed end of the large intestine, which is called the appendix. The other side of the cecum connects to the second portion of the large intestine, which is called the colon. Colon is divided into four distinct portions that are named according to their location in the abdominal cavity. The first portion of the colon is the *ascending colon*, which extends upward through the right lower quadrant. It then becomes the *transverse colon* as it travels across the abdominal cavity. The transverse colon then turns downward through the left lower quadrant to become the third portion, which is called the *descending colon*. The descending colon makes an S-shaped curve and then becomes the final part, which is known as the *sigmoid colon*. The sigmoid colon then joins with the third portion of the large intestine, the rectum. Rectum extends below the tip of the coccyx and leads to the final portion of the large intestine, the *anal canal*. Anal canal is actually the last 1 to 1½ inches of the large intestine. The anal canal extends to the outside of the body through an opening called the *anus*. Two muscles protect this opening. The internal anal sphincter is composed of smooth muscle and is under involuntary control. The external anal sphincter is composed of skeletal muscle and is under voluntary control.

### Accessory organs of the digestive system

The pancreas, liver, and gallbladder serve as accessory organs of the digestive system (fig. 3-6). The pancreas is located in the central portion of the abdomen, between the duodenum and the spleen. A duct, known as the pancreatic duct, extends into the duodenum. The pancreas also serves a function in the endocrine system. Most of the liver is located in the RUQ of the abdomen and it extends toward the center of the abdominal cavity just below the diaphragm. Veins from the digestive system lead to the liver. Ducts lead from the liver to the gallbladder. The gallbladder is a small, pear-shaped organ that is located along the inferior surface of the liver. It has a capacity to hold approximately 30 to 50 milliliters of fluid. Ducts lead from the gallbladder to the duodenum.

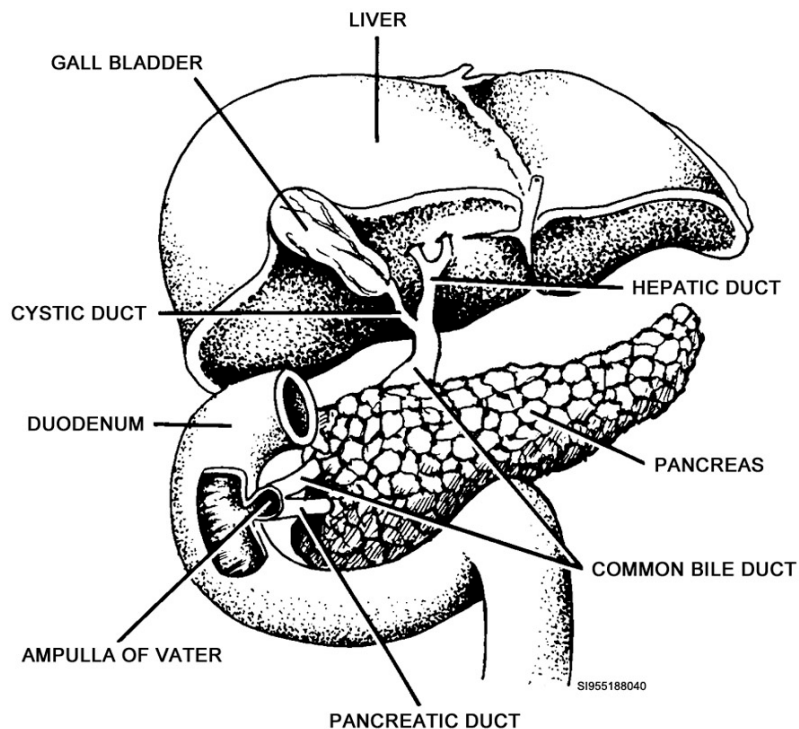


Figure 3-6. Accessory organs

## 221. Physiology of digestion

Digestion is the process by which food is broken down mechanically and chemically for use by the body. The process of digestion begins in the mouth and is completed when solid waste products are expelled from the body.

### Processes in the mouth

In the mouth, large food particles are mechanically reduced in size by the teeth through a chewing action. Taste buds located on the surface of the tongue connect to nerve endings that transmit the sensations of sweet, salty, sour, and bitter to the brain. The salivary glands in the mouth secrete saliva that helps to moisten the food particles and facilitate swallowing. Swallowing is accomplished as the tongue pushes the food back into the pharynx. The pharynx then contracts and pushes the food into the esophagus. Involuntary muscle contractions of the esophagus move the food toward the stomach. This wave-like motion is known as *peristalsis*.

### Processes in the stomach

Once the food enters the stomach, the cardiac sphincter valve prevents the food from pushing up into the esophagus. Then the stomach muscles churn the food to reduce its size even more. As this occurs, gastric juices from the inner lining of the stomach are secreted and mixed with the food. The result is a semiliquid substance called *chyme*. The chyme is then pushed from the stomach through the pyloric sphincter valve and into the duodenum of the small intestine.

### Processes in the small intestines

Once the chyme is in the duodenum, a liquid known as *bile*, which is produced by the liver and stored in the gallbladder, is added. Additional juices from both the pancreas and small intestines are also added. All of these digestive juices help to further the break down of the chyme through chemical actions. The villi that line the intestines assist in movement and absorption of the contents of the small intestines.

Peristalsis causes the chyme to continue through the jejunum and ileum. During this process, the villi that line the small intestines absorb nutrients from the chyme for use by the body. These nutrients are then passed to capillaries, making it possible for the nutrients to enter the circulatory system for distribution throughout the body.

### Processes in the large intestines

Undigested chyme passes from the ileum in the small intestines to the cecum in the large intestines, where peristalsis continues to move the chyme. The colon absorbs beneficial water for use by the body and the remaining waste substance (which is called feces) passes on through the colon and into the rectum. Finally, the feces are expelled from the body through the anal canal.

---

## Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

## 220. Anatomy of the digestive system

1. What is contained in the third layer of the alimentary canal wall?
2. What are “deciduous” teeth?



3. What portion of the pharynx is located behind the palate and serves as a passageway for food and air?
4. What quadrant is the stomach located in?
5. Where is the gall bladder located?

### **221. Physiology of digestion**

1. What are the involuntary muscle contractions that move food from the esophagus to the stomach?
2. Where is bile produced and stored?
3. What is the function of the villi in the small intestine?

## **3-2. Anatomy and Physiology of the Urinary System**

This unit focuses on the structure of the urinary system, the important role it plays in the human body. Though other systems play a role in eliminating waste products from the body, the urinary system is the only system with that function as its primary responsibility. The urinary system removes waste from the body only through the proper functioning of all of the system components. In this section, you will learn about the anatomy of the urinary system and read a brief introduction to the intricate physiological processes involved in this function that is vital for human survival.

### **222. Anatomy of the urinary system**

The urinary system consists of four main parts; the kidneys, ureters, urinary bladder and urethra (fig. 3-7). Each of these parts plays an important role in removing waste from the body. After reading and studying this lesson, you will know where these parts are, what they look like, and how they work together to remove waste.

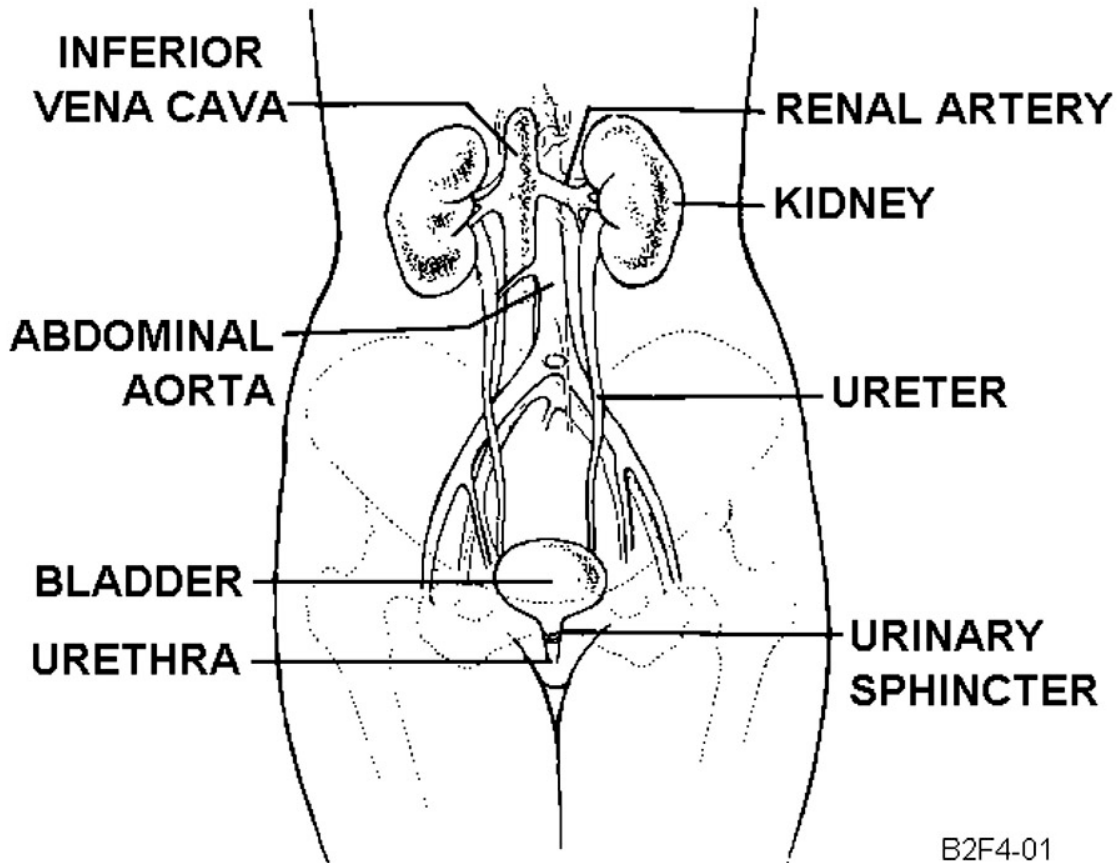


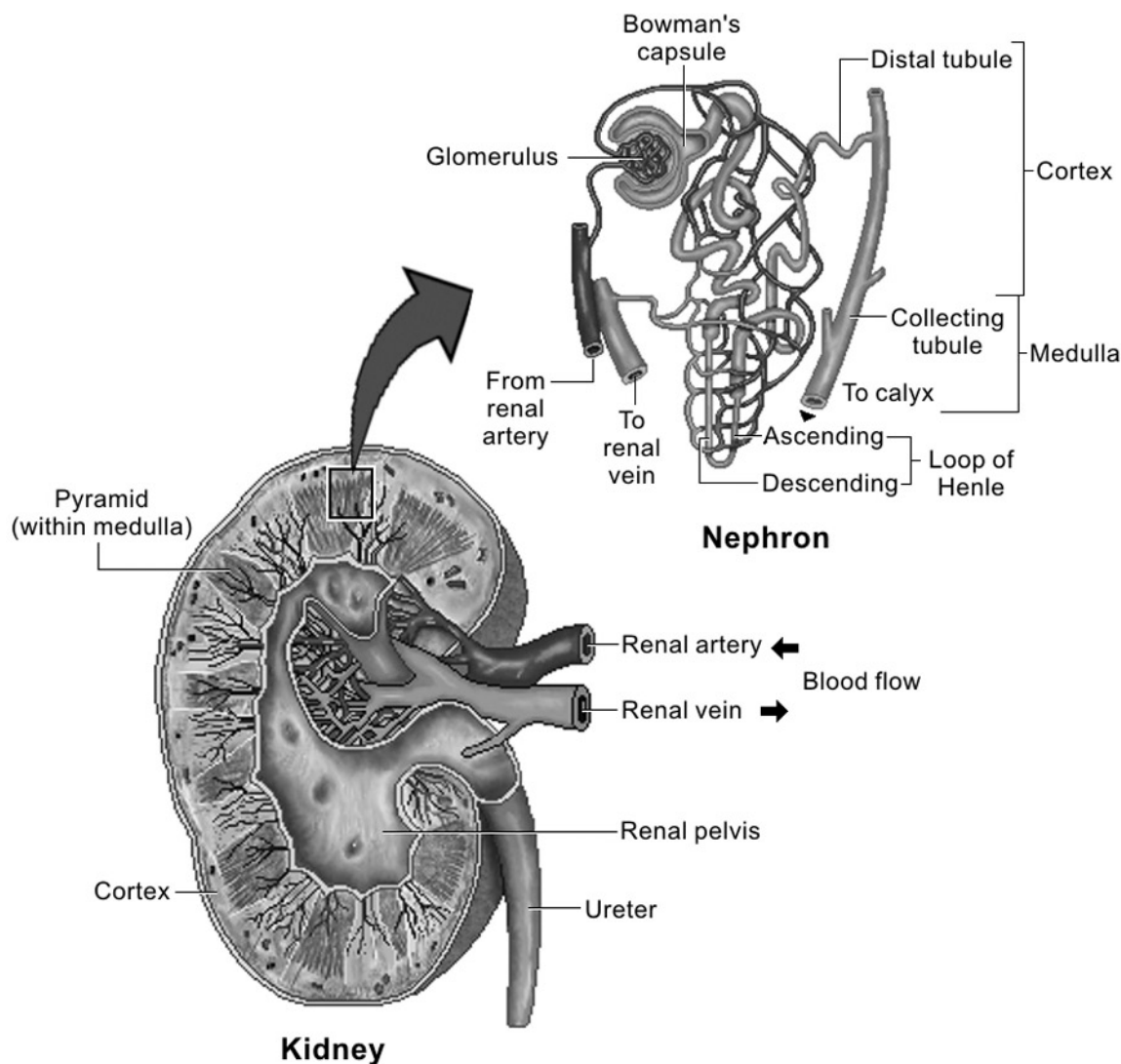
Figure 3-7. Anatomy of the urinary system

### Kidneys

The human body has two kidneys, each of which, in adults is approximately 12 centimeters long, 6 centimeters wide and 3 centimeters thick. The kidneys are bean-shaped organs that are located in the superior portion of the posterior abdominal cavity (near the back). Specifically, the kidneys lie on either side of the spinal column and extend from near the twelfth thoracic vertebrae to the third lumbar vertebrae. As you can quickly surmise, very little protection is provided to the kidneys, except from the lower ribs. These are important facts for you to remember when assessing patients for pain or injury in this area of the back.

The *renal pelvis* is the concave or indented portion of the kidneys, where blood vessels, lymphatic vessels, nerves and the ureter connect to the kidney (fig. 3-8). These structures enter into a hollow chamber known as the *renal sinus*. Within each kidney there are two main areas. The outer area is the *renal cortex* and the inner portion is the *renal medulla*. The primary purpose of the renal cortex is to protect the vital kidney functions that occur within the renal medulla.

Each kidney contains approximately one million microscopic structures called *nephrons*. The nephrons make up the complex filtration system that performs the primary function of the kidneys. A nephron is composed of a cluster of capillaries called a *glomerulus*. The glomerulus is enclosed within a thin sac called the *Bowman's capsule*. A tiny system of coiled tubules leads to and from the glomerulus.



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Figure 3-8. Kidney and Nephron

### Ureters

Extending from the renal pelvis of each kidney is a tubular structure known as the *ureter*. In adults, each ureter is approximately 10 inches long. The ureters are muscular organs that provide a passage for urine from the kidneys to the urinary bladder. A flap of mucous membrane is located at the distal end of each ureter.

### Urinary bladder

This organ is a hollow, muscular structure located in the pelvic cavity. The shape of the bladder varies, depending on the amount of urine it contains.

### Urethra

The urethra is the final passageway urine passes through. It leads from the bladder to the exterior of the body. In adult males, the urethra is approximately 6 inches long; in females, it is approximately 1½ inches long. The urethra leads to the exterior of the body through an opening called the *urinary meatus*. In both the male and female, there are two sphincter muscles in the urethra. The *internal sphincter* is an involuntary muscle located at the base of the bladder. The *external sphincter* is under

voluntary control. In females, it is located at the midpoint of the urethra; in males, it is located near the distal end of the urethra.

### **223. Physiology of the urinary system**

As you read, the following brief explanation of the physiology of this system, you will easily understand how the entire body can be adversely affected if the urinary system is not functioning properly.

Once the blood enters the urinary system, it undergoes a final filtration process. The nephrons within each kidney filter the blood to remove metabolic waste products and to regulate water and electrolyte concentrations within the body fluids. As the blood enters the glomerulus, it is filtered by the capillaries there. The remaining fluid waste is squeezed into the Bowman's capsule. This waste, known as urine, collects in the renal pelvis of each kidney. From the kidneys, the urine then enters the ureters.

The ureters move the urine toward the urinary bladder through a muscular peristaltic motion. At the distal end of each ureter, urine is expelled into the urinary bladder. The flap of mucous membrane at the end of each ureter permits the urine to enter the bladder and prevents backflow into the ureters.

The bladder stores urine and will send a signal to the spinal cord when it becomes full, to signal the need for emptying. The signal usually occurs when the bladder contains approximately 250 milliliters of urine. The adult urinary bladder can hold 1,000 to 1,800 milliliters of urine. The urethra carries the urine from the bladder to the outside of the body. The meatus is the exit point for urination. The internal sphincter relaxes in response to the micturition (urinating) reflex. Voluntary contraction of the external sphincter stops the expulsion of urine. Relaxing the external sphincter starts the flow of urine for excretion.

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## **Self-Test Questions**

**After you complete these questions, you may check your answers at the end of the unit.**

### **222. Anatomy of the urinary system**

1. Where are the kidneys located?
2. What is the concave portion of the kidney called?
3. Between what two parts of the urinary system do the ureters extend?
4. What is the approximate length of the female urethra?

### **223. Physiology of the urinary system**

1. What happens to the fluid waste that is filtered from the blood by capillaries in the glomerulus?
2. What is the capacity of an adult's urinary bladder?

3. What is the final step of the urination process?

### 3-3. Anatomy and Physiology of the Reproductive and Endocrine Systems

Some of the organs in the male reproductive system play a dual role in both the function of this system, as well as in the function of the urinary system. The female reproductive system performs many functions, beginning with conception and continuing through to the nourishing a newborn. In this section, you will learn a bit more about the various components of these systems.

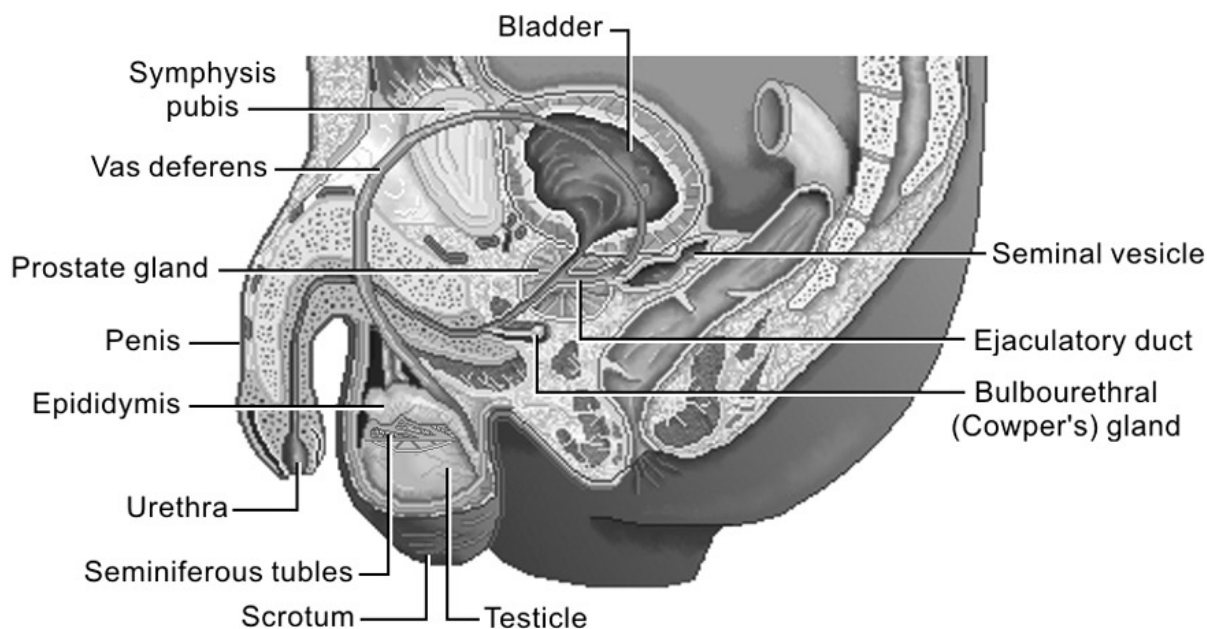
The endocrine system works with the nervous system to direct body functions. The nervous system communicates with the body by sending impulses through the nerves, while the endocrine system controls functions and helps to maintain stabilization by releasing hormones. In this section, you will also learn something about all of the major glands that make up the endocrine system.

#### 224. Male reproductive system

Some of the organs in the male reproductive system also play a role in urinary system function. The various components of the male reproductive system are discussed in this lesson.

##### Anatomy of the male reproductive system

The components of the male reproductive system are divided into two groups: the primary sex organs (the two testes) and the accessory sex organs (fig. 3-9). Accessory sex organs are further divided into two groups: internal organs and external organs.



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Figure 3-9. Male reproductive system.

##### Primary sex organs

The testes are two oval-shaped structures. They are made of a tough, fibrous capsule composed of connective tissue. Within the testes, there are many coiled tubules called *seminiferous tubules*.

**Internal accessory sex organs**

The six male internal accessory sex organs are described in the table on the next page.

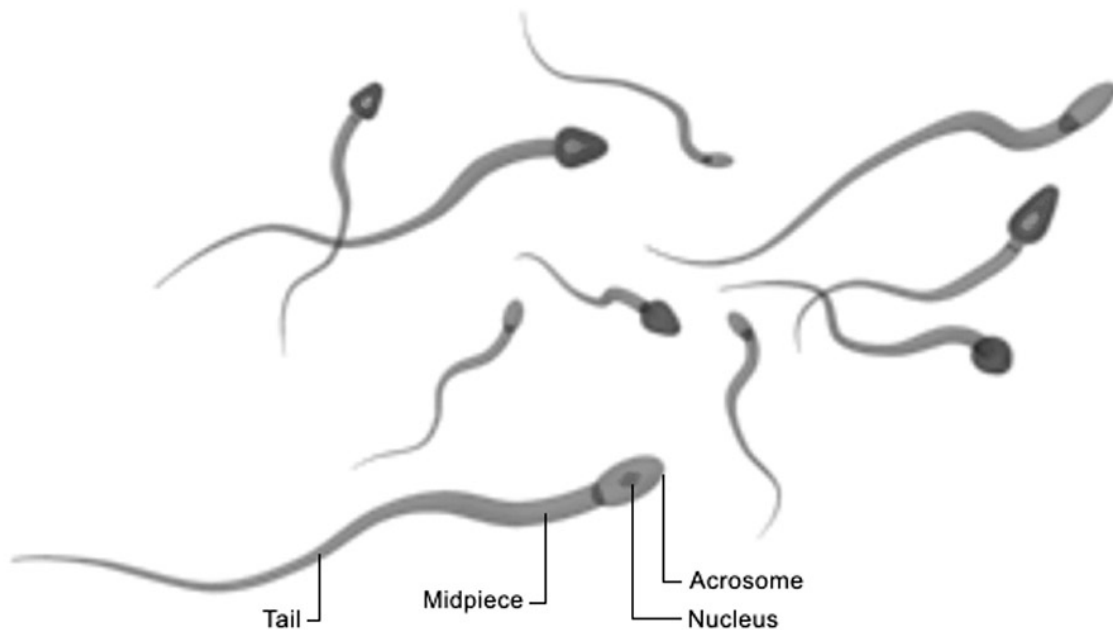
Organ	Description
Epididymis	Coiled tubule that is located on the top and to the side of each testis.
Vas deferens	A tubule that connects the epididymis with the seminal vesicle.
Seminal vesicles	Passageways that lead from the vas deferens. The ducts of these vesicles unite to form the ejaculatory duct.
Ejaculatory duct	The part of the system that passes through the prostate gland and on to the urethra.
Prostate gland	A semiround organ that surrounds the beginning of the urethra, just below the urinary bladder.
Urethra	Tubule that leads from the urinary bladder to the exterior of the body.

**External accessory sex organs**

Two external organs, the penis and scrotum, are part of the accessory sex organs in the male. The penis is composed of both erectile and connective tissue. Erectile tissue is comprised mainly of masses of blood vessels. The distal end of the penis is called the *glans penis*. A loose flap of skin, known as the *foreskin*, covers the glans penis. The surgical removal of the foreskin is called a *circumcision*. The urethra extends along the lower interior surface of the penis and opens to the exterior of the body through an opening called the *external urinary meatus*. The scrotum is made of both skin and muscle. This sac-like structure contains the two testes.

**Physiology of the male reproductive system**

The purpose of the male reproductive system is to produce male sex cells (sperm cells), transport these cells to the female reproductive system, and secrete male sex hormones within the body (figure 3-10). Sperm cells are produced in the testes and transported to the epididymis where they mature. During sexual stimulation, the sperm cells are forced through the vas deferens to the ejaculatory duct. Additional fluid is secreted from the seminal vesicles to help carry the sperm through the ejaculatory duct.



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Figure 3-10. Sperm cells.

The prostate gland also secretes a fluid into the ejaculatory duct that helps protect the sperm from acidic secretions present in the female vagina. The sperm and fluid secretions (semen) are then released into the vagina during sexual intercourse.

The testes are the primary male sexual characteristic. An additional physiological role of the male reproductive system is to produce secondary male sexual characteristics. This is accomplished by the production of the male hormone testosterone. Testosterone is responsible for the following male characteristics:

- Growth of body hair.
- Thickening of the skin.
- Thickening and strengthening of the bones.
- Enlargement of the larynx and thickening of the vocal cords, which result in a lower-pitched voice.
- Increased muscle growth, and development of broader shoulders and a relatively narrow waist.

### 225. Female reproductive system

Various organs work together to make up the anatomy of the female reproductive system (fig.3-11). As in the male, the female organs are divided into two main categories: the primary sex organs (ovaries) and the internal and external accessory organs.



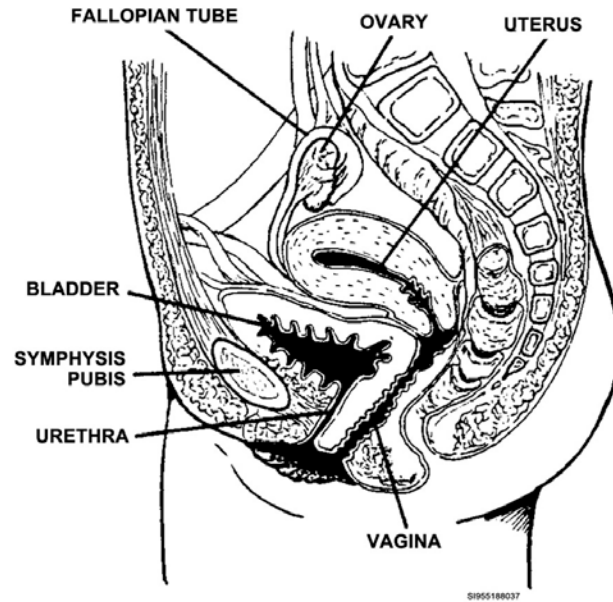


Figure 3-11. Female reproductive system.

### Primary sex organs

The two ovaries are solid, round-shaped structures. Both ovaries are located inside the lateral wall of the pelvic cavity. The ovaries are held in position by several ligaments. Each ovary has two main parts: an *inner medulla* and an *outer cortex*.

### Internal accessory sex organs

The three female internal accessory sex organs include the *fallopian tubes*, *uterus* and *vagina*. Let's take a quick look at each of these organs (figure 3-12).

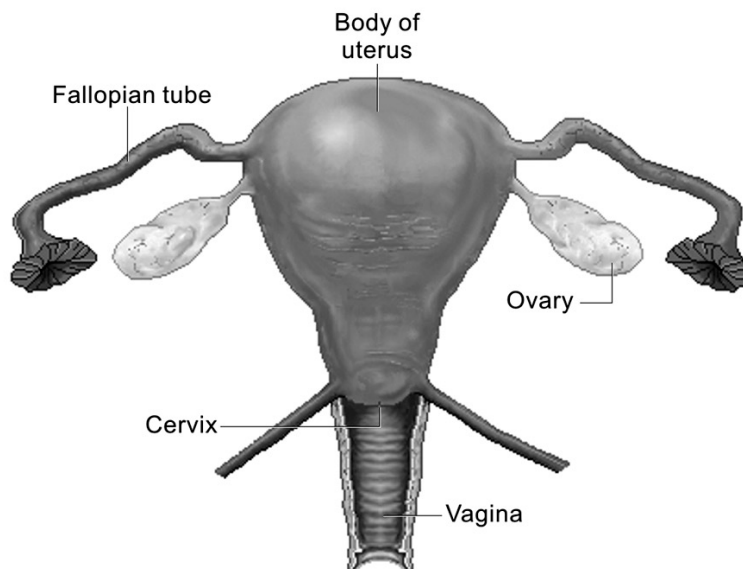


Figure 3-12. Accessory sex organs



### **Fallopian tubes**

There are two fallopian tubes, each of which is approximately four inches long. They extend from the uterus to the ovaries, with the open end of each tube located near an ovary. The openings in the fallopian tubes have finger-like extensions called *fimbriae*. One of the longer fimbriae is attached directly to the ovary; the rest of the fimbriae remain free.

### **Uterus**

The uterus is a hollow, muscular, pear-shaped organ. It is located in the anterior portion of the pelvic cavity above the vagina. The upper two-thirds of the uterus is called the *body* and the top of the body is called the *fundus*. The lower third of the uterus is known as the *cervix*. The cervix extends to the vagina.

The uterine wall is divided into three layers; perimetrium, myometrium, and endometrium. Perimetrium is the outer layer that covers the uterine body and part of the cervix. Myometrium is the thick, muscular inner portion of the uterus. Endometrium lines the inner wall of the uterus.

### **Vagina**

The vagina is a tube-like organ that extends from the uterus to the exterior of the body. It is approximately three inches long. The opening of the vagina is called the vaginal orifice and it is partially covered by a thin membrane of connective tissue called the hymen.

### **External accessory sex organs**

Four external organs are part of the accessory sex organs in the female. These organs, which are collectively known as the *vulva*, are the labia majora, labia minora, clitoris and vestibule. Labia majora encloses and protects the external reproductive organs. It is actually a large fold of adipose tissue that contains sweat glands, sebaceous glands and hair follicles. The pad of fatty tissue located superior to the labia majora is known as the mons pubis. Labia minora is a layer of connective tissue that contains many blood vessels. It is located beneath the labia majora. Clitoris is a small organ that is made of erectile tissue. It is located anteriorly between the labia minora. Vestibule is the area of the vulva that is enclosed by the labia minora. The vagina opens into the vestibule, as does the urethra. The vestibular glands are within the vestibule.

In addition to these four organs, the mammary glands (breasts) also play an important role in the female reproductive system. Each mammary gland is comprised of numerous irregularly shaped lobes. Each of these lobes is a highly branched gland that has a separate duct leading to the nipple.

### **Menstrual cycle**

The female reproductive system is designed to produce ova, receive sperm from the male for fertilization of the ova, generate the growth of unborn offspring, give birth and nourish the newborn. Once puberty is reached, around the age of 13, the female menstrual cycles begin. This first menstrual cycle is known as *menarche*. The first phase of the cycle begins with menstruation (sometimes called *menses*). Blood, secretions and tissue debris flow from the uterus through the vagina for approximately three to seven days. The second phase of the cycle begins on approximately the 14<sup>th</sup> day, when an egg (ovum) is released from one of the ovaries. This is called ovulation. The ovum travels to the fallopian tube where it awaits possible fertilization by the sperm. If a sperm fertilizes the ovum, the ovum will travel to the uterus where it attaches to the endometrium. Pregnancy has occurred and growth of the fetus begins. If the ovum is not fertilized, the endometrium breaks up and discharges through the vagina on approximately the 28<sup>th</sup> day of the cycle. The entire process is then repeated. The menstrual cycle continues to repeat until the female is in her late forties or early fifties, when she is said to have reached menopause.

## Hormones

During the menstrual cycle, the female hormones estrogen and progesterone are secreted to perform various functions and stimulate changes in the uterine lining. These hormones are also essential in the development of the following secondary sex characteristics in the female:

- Development of pubic hair.
- Development of broader hips and narrower shoulders.
- Increased tissue mass in the hips, abdomen and buttocks.
- Development of the mammary glands.

## 226. Endocrine system

Hormones are chemical substances secreted by certain cells to control various bodily functions. The endocrine system is the network of glands that produce and secrete the hormones. This system of glands and the hormones they produce influence everything that's going on in your body, whether you are digesting your lunch or running from a wild tiger. In this section, you will learn what the glands of the endocrine system are and a little about what each of them does for us.

Each of the glands within the endocrine system secretes a specific hormone (fig. 3-13). These hormones either travel short distances to nearby cells or are released into the bloodstream to travel to other parts of the body. Cells that receive the hormones and act as receptors are known as “target cells.” Though some small, specialized cell groups produce and secrete hormones, this lesson focuses only on the major glands of the body—pituitary, thyroid, parathyroid, adrenal and pancreas.

### Pituitary gland

The pituitary gland is also referred to as the body's “master gland” because of the controlling effect it has on the other glands. This gland is approximately one centimeter in diameter (about the size of a cherry). It is located at the base of the brain and is attached to the hypothalamus. The pituitary gland is divided into two main sections called the anterior lobe and the posterior lobe. The anterior lobe secretes six hormones. The following table explains the function of these hormones:

Hormone	Explanation
Somatotropin (STH)	Also known as the growth hormone (GH). Stimulates cells to increase in size and to divide faster than usual. Accomplishes this by causing amino acids to perfuse cell membranes, resulting in the cells converting the amino acid into protein. Promotes growth of long bones.
Thyroid stimulating hormone (TSH)	Also known as thyrotropin. Controls the release of certain hormones from the thyroid gland.
Adrenocorticotrophic hormone (ACTH)	Controls the release of certain hormones from the adrenal cortex.
Prolactin (PRL)	Promotes the production of maternal milk following childbirth.
Follicle stimulating hormone (FSH)	Stimulates growth and development of egg cell-containing follicles in the ovaries. Stimulates secretion of estrogen.
Luteinizing hormone (LH)	Stimulates the initial production of sperm cells.

The posterior lobe secretes the antidiuretic and oxytocin hormones. The antidiuretic hormone (ADH) reduces the amount of water excreted by the kidneys. High concentrations of this hormone cause the blood pressure to rise. Oxytocin (OT) stimulates uterine wall contractions. It also stimulates contractions within the mammary glands to produce milk.

### Thyroid gland

The thyroid gland is located just below the larynx and anterior to the trachea. It has two large lateral lobes that are attached to a central stem, which gives the thyroid gland a butterfly shape. The thyroid gland secretes three hormones. This table explains the functions of these hormones:

Hormone	Explanation
Calcitonin	Lowers calcium and phosphate concentrations in the blood. Accomplishes this by limiting the release of these substances from the bones and by stimulating the kidneys to excrete excess amounts of the substances.
Thyroxine	Accounts for approximately 95% of the thyroid hormones. Stimulates release of energy from carbohydrates. Increases protein metabolism. Stimulates growth. Stimulates nervous system activity.
Triiodothyronine	Same as thyroxine, but is five times more potent and, therefore, circulated in a much smaller amount.

### Parathyroid glands

There are four parathyroid glands, all of which are located on the posterior surface of the thyroid gland. One parathyroid gland is attached to the top of each lobe of the thyroid gland and one is attached to the bottom of each lobe. These glands secrete one hormone, parathormone. Parathormone stimulates the release of calcium from the bones, causes kidneys to conserve calcium by preventing overexcretion and assists in stimulating the intestines to absorb calcium.

### Adrenal glands

There are two adrenal glands—one on the superior portion of each kidney. Adrenal glands are generally shaped like pyramids. Each adrenal gland has two parts: the adrenal cortex and adrenal medulla.

The adrenal cortex is the outer part of the adrenal glands. It makes up most of the gland and is composed of layers of cells that are packed closely together. The adrenal cortex secretes the aldosterone, cortisol, and sex hormones. Aldosterone helps regulate electrolytes by causing sodium to be reabsorbed and potassium to be excreted. Cortisol promotes the metabolism of proteins and fats. It causes an increase in use of fatty acids for energy and a decrease in use of glucose for energy. Cortisol also promotes an increase in blood glucose concentration. Sex hormones assist in stimulating the development of sex organs.

The adrenal medulla is the inner part of the adrenal glands. It contains irregularly shaped cells that are grouped around blood vessels. This portion of the adrenal gland is connected with the sympathetic nervous system. The adrenal medulla secretes the epinephrine and norepinephrine hormones. Epinephrine increases heart rate by stimulating more forceful contractions. It causes skeletal muscle blood vessels and the airway to dilate. Epinephrine increases the level of blood sugar and the metabolism. Norepinephrine increases the force of heart contractions, but has less effect on heart rate than epinephrine. This hormone causes skin blood vessels to constrict, which results in a greater flow of blood to skeletal muscles. Norepinephrine affects the airway less than epinephrine does and it has little effect on blood sugar level; however, it does increase the metabolism.

### Pancreas

The pancreas is a long, flat organ that lies posterior to the stomach. It is attached to the duodenum by a duct. The portion of the pancreas that functions as part of the endocrine system is called the “Islets of Langerhans.” The Islets of Langerhans contain cells that are closely associated with blood vessels, and secrete three hormones: glucagon, insulin, and somatostatin. Glucagon stimulates the liver to break down fats into fatty acids and glycerol and to convert certain substances into glucose. Insulin regulates metabolism of glucose and inhibits the conversion of certain substances into glucose. Insulin also stimulates the transportation of amino acids into the cells and the storage of fat by adipose cells. Somatostatin helps regulate carbohydrates by inhibiting the secretion of glucagons.

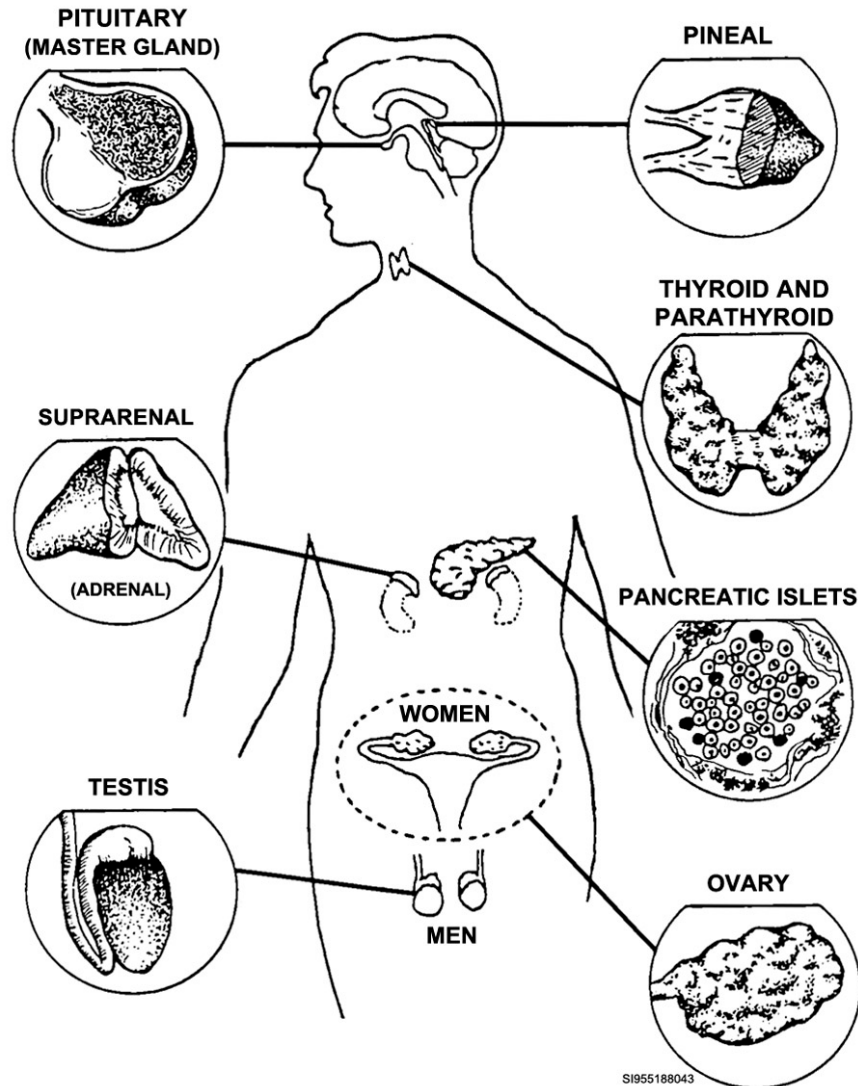


Figure 3-13. Major glands.

### Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

#### 224. Male reproductive system

1. What are the primary male sex organs?
2. What are the two male external accessory sex organs?
3. Where is the prostate gland located?

4. What two male internal accessory sex organs does the vas deferens connect?
5. After sperm cells are produced, where do they mature?
6. Why does the prostate gland secrete fluid into the ejaculatory duct?
7. What male hormone is responsible for certain male characteristics?

### **225. Female reproductive system**

1. What are the primary female sex organs?
2. What holds ovaries in their position?
3. How many layers does the uterine wall have?
4. How many female external accessory organs are there?
5. At what age do females usually reach puberty?
6. What is the first menstrual cycle in the life of a female called?
7. What are the two “female” hormones?
8. When do menses begin?

### **226. Endocrine system**

1. What are cells that act as hormone receptors called?

2. What is the “master gland”?
3. What gland secretes STH?
4. What hormone promotes the production of maternal milk following childbirth?
5. Where are the adrenal glands located?
6. How many hormones are secreted by the Islets of Langerhans?
7. Glucagon has a direct effect on which organ?

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### **Answers to Self-Test Questions**

**220**

1. Contains blood vessels, nerves, glands, and lymphatic vessels.
2. First set of teeth to develop.
3. Oropharynx.
4. Upper left quadrant of the abdominal cavity
5. Along the inferior surface of the liver.

**221**

1. Peristalsis.
2. Produced in the liver and stored in the gallbladder.
3. Assist movement and absorption of nutrients.

**222**

1. In the superior portion of the posterior abdominal cavity.
2. Renal pelvis.
3. Kidneys and bladder.
4. 1½ inches.

**223**

1. It is squeezed into the Bowman’s capsule.
2. 1,000 to 1,800 milliliters.
3. The relaxation of the external sphincter of the urethra.

**224**

1. Testes.
2. Penis and scrotum.
3. Below the urinary bladder.
4. Epididymis and seminal vesicle.
5. Epididymis.
6. To protect sperm from acidic vaginal secretions.
7. Testosterone.

**225**

1. Ovaries.
2. Ligaments.
3. Three.
4. Four.
5. 13 years.
6. Menarche.
7. Estrogen and progesterone.
8. Approximately day 28.

**226**

1. Target cells.
2. Pituitary.
3. Pituitary gland.
4. Prolactin.
5. On the superior portion of each kidney.
6. Three.
7. The liver.

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## Unit Review Exercises

**Note to Student:** Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to a Field Scoring Answer Sheet.

**Do not return your answer sheet to AFCDA.**

72. (220) Where is the sigmoid colon located in the abdominal cavity?
  - a. RUQ.
  - b. LUQ.
  - c. LLQ.
  - d. RLQ.
73. (220) The layer of the alimentary canal that is responsible for movement of substances through the canal is the
  - a. serous.
  - b. muscular.
  - c. submucosa.
  - d. mucous membrane.

74. (220) What part of the alimentary canal is between the pharynx and the stomach?
- a. Jejunum.
  - b. Esophagus.
  - c. Ileocecal valve.
  - d. Pyloric sphincter.
75. (220) The ileocecal valve in the small intestine connects to the
- a. colon.
  - b. cecum.
  - c. jejunum.
  - d. pyloric region.
76. (220) What is the mucous membrane that attaches the tongue to the floor of the mouth?
- a. Septum.
  - b. Papillae.
  - c. Frenulum.
  - d. Gastric gland.
77. (220) What is the difference in the number of primary teeth and the number of permanent teeth a person will develop?
- a. 5.
  - b. 10.
  - c. 12.
  - d. 16.
78. (221) Where will undigested chyme go after leaving the ileum?
- a. Liver.
  - b. Cecum.
  - c. Duodenum.
  - d. Anal canal.
79. (221) Which organ absorbs beneficial water for use by the body?
- a. Ileum.
  - b. Colon.
  - c. Duodenum.
  - d. Small intestines.
80. (221) What gland secretes a substance to moisten food particles and help with swallowing?
- a. Bile.
  - b. Thymus.
  - c. Salivary.
  - d. Adenoid.
81. (221) What liquid is produced by the liver and stored in the gallbladder?
- a. Bile.
  - b. Chyme.
  - c. Saliva.
  - d. Blood.
82. (222) Kidneys are in the posterior abdominal cavity and extend from the
- a. thoracic to the lumbar spinal region.
  - b. thoracic to the coccyx spinal region.
  - c. lumbar to the coccyx spinal region.
  - d. lumbar to the sacrum spinal region.



83. (222) What is the *primary* function of the renal cortex?
- Provide a filtration system.
  - Connect nerves and blood vessels.
  - To hold tiny systems of coiled tubules.
  - Protect kidney functions in the renal medulla.
84. (223) Backflow of urine into the ureters is prevented by
- conscious control.
  - the internal sphincter.
  - the external sphincter.
  - a flap of mucous membrane.
85. (223) The urge to urinate is usually first experienced when the bladder contains *approximately* how many milliliters of urine?
- 50.
  - 250.
  - 500.
  - 600.
86. (223) What part of the kidney filters blood to remove waste and regulate water and electrolyte concentrations?
- Ureter.
  - Cortex.
  - Nephron.
  - External sphincter.
87. (224) The testes are two oval-shaped structures that are made of
- adipose tissue.
  - seminal muscle.
  - connective tissue.
  - seminiferous muscle.
88. (224) The coiled tubule located on the top and to the side of each testis is the
- ejaculatory duct.
  - seminal vesicles.
  - vas deferens.
  - epididymis.
89. (224) What is the tubule that leads from the urinary bladder to the exterior of the body?
- Urethra.
  - Epididymis.
  - Ejaculatory duct.
  - Seminal vesicles.
90. (224) Where are sperm cells produced?
- testes.
  - semen.
  - epididymis.
  - ejaculatory duct.
91. (224) Fluid is secreted from the seminal vesicles to help carry sperm through the
- testes.
  - epididymis.
  - prostate gland.
  - ejaculatory duct.

92. (225) What is the inner wall of the uterus called?
- a. Fundus.
  - b. Perimetrium.
  - c. Endometrium.
  - d. Myometrium.
93. (225) What happens to the ovum after a sperm fertilizes it?
- a. Travels to the uterus and attaches to the endometrium.
  - b. Remains in the ovaries then travels to the perimetrium.
  - c. Travels to the uterus and attaches to the myometrium.
  - d. Remains in the ovaries then attaches to the prometrium.
94. (225) The second phase of the menstrual cycle begins when
- a. fertilization occurs.
  - b. an ovum travels through the fallopian tube.
  - c. an ovum is released from one of the ovaries.
  - d. blood flows from the uterus through the vagina.
95. (225) What is the term used to describe the first menstrual cycle that occurs once puberty is reached?
- a. Ova.
  - b. Menses.
  - c. Estrogen.
  - d. Menarche.
96. (225) What hormone is secreted during the menstrual cycle?
- a. Perimetrium.
  - b. Testosterone.
  - c. Progesterone.
  - d. Prostaglandin.
97. (226) The pituitary gland is divided into two sections called the
- a. Islets of Langerhans.
  - b. cortex and medulla.
  - c. stomatotropin and thyrotropin.
  - d. anterior lobe and the posterior lobe.
98. (226) Which organ secretes the adrenocorticotrophic hormone?
- a. Thyroid gland.
  - b. Adrenal cortex.
  - c. Anterior lobe of the pituitary gland.
  - d. Posterior lobe of the pituitary gland.
99. (226) Which hormone accounts for the majority of the thyroid hormones?
- a. TSH.
  - b. Thyroxine.
  - c. Aldosterone.
  - d. Triiodothyronine.
100. (226) Which part of the adrenal gland makes up most of it?
- a. Adrenal cortex.
  - b. Adrenal medulla.
  - c. Parathyroid.
  - d. Pituitary.

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## Glossary of Abbreviations and Acronyms

<b>ac</b>	Before meals
<b>ACTH</b>	adrenocorticotrophic hormone
<b>AD</b>	Right ear
<b>ADH</b>	antidiuretic hormone
<b>Ad lib</b>	as desired
<b>AS</b>	Left ear
<b>AU</b>	Both ears
<b>Bid</b>	twice a day
<b><math>\bar{c}</math></b>	with
<b>cc</b>	Cubic centimeter
<b>CNS</b>	central nervous system
<b>CSF</b>	cerebrospinal fluid
<b>DNA</b>	deoxyribonucleic acid
<b>EENT</b>	eyes, ears, nose, and throat
<b>FSH</b>	follicle stimulating hormone
<b>GH</b>	growth hormone
<b>GI</b>	gastrointestinal
<b>gtt(s)</b>	drop(s)
<b>JC</b>	The Joint Commission
<b>IM</b>	intramuscular
<b>IV</b>	intravenous
<b>hs</b>	Bed time
<b>kg</b>	kilogram
<b>L</b>	liter
<b>LH</b>	luteinizing hormone
<b>LLQ</b>	left lower quadrant (of the abdomen)
<b>LUQ</b>	left upper quadrant (of the abdomen)
<b>mg</b>	milligram
<b>ml</b>	milliliter
<b>mm</b>	millimeter
<b>NPO</b>	Nothing by mouth
<b>OD</b>	right eye
<b>OS</b>	left eye

<b>OT</b>	oxytocin
<b>OU</b>	both eyes
<b>—</b>	
<b>p</b>	after
<b>po</b>	By mouth
<b>PNS</b>	peripheral nervous system
<b>PRL</b>	prolactin
<b>PRN</b>	As needed
<b>pt</b>	Patient
<b>q</b>	every
<b>qd</b>	Every day
<b>qh</b>	Every hour
<b>q2h</b>	Every 2 hours
<b>qid</b>	Four times a day
<b>qod</b>	Every other day
<b>RBC</b>	red blood cell
<b>RLQ</b>	right lower quadrant (of the abdomen)
<b>RUQ</b>	right upper quadrant (of the abdomen)
<b>s</b>	without
<b>sc</b>	subcutaneous
<b>stat</b>	At once
<b>STH</b>	somatotropin
<b>tab</b>	tablet
<b>Tbs</b>	tablespoon
<b>tid</b>	Three times a day
<b>TSH</b>	thyroid stimulating hormone
<b>tsp</b>	teaspoon
<b>WBC</b>	white blood cell

## **Student Notes**

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