**NONRESIDENT TRAINING COURSE**

**August 2000**

# Hospital Corpsman

## NAVEDTRA 14295

**NOTICE**

Pages 1-29, 1-30, 7-15, and 7-20
must be printed on a
**COLOR** printer.

**Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.**

# PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

**THE COURSE**: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

**THE QUESTIONS**: The questions that appear in this course are designed to help you understand the material in the text.

**VALUE**: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

**THANKS:** A special note of thanks is given to the following activities and their staffs for providing valuable information during the preparation of this course: Bureau of Medicine and Surgery, Washington, DC; Navy Environmental Health Center, Norfolk, Virginia; and Naval Hospital, Pensacola, Florida.

*2000 Edition Prepared by*
*HMCM(SW) Steve Kilroy, USN*
*HMCM(SW) Lawrence A. Yates, USN*
*HMCS(AW) Charla Bethune, USN (Ret.)*

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## Sailor's Creed

**"**I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country's Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all."

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# INSTRUCTIONS FOR TAKING THE COURSE

## ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

## SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

## SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

**Grading on the Internet:** Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the assignments. To submit your assignment answers via the Internet, go to:

**http://courses.cnet.navy.mil**

**Grading by Mail:** When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

**Answer Sheets:** All courses include one "scannable" answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

**Do not use answer sheet reproductions:** Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

## COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

## PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed**

**assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

## COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

## ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

**http://www.cnet.navy.mil/netpdtc/nac/neas.htm**

## STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

**For subject matter questions:**

E-mail: n313.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 2167
DSN: 922-1001, Ext. 2167
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC (CODE N313)
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5000

**For enrollment, shipping, grading, or completion letter questions**

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
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## NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you will receive retirement points if you are authorized to receive them under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 14 points: 12 points upon satisfactory completion of unit 1, assignments 1-8; and 2 points upon satisfactory completion of unit 2, assignment 9. (Refer to *Administrative Procedures for Naval Reservists on Inactive Duty*, BUPERSINST 1001.39, for more information about retirement points.)

## COURSE OBJECTIVES

In completing this nonresident training course, you will demonstrate a knowledge of the subject matter by correctly answering questions on the following subjects: anatomy and physiology; fundamentals of patient care; first aid equipment, supplies, rescue, and transportation; emergency medical care procedures; poisoning, drug abuse, and hazardous material exposure; pharmacy and toxicology; clinical laboratory; medical aspects of chemical, biological, and radiological warfare; diet and nutrition; emergency dental care; preventive medicine; physical examinations; health records; supply; administration; healthcare administration; and decedent affairs.

# Student Comments

**Course Title:** *Hospital Corpsman*

**NAVEDTRA:** 14295 **Date**: _____

**We need some information about you**:

Rate/Rank and Name: _____ SSN: _____ Command/Unit _____

Street Address: _____ City: _____ State/FPO: _____ Zip _____

**Your comments, suggestions, etc**.:

**Privacy Act Statement:** Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.

NETPDTC 1550/41 (Rev 4-00)

# CHAPTER 1

# ANATOMY AND PHYSIOLOGY

Knowledge of how the human body is constructed and how it works is an important part of the training of everyone concerned with healing the sick or managing conditions following injury. This chapter will provide you with a general knowledge of the structures and functions of the body.

The human body is a combination of organ systems, with a supporting framework of muscles and bones and an external covering of skin. The study of the body is divided into three sciences:

**Anatomy**—the study of body structures and the relation of one part to another.

**Physiology**—the study of the processes and functions of the body tissue and organs. Physiology is the study of how the body works and how the various parts function individually and in relation to each other.

**Embryology**—the study of the development of the body from a fertilized egg, or ovum.

## TERMS OF POSITION AND DIRECTION

**LEARNING OBJECTIVE:** *Identify anatomical terms of position and direction.*

The planes of the body are imaginary lines dividing it into sections. These planes are used as reference points in locating anatomical structures. As shown in figure 1-1, the **median**, or **midsagittal**, **plane** divides the body into right and left halves on its vertical axis. This plane passes through the sagittal suture of the cranium; therefore, any plane parallel to it is called a **sagittal plane**. **Frontal planes** are drawn perpendicular to the sagittal lines and divide the body into anterior (front) and posterior (rear) sections. Since this line passes through the coronal suture of the cranium, frontal planes are also called **coronal planes**. The **horizontal**, or **transverse**, **plane**, which is drawn at right angles to both sagittal and frontal planes, divides the body into superior (upper) and inferior (lower) sections.

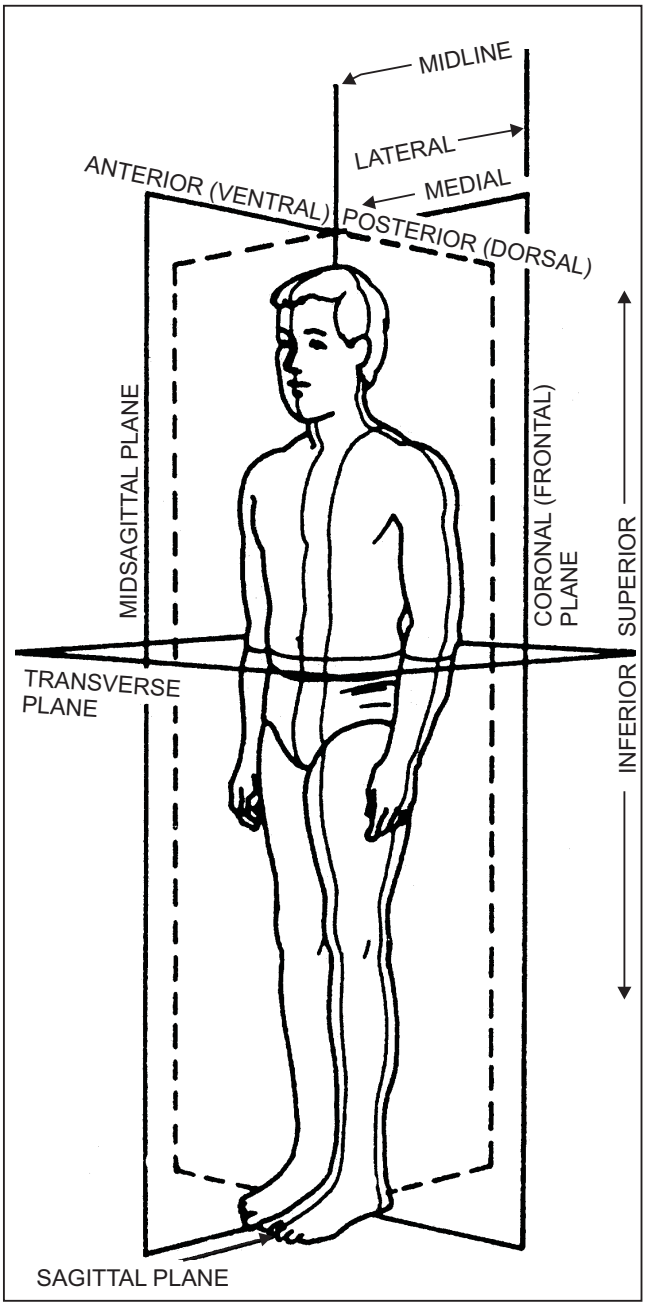


**Figure 1-1.—Planes of the body.**

To aid in understanding the location of anatomical structures, you should use a standard body position called the **anatomical position** as a point of reference. This anatomical position is assumed when the body

stands erect with the arms hanging at the sides and the palms of the hands turned forward (fig. 1-2).

Other commonly used anatomical terms include the following:

**Anterior or ventral**—toward the front, or ventral (pertaining to the belly; abdomen), side of the body.

**Posterior or dorsal**—toward the back, or rear, side of the body.

**Medial**—near or toward the midline of the body.

**Lateral**—farther away from the midline of the body.

**Internal**—inside.

**External**—outside.

**Proximal**—nearer the point of origin or closer to the body.

**Distal**—away from the point of origin or away from the body.

**Superior**—higher than or above.

**Cranial**—toward the head.

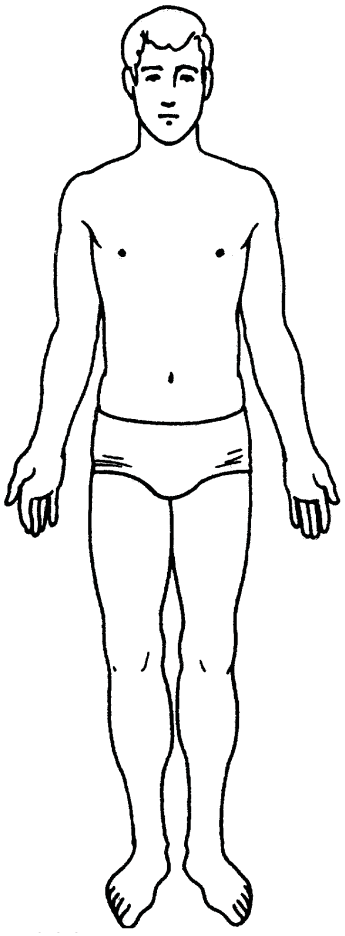

**Figure 1-2.—Anatomical position.**

**Caudal**—toward the lower end of the body.

**Inferior**—lower than or below.

**Erect**—normal standing position of the body.

**Supine**—lying position of the body, face up.

**Prone**—lying position of the body, face down.

**Lateral recumbent**—lying position of the body on either side.

**Peripheral**—the outward part or surface of a structure.

## CHARACTERISTICS OF LIVING MATTER

**LEARNING OBJECTIVE**: *Identify the characteristics of living matter.*

All living things, animals and plants, are organisms that undergo chemical processes by which they sustain life and regenerate cells. The difference between animals and plants is that animals have sensations and the power of voluntary movement, and they require oxygen and organic food. On the other hand, plants require only carbon dioxide and inorganic matter for food and have neither voluntary movement nor special sensory organs.

In man, some of the characteristic functions necessary for survival include **digestion**, **metabolism**, and **homeostasis**. Digestion involves the physical and chemical breakdown of the food we eat into its simplest forms. Metabolism is the process of absorption, storage, and use of these foods for body growth, maintenance, and repair. Homeostasis is the body's self-regulated control of its internal environment. It allows the organism to maintain a state of constancy or equilibrium, in spite of vast changes in the external environment.

## THE CELL

**LEARNING OBJECTIVE:** *Identify the parts of the cell and their functions.*

The cell, the smallest unit of life, is the basic structural unit of all living things and a functional unit all by itself. Cells are composed of a viscid, jellylike substance, called **protoplasm**, upon which depend all the vital functions of nutrition, secretion, growth,

circulation, reproduction, excitability, and movement. Protoplasm, thus, has often been called "the secret of life."

A typical cell is made up of the plasma membrane, the nucleus, and the cytoplasm.

The **plasma membrane** is a selectively permeable membrane surrounding the cell. In addition to holding the cell together, the membrane selectively controls the exchange of materials between the cell and its environment by physical and chemical means. Gases (such as oxygen) and solids (such as proteins, carbohydrates, and mineral salts) pass through the plasma membrane by a process known as **diffusion**.

The **nucleus** is a small, dense, usually spherical body that controls the chemical reactions occurring in the cell. The substance contained in the nucleus is called **nucleoplasm**. The nucleus is also important in the cell's reproduction, since genetic information for the cell is stored there. Every human cell contains 46 chromosomes, and each chromosome has thousands of genes that determine the cell's function.

The **cytoplasm** is a gelatinous substance surrounding the nucleus and is contained by the plasma membrane. The cytoplasm is composed of all of the cell protoplasm except the nucleus.

The simplest living organism consists of a single cell. The amoeba is a unicellular animal. The single cell of such a one-celled organism must be able to carry on all processes necessary for life. This cell is called a **simple** or **undifferentiated cell**, one that has not acquired distinguishing characteristics.

In multicellular organisms, cells vary in size, shape, and number of nuclei. When stained, the various cell structures can be more readily recognized under a microscope. Other differences such as the number and type of cells can be seen with the aid of a microscope. Many cells are highly specialized. **Specialized cells** perform special functions (e.g., muscle cells, which contract, and epithelial cells, which protect the skin).

## TISSUES

**LEARNING OBJECTIVES:** *Identify the types of tissues in the human body and their functions.*

Tissues are groups of specialized cells similar in structure and function. They are classified into four main groups: epithelial, connective, muscular, and nervous.

### EPITHELIAL TISSUE

The lining tissue of the body is called **epithelium**. It forms the outer covering of the body known as the free surface of the skin. It also forms the lining of the digestive, respiratory, and urinary tracts; blood and lymph vessels; serous cavities (cavities which have no communication with the outside of the body, and whose lining membrane secretes a serous fluid), such as the peritoneum or pericardium; and tubules (small tubes which convey fluids) of certain secretory glands, such as the liver and kidneys. Epithelial tissues are classified according to their shape, arrangement, and the function of their cells. For example, epithelial tissues that are composed of single layers of cells are called "simple," while cells with many layers are said to be "stratified." In the following paragraphs we will discuss the three categories of epithelial tissue: columnar, squamous, and cuboidal.

#### Columnar Epithelial Tissue

Epithelial cells of this type are elongated, longer than they are wide. Columnar tissue is composed of a single layer of cells whose nuclei are located at about the same level as the nuclei in their neighboring cells (fig. 1-3). These cells can be located in the linings of the uterus, in various organs of the digestive system, and in the passages of the respiratory system. In the digestive system, the chief function of columnar tissue is the secretion of digestive fluids and the absorption of nutrients from digested foods. In certain areas (such as the nostrils, bronchial tubes, and trachea), this tissue has a crown of microscopic hairlike processes known as **cilia**. These cilia provide motion to move secretions

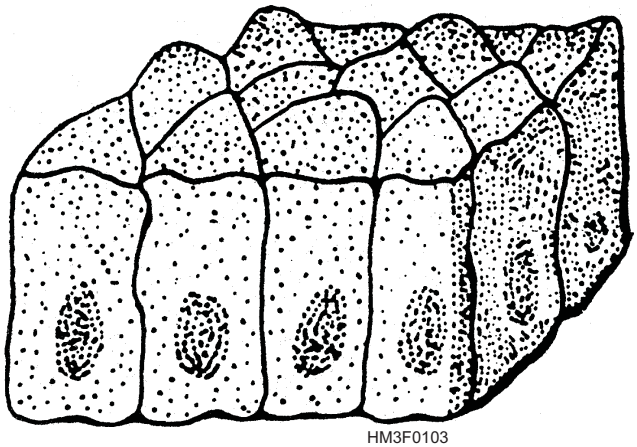


**Figure 1-3.—Columnar epithelial tissue.**

and other matter along the surfaces from which they extend. They also act as a barrier, preventing foreign matter from entering these cavities.

### Squamous Epithelial Tissue

Squamous epithelial tissue is composed of thin platelike or scalelike cells forming a mosaic pattern (fig. 1-4). This tissue is found in the tympanic membrane (eardrum) as a single layer of cells, or in the free skin surface in multiple layers. Squamous tissue is the main protective tissue of the body.

### Cuboidal Epithelial Tissue

The cells of cuboidal tissue are cubical in shape (fig. 1-5) and are found in the more highly specialized organs of the body, such as the ovary and the kidney. In the kidneys, cuboidal tissue functions in the secretion and absorption of fluids.

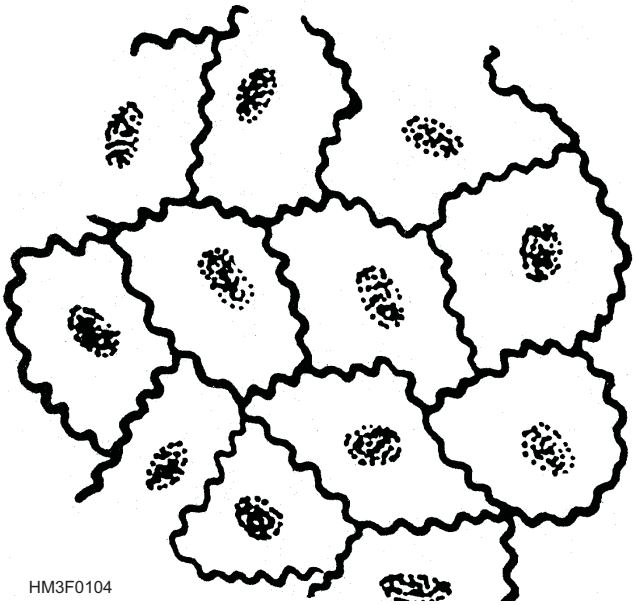


**Figure 1-4.—Squamous epithelial tissue.**

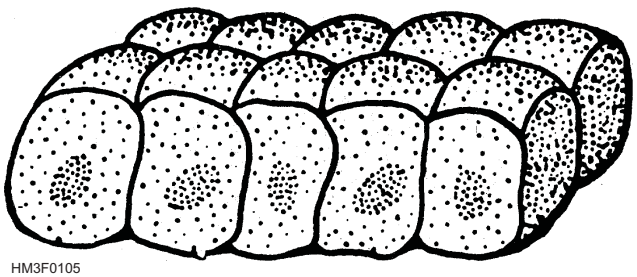


**Figure 1-5.—Cuboidal epithelial tissue.**

## CONNECTIVE TISSUE

This is the supporting tissue of the various structures of the body. It has many variations and is the most widespread tissue of the body. Connective tissue is highly vascular, surrounds other cells, encases internal organs, sheathes muscles, wraps bones, encloses joints, and provides the supporting framework of the body. Structures of connective tissue differ widely, ranging from delicate tissue-paper membranes to rigid bones. Connective tissue is composed of cells and **extracellular materials** (materials found outside the cells). Extracellular materials include fibers and the **ground substance**. The ground substance contains proteins, water, salts, and other diffusible substances. These extracellular materials give connective tissue varying amounts of elasticity and strength, depending on the type of tissue and location. In the following paragraphs we will discuss the three predominant types of connective tissue: areolar, adipose, and osseous.

### Areolar Connective Tissue

Areolar tissue consists of a meshwork of thin fibers that interlace in all directions, giving the tissue both elasticity and tensile strength (fig. 1-6). This type of connective tissue is extensively distributed throughout the body, and its chief function is to bind parts of the body together. Areolar tissue allows a considerable amount of movement to take place because of its elasticity. It is found between muscles and as an outside covering for blood vessels and nerves. The areolar tissue layer connects the blood vessels and nerves to the surrounding structures.


**Figure 1-6.—Areolar connective tissue.**

### Adipose Connective Tissue

Adipose tissue is "fatty tissue." The adipose cell at first appears star-shaped. When the cell begins to store fat in its cytoplasm, it enlarges, losing its star shape as the nucleus is pushed to one side (fig. 1-7). When this process occurs to many cells, the other cell types are crowded out and adipose tissue is formed. Adipose tissue is found beneath skin, between muscles, and around joints and various organs of the body. Adipose tissue acts as a reservoir for energy-producing foods; helps to reduce body heat loss (because of its poor heat conductivity); and serves as support for various organs and fragile structures, such as the kidneys, blood vessels, and nerves.

### Osseous Connective Tissue

This type of tissue, known as "bone tissue," is a dense fibrous connective tissue that forms tendons, ligaments, cartilage, and bones (fig. 1-8). These tissues form the supporting framework of the body.

## MUSCULAR TISSUE

Muscular tissue provides for all body movement. Contracting muscles cause body parts to move. The three types of muscle tissue are skeletal, smooth, and cardiac.

### Skeletal Muscle Tissue

Skeletal (voluntary) muscle fiber is striated, or striped, and is under the control of the individual's will (fig. 1-9). For this reason, it is often called "voluntary" muscle tissue. Skeletal muscle tissues are usually attached to bones. When muscle fibers are stimulated by an action of a nerve fiber, the fibers contract and relax. This interaction between muscle and nervous fibers produces movement.

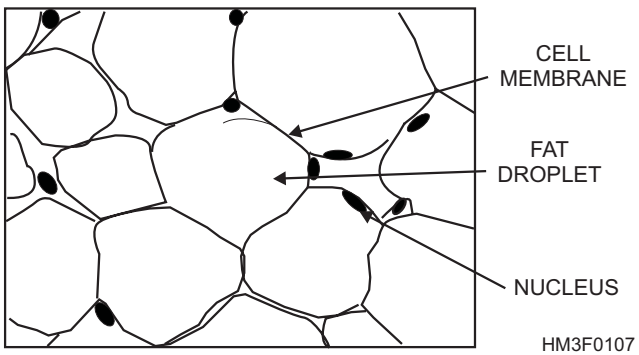


**Figure 1-7.—Adipose connective tissue.**

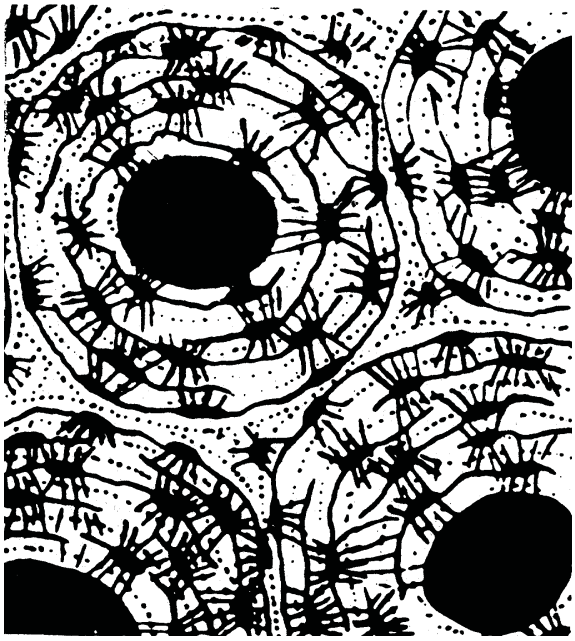


**Figure 1-8.—Osseous (bone) connective tissue.**

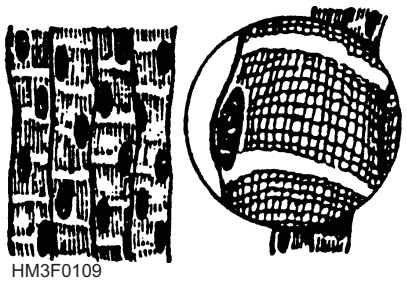


**Figure 1-9.—Skeletal muscle tissue.**

### Smooth Muscle Tissue

These muscle fibers are smooth, or nonstriated, and are not under the control of the individual's will (fig. 1-10). For this reason, this type of muscle tissue is called "involuntary." Smooth muscle tissue is found in the walls of hollow organs, such as the stomach, intestines, blood vessels, and urinary bladder. Smooth muscle tissues are responsible for the movement of food through the digestive system, constricting blood vessels, and emptying the bladder.

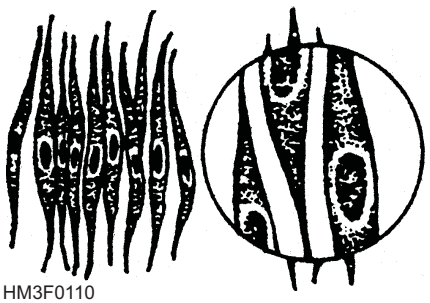


**Figure 1-10.—Smooth muscle tissue.**

### Cardiac Muscle Tissue

The cardiac muscle cells are striated and are joined end to end, resulting in a complex network of interlocking cells (fig. 1-11). Cardiac muscles are involuntary muscles and are located only in the heart. These tissues are responsible for pumping blood through the heart chambers and into certain blood vessels.

### NERVE TISSUE

Nerve tissue is the most complex tissue in the body. It is the substance of the brain, spinal cord, and nerves. Nerve tissue requires more oxygen and nutrients than any other body tissue. The basic cell of the nerve tissue is the **neuron** (fig. 1-12). This highly specialized cell receives stimuli from, and conducts impulses to, all parts of the body.

## ORGANS

**LEARNING OBJECTIVE:** *Recall how organs and body systems are composed of two or more kinds of tissue that perform specialized functions within the body.*

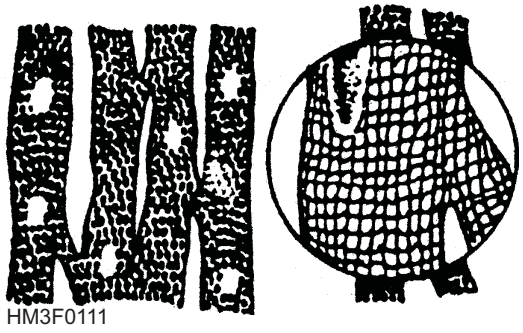


**Figure 1-11.—Cardiac muscle tissue.**

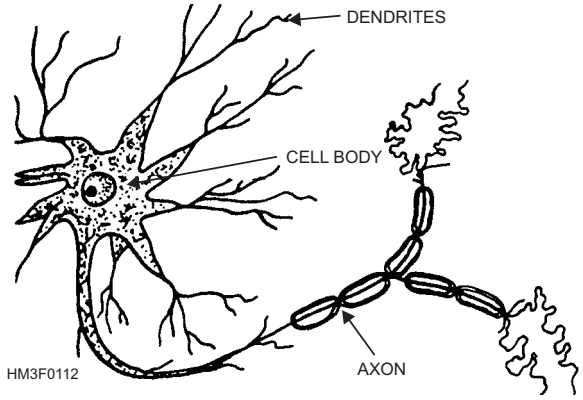


**Figure 1-12.—Neuron.**

As a group of similar cells forms tissues, two or more kinds of tissues grouped together and performing specialized functions constitute an organ. Organs are grouped together to form systems (such as the urinary system, composed of the kidneys, ureters, bladder, and urethra).

## THE SKELETAL SYSTEM

**LEARNING OBJECTIVE:** *Identify the parts of bone and their functions.*

The skeleton, the bony framework of the body, is composed of 206 bones (fig. 1-13). It supports and gives shape to the body; protects vital organs; and provides sites of attachment for tendons, muscles, and ligaments. The skeletal bones are joined members that make muscle movement possible.

### ANATOMY OF BONES

**Osteology** is the study of the structure of bone. Bone is made up of inorganic mineral salts (calcium and phosphorus being the most prevalent) and an organic substance called **ossein**. If human bones were soaked in dilute acid until all inorganic mineral salts were washed out, all that would remain would be a flexible piece of tissue that could be easily bent and twisted. Inorganic mineral salts give bone its strength and hardness.

Bone consists of a hard outer shell, called **compact bone**, and an inner spongy, porous portion, called **cancellous tissue** (fig. 1-14). In the center of the bone is the **medullary canal**, which contains **marrow**. There are two types of marrow, red and yellow. Yellow marrow is ordinary bone marrow in which fat cells predominate. It is found in the medullary canals and cancellous tissue of long bones. Red marrow is one of the manufacturing centers of red blood cells and is found in the articular ends of long bones and in cancellous tissue.

At the ends of the long bones is a smooth, glossy tissue that forms the joint surfaces. This tissue is called **articular cartilage** because it articulates (or joins) with, fits into, or moves in contact with similar surfaces of other bones. The thin outer membrane surrounding the bone is called the **periosteum**. An important function of the periosteum is to supply nourishment to the bone. Capillaries and blood vessels run through the periosteum and dip into the bone surface, supplying it with blood and nutrients. The

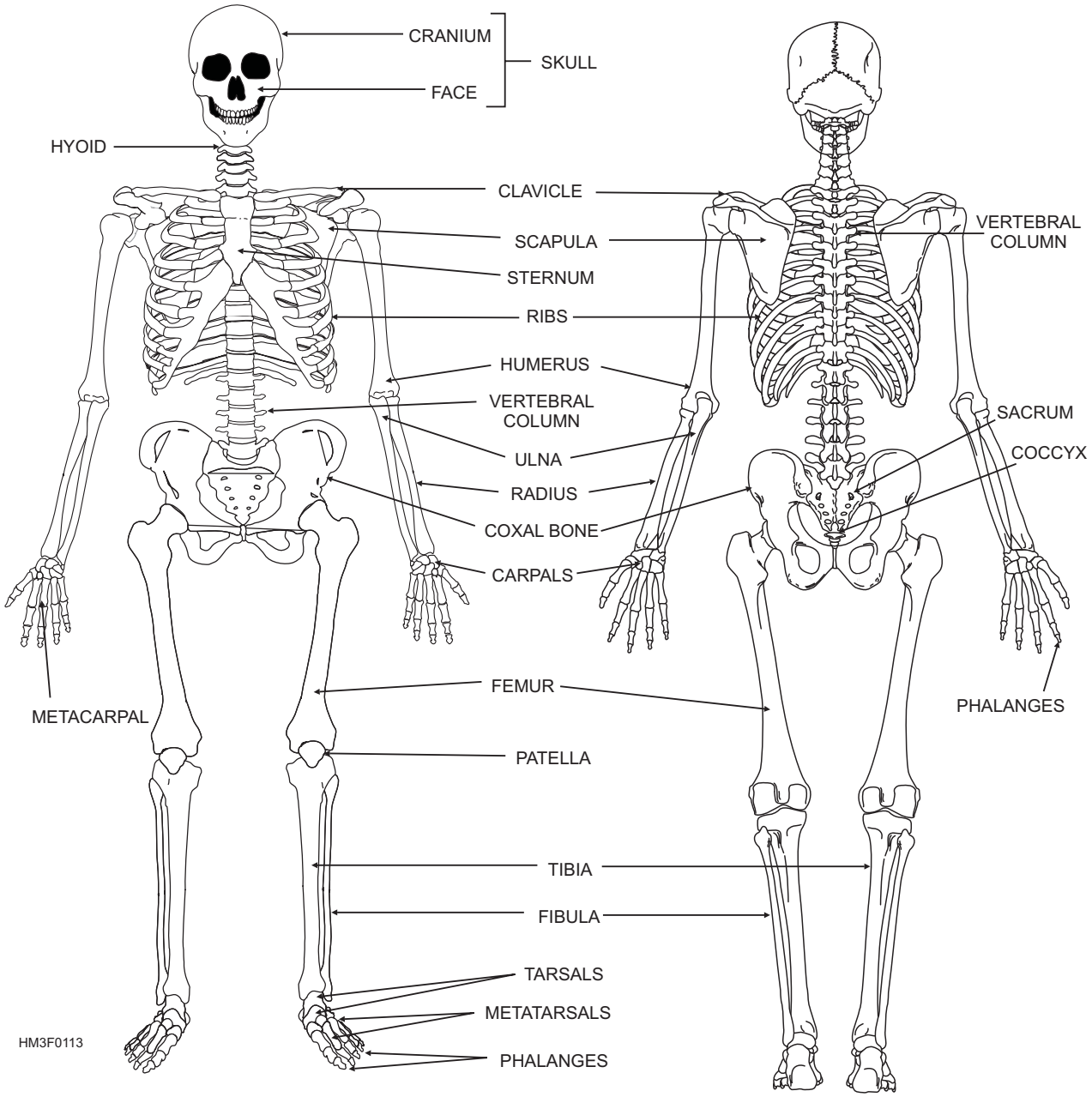


**Figure 1-13.—Human skeleton.**

periosteum is the pain center of the bone. When a bone fractures, the pain that is felt comes from the periosteum, not the bone proper. Periosteum also forms new bone. The **diaphysis** is the elongated, cylindrical portion (or "shaft") of the bone that is between the **epiphyses** (*sing.* epiphysis) or ends of the bone.

## BONE CLASSIFICATIONS

Bones are classified according to their shape. The four bone classifications and examples of each are as follows:

- **Long bones**—femur and humerus
- **Short bones**—wrist and ankle bones
- **Flat bones**—skull, sternum, and scapula
- **Irregular bones**—vertebrae, mandible, and pelvic bones

## DIVISIONS OF SKELETON

The human skeleton is divided into two main divisions, the axial skeleton and the appendicular skeleton.

### Axial Skeleton

The axial skeleton consists of the skull, the vertebral column, and the thorax.

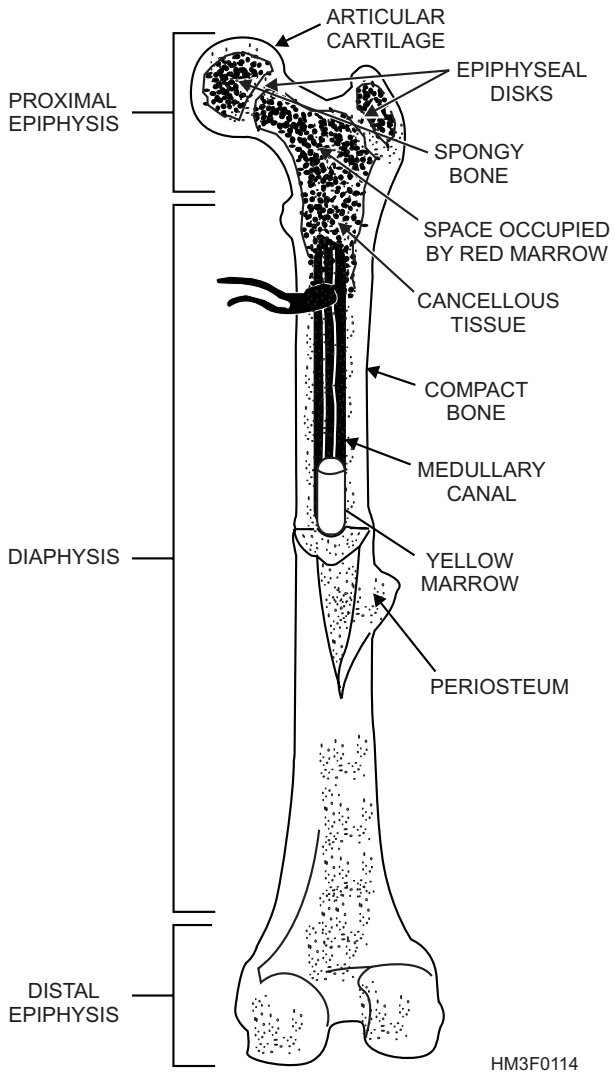


**Figure 1-14.—Anatomy of a long bone.**

**SKULL**.—The skull consists of 28 bones (figs. 1-15 and 1-16), 22 of which form the framework of the head and provide protection for the brain, eyes, and ears; six are ear bones. With the exception of the lower jaw bone and the ear bones, all skull bones are joined together and fixed in one position. The seams where they join are known as **sutures**. The bones of the skull are classified as either cranial or facial bones.

**Cranial Bones**.—The cranium is formed by eight major bones, most of which are in pairs (fig. 1-15). The **frontal bone** forms the forehead and the roof of each orbit (or eye socket) and the nasal cavity. The **parietal bones** form the roof of the skull. The **temporal bones** help form the sides and base of the skull and also house the auditory and hearing organs. The **occipital bone** forms part of the base and back of the skull, and contains a large hole called the foramen magnum. This opening permits passage of the spinal cord from the cranium into the spinal column. The **sphenoid bones** are wedged between several other bones in the anterior portion of the skull. These bones help form the base of the cranium, the sides of the skull, and the floors and sides of the orbits. The **ethmoid bones** are located in front of the sphenoid bone. They form sections of the nasal cavity roof, the cranial floor, and the orbital wall.

**Facial Bones**.—The facial bones of the skull consists of 14 bones: 13 immovable bones and a movable lower jawbone (fig. 1-16). The facial bones give the face its basic shape and provide attachment sites for various muscles that move the jaw and control facial expressions.

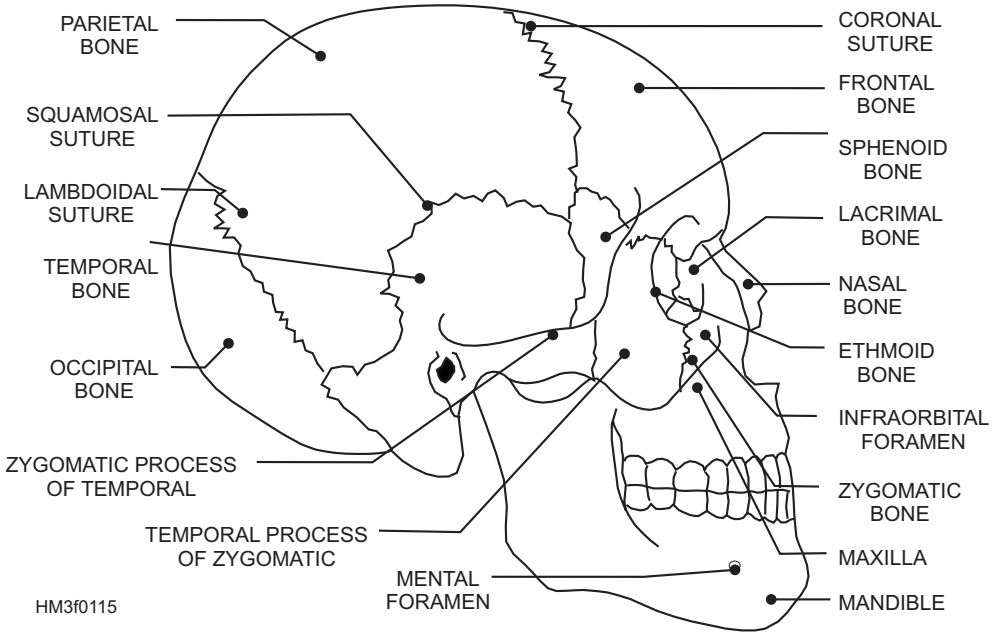


**Figure 1-15.—Lateral view of the skull.**

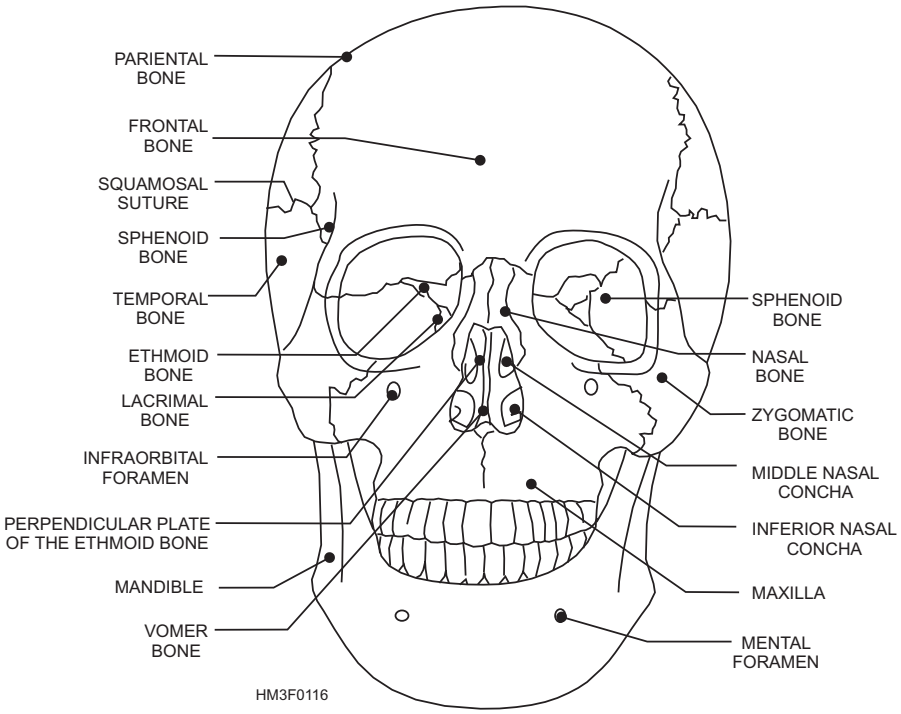


**Figure 1-16.—Facial bones.**

The **maxillary bones** form the upper jaw, the anterior roof of the mouth, the floors of the orbits, and the sides and floor of the nasal cavity. The small holes on each side of the nasal opening are called the **infraorbital foramina (***sing*. foramen). The maxillary bones contain large cavities called **maxillary sinuses**.

The palatine bones are L-shaped bones located behind the maxillary bones. They form the posterior section of the hard palate and the floor of the nasal cavity.

The **zygomatic bones** are responsible for the prominence of the cheeks. The zygomatic bones serve as part of the posterior section of the hard palate and the floor of the nasal cavity.

The **lacrimal bones** provide a pathway for a tube that carries tears from the eye to the nasal cavity. The lacrimal bone is a thin, scalelike structure located in the medial wall of each orbit.

The **nasal bones** have cartilaginous tissues attached to them. These tissues contribute significantly to the shape of the nose. The nasal bones are long, thin, and nearly rectangular in shape. They lie side by side and are fused together to form the bridge of the nose.

The **vomer bone** is connected to the ethmoid bone, and together they form the nasal septum (the wall separating the two nasal cavities).

The **middle and inferior nasal conchae** are fragile, scroll-shaped bones that are attached to the lateral wall of the nasal cavity. The inferior nasal concha provides support for mucous membranes within the nasal cavity.

The lower jawbone is called the **mandible**. The mandible is horseshoe-shaped with flat, bony projections on each end. The two small holes on the jawbone are called the **mental foramina.** The mandible's main function is mastication (chewing food).

**VERTEBRAL (SPINAL) COLUMN**.—The vertebral column consists of 24 movable or true vertebrae; the sacrum; and the coccyx, or tail bone (fig. 1-17). The vertebrae protect the spinal cord and the nerves that branch out from the spinal cord. Each vertebra has an anterior portion, called the body, which is the large solid segment of the bone (fig. 1-18). This vertebral body supports not only the spinal cord but other structures of the body as well. At the bottom of the spinal column is the **sacrum** and the **coccyx.** Many of the main muscles are attached to the vertebrae.

The **vertebral foramen** is a hole directly behind the body of the vertebrae that forms the passage for the spinal cord. The vertebral projections are for the attachments of muscles and ligaments and for facilitating movement of one vertebra over another. The spinal column is divided into five regions in the following order: cervical (neck), thoracic (chest),

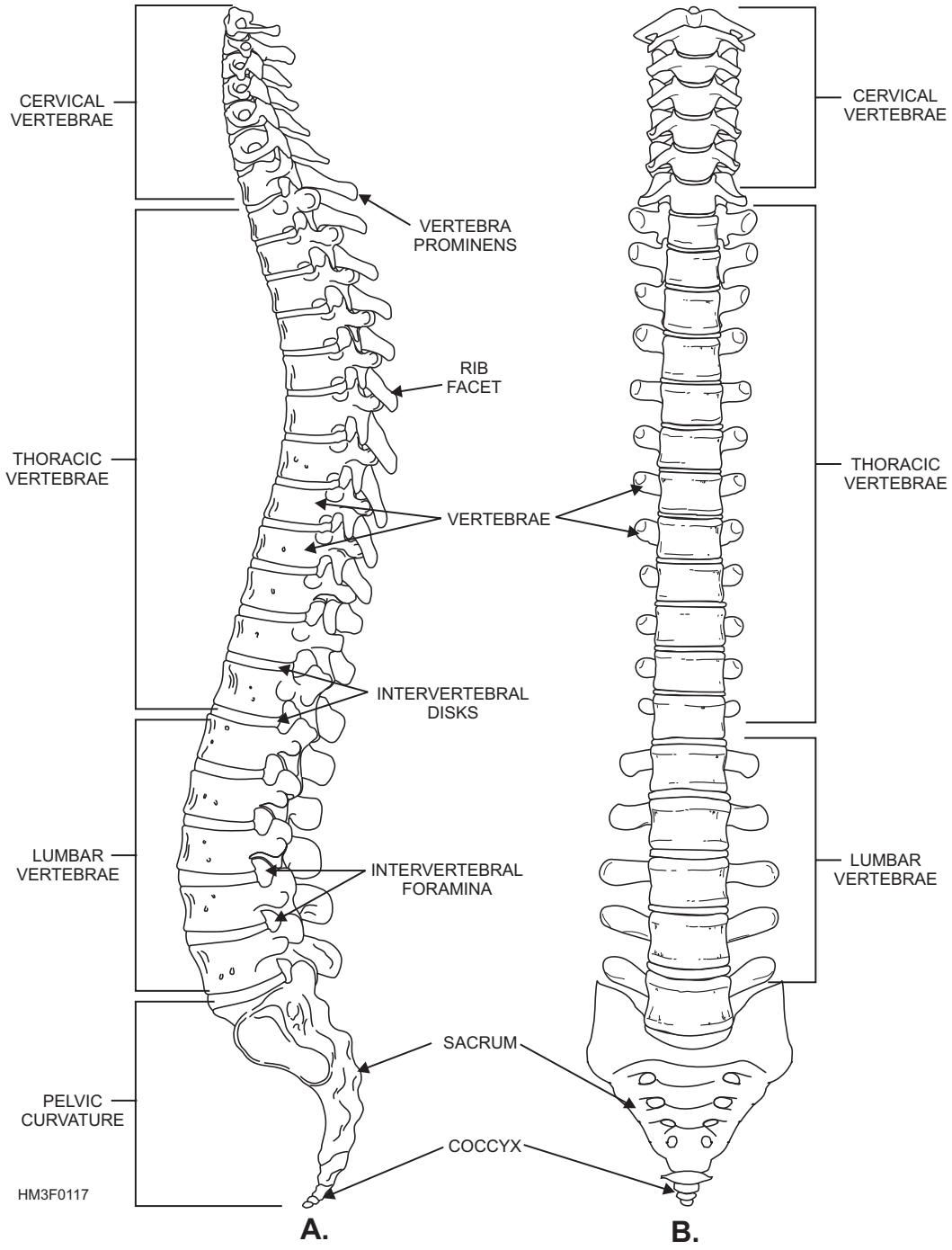


**Figure 1-17.—Vertebral column: A. Left lateral view of vertebral column; B. Posterior view of vertebral column.**

lumbar (lower back), and sacral and coccygeal (pelvis).

**Cervical**.—There are seven cervical vertebrae in the neck. The first is called the **atlas** and resembles a bony ring. It supports the head. The second is the highly specialized **axis**. It has a bony prominence that fits into the ring of the atlas, thus permitting the head to rotate from side to side. The atlas and the axis are the only named vertebrae; all others are numbered. See figure 1-19. Each cervical vertebra has a transverse (or intervertebral) foramen (fig. 1-19) to allow passage of nerves, the vertebral artery, and a vein. The seventh cervical vertebra has a prominent projection that can easily be felt at the nape of the neck. This landmark makes it possible for physicians to count and identify the vertebrae above and below it.

**Thoracic**.—There are 12 vertebrae in the thoracic region. The thoracic vertebrae articulate with the posterior portion of the 12 ribs to form the posterior wall of the thoracic, or chest, cage.

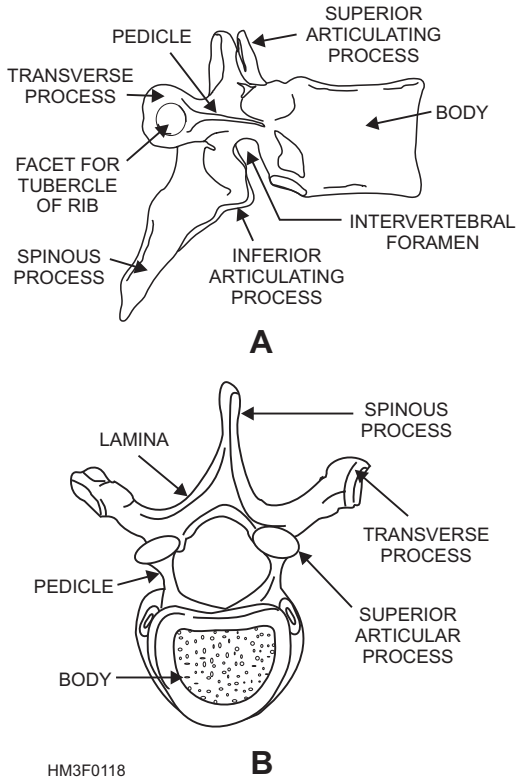


**Figure 1-18.—Typical vertebra: A. Lateral view of a typical vertebra; B. Superior view of a typical thoracic vertebra.**

**Lumbar**.—There are five lumbar vertebrae. Located in the small of the back, these vertebrae are the larger and stronger segments of the vertebral column.

**Sacrum**.—The sacrum is the triangular bone immediately below the lumbar vertebrae. It is composed of five separate vertebrae that gradually fuse together between 18 and 30 years of age. The sacrum is connected on each side with the hip bone and with the **coccyx** to form the posterior wall of the **pelvis**.

**THORAX**.—This cone-shaped bony cage is about as wide as it is deep (fig. 1-20). The thorax is formed by 12 ribs on each side and articulates posteriorly with the thoracic vertebrae. The first set of ribs are attached to the **manubrium,** a flat irregular bone atop the sternum. The first seven pairs of ribs are called **true ribs**. The remaining five pairs are called **false ribs**. They are called false ribs because their cartilages do not reach the sternum directly. The eighth, ninth, and tenth ribs are united by their cartilages and joined to the rib above. The last two rib pairs, also known as **floating ribs**, have no cartilaginous attachments to the **sternum**. The sternum is an elongated flat bone, forming the middle portion of the upper half of the chest wall in front. The **xiphoid process**, located at the inferior aspect of the sternum, serves as a landmark in the administration of cardiopulmonary resuscitation.

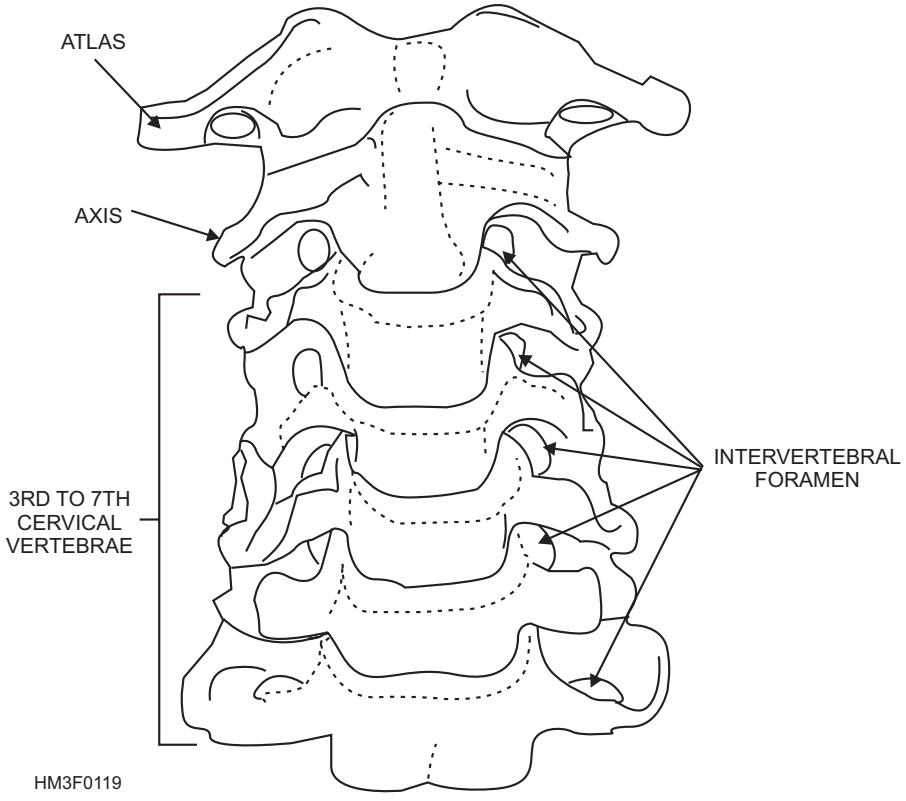


**Figure 1-19.—Cervical vertebrae.**

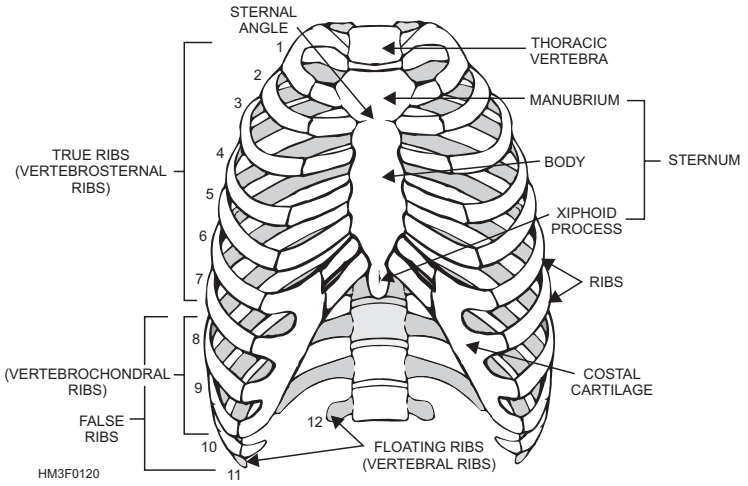


**Figure 1-20.—Anterior view of thorax,**

## Appendicular Skeleton

The appendicular skeleton consists of the bones of the upper and lower extremities.

**UPPER EXTREMITY**.—The upper extremity consists of the bones of the shoulder, the arm, the forearm, the wrist, and the hand (figs. 1-21 and 1-22). The bones that form the framework for the upper extremities are listed in table 1-1.

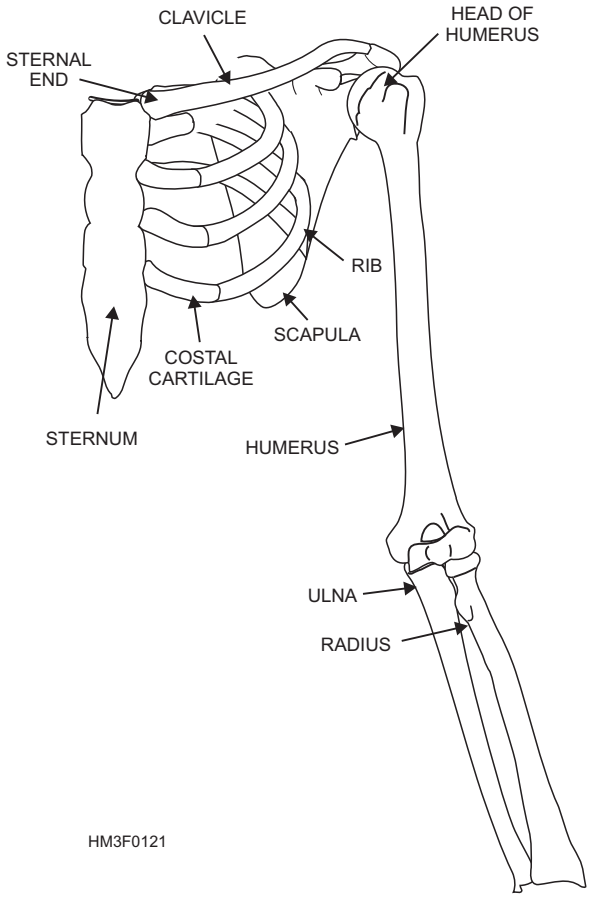


**Figure 1-21.—Pectoral girdle.**

**Table 1-1.—Bones of the Upper Extremities**

| BONE | COMMON NAME | TOTAL NUMBER IN BODY |
|---|---|---|
| clavicle | collar bone | 2 |
| scapula | shoulder blade | 2 |
| humerus | arm bone | 2 |
| radius and ulna | forearm bones | 4 |
| carpals | wrist bones | 16 |
| metacarpals | bones of the palm | 10 |
| phalanges | finger bones | 28 |

**Clavicle**.—The clavicle (commonly called the collar bone) lies nearly horizontally above the first rib and is shaped like a flat letter S. The clavicle is a thin brace bone that fractures easily. Its inner end is round and attached to the sternum; its outer end is flattened and fixed to the scapula. The clavicle forms the anterior portion of the pectoral girdle (fig. 1-21). The pectoral girdle is composed of the two clavicles and two scapulae (shoulder blades). It functions as a support for the arms and serves as an attachment for several muscles.

**Scapula**.—The scapula is a triangular bone that lies in the upper part of the back on both sides, between the second and seventh ribs, forming the posterior portion of the pectoral girdle. Its lateral corner forms part of the shoulder joint, articulating with the humerus.

**Humerus**.—The humerus is the longest bone of the upper extremity and is often called the arm bone (fig. 1-22). It articulates with the pectoral girdle to form the shoulder joint, and with the bones of the

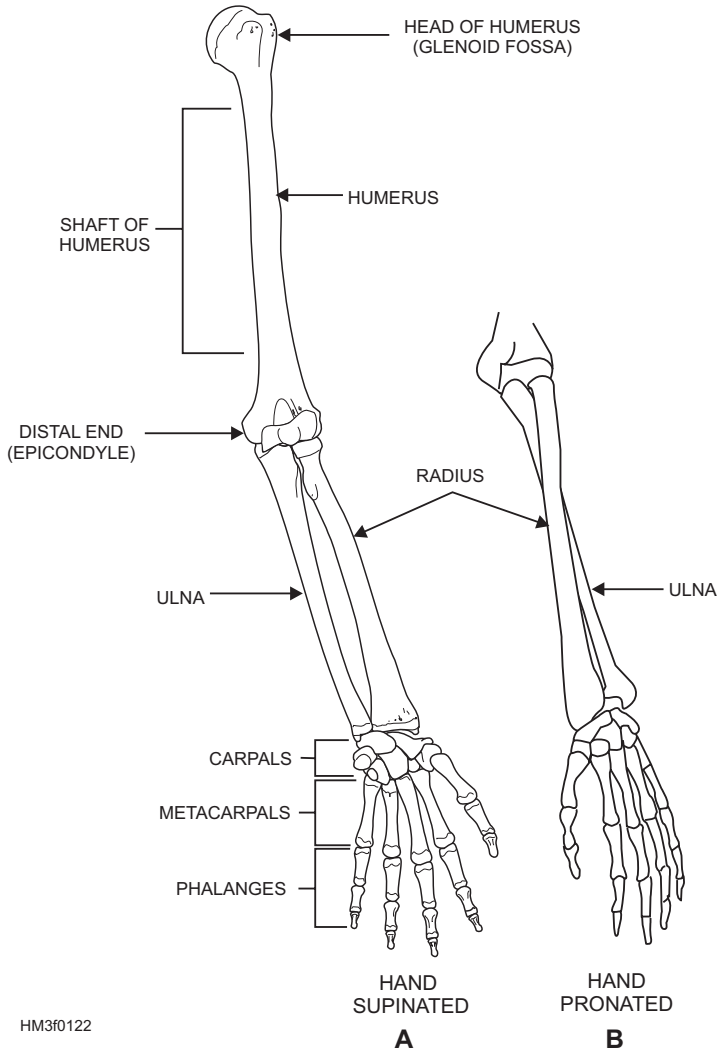


**Figure 1-22.—Left arm: A. Frontal view of left arm with hand supinated; B. Frontal view of left arm with hand pronated.**

forearm to form the elbow. Its anatomical portions include a head (a rounded portion that fits into a recess of the scapula) called the **glenoid fossa**; the **shaft**, which is the main part of the humerus; and the **distal end**, which includes the prominence (called an **epicondyle**) and the surfaces that articulate with the bones of the forearm.

**Radius and Ulna**.—When the arm is in the anatomical position with the palm turned forward, the **radius** is on the lateral (thumb) side and the **ulna** is on the medial (little finger) side of the forearm (fig. 1-22). When the hand is pronated (with the palm turned downward), the bones rotate on each other and cross in the middle. This pronation makes it possible to turn the wrist and hand (as when opening doors). The ulna and the radius articulate at their proximal ends with the humerus, at their distal ends with some of the carpal bones, and with each other at both ends.

**Carpal**.—There are eight carpal bones, arranged in two rows, forming the wrist.

**Metacarpal**.—The metacarpal bones are numbered one to five, corresponding with the five fingers, or digits, with which they articulate. The fingers are named as follows: 1st—thumb; 2nd—index; 3rd—middle; 4th—ring; and 5th—little.

**Phalanges**.—The small bones of the fingers are called phalanges, and each one of these bones is called a **phalanx**. Each finger has three phalanges, except the thumb (which has two). The phalanges are named for their anatomical position: The proximal phalanx is the bone closest to the hand; the distal phalanx is the bone at the end of the finger; and the middle phalanx is the bone located between the proximal and distal phalanges.

**LOWER EXTREMITY**.—The lower extremity includes the bones of the hip, thigh, leg, ankle, and foot. The bones that form the framework of the lower extremities are listed in table 1-2.

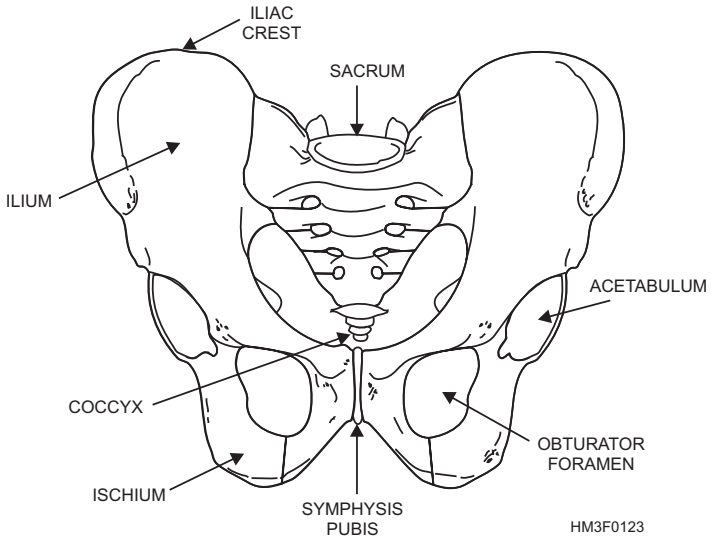


**Figure 1-23.—Pelvic girdle.**

**Table 1-2.—Bones of the Lower Extremities**

| BONE | COMMON NAME | TOTAL NUMBER IN BODY |
|---|---|---|
| innominate | hip bone | 2 |
| femur | thigh bone | 2 |
| patella | knee cap | 2 |
| tibia | leg bone | 2 |
| fibula | leg bone | 2 |
| tarsals | ankle bones | 14 |
| metatarsals | foot bones | 10 |
| phalanges | toe bones | 28 |

**Innominate**.—The innominate bone, commonly known as the hip, is a large, irregularly shaped bone composed of three parts: the ilium, ischium, and pubis (fig. 1-23). In children these three parts are separate bones, but in adults they are firmly united to form a cuplike structure, called the **acetabulum**, into which the head of the femur fits. The **ilium** forms the outer prominence of the hip bone (the crest of the ilium, referred to as the **iliac crest**, provides an anatomical landmark above the ilium); the **ischium** forms the hard lower part; and the **pubis** forms the front part of the pelvis.

**Symphysis Pubis**.—The area where the two pubic bones meet is called the symphysis pubis and is often used in anatomical measurements. The largest foramen, or opening, is located in the hip bone, between the ischium and the pubis, and is called the **obturator foramen** (fig. 1-23). The crest of the ilium

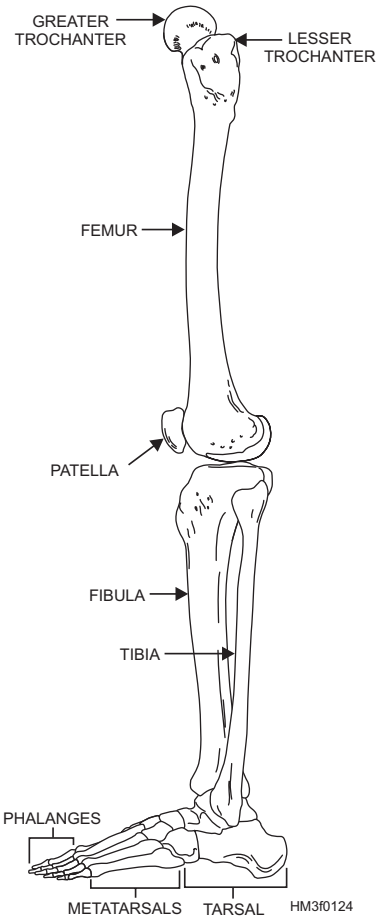


**Figure 1-24.—Anterior view of the right leg.**

is used in making anatomical and surgical measurements (e.g., location of the appendix, which is approximately halfway between the crest of the ilium and the umbilicus).

**Femur**.—The femur, or thigh bone, is the longest bone in the body (fig. 1-24). The proximal end is rounded and has a head supported by a constricted neck

that fits into the acetabulum. Two processes called the **greater** and **lesser trochanters** are at the proximal end for the attachment of muscles. The neck of the femur, located between the head and the trochanters, is the site on the femur most frequently fractured. At the distal end are two bony prominences, called the **lateral** and **medial condyles**, which articulate with the tibia and the patella.

**Patella**.—The patella is a small oval-shaped bone overlying the knee joint. It is enclosed within the tendon of the quadriceps muscle of the thigh. Bones like the patella that develop within a tendon are known as **sesamoid** bones.

**Tibia**.—The tibia, or shin bone, is the larger of the two leg bones and lies at the medial side. The proximal end articulates with the femur and the fibula. Its distal end articulates with the talus (one of the foot bones) and the fibula (fig. 1-25). A prominence easily felt on the inner aspect of the ankle is called the **medial malleolus**.

**Fibula**.—The fibula, the smaller of the two leg bones, is located on the lateral side of the leg, parallel to the tibia. The prominence at the distal end forms the outer ankle and is known as the **lateral malleolus**.

**Tarsus**.—The tarsus, or ankle, is formed by seven tarsal bones: **medial cuneiform, intermediate cuneiform, lateral cuneiform, cuboid, navicular, talus,** and **calcaneus**. The strongest of these is the heel bone, or **calcaneus**.

**Metatarsus**.—The sole and instep of the foot is called the metatarsus and is made up of five **metatarsal** bones (fig. 1-25). They are similar in arrangement to the metacarpals of the hand.

**Phalanges**.—The phalanges are the bones of the toes and are similar in number, structure, and arrangement to the bones of the fingers.

## JOINTS

**LEARNING OBJECTIVE:** *Recognize joint classifications and identify joint movements for the key joints in the body.*

Wherever two or more bones meet, a joint is formed. A joint binds various parts of the skeletal system together and enables body parts to move in response to skeletal muscle contractions.

### JOINT CLASSIFICATIONS

Joints are classified according to the amount of movement they permit (fig. 1-26). Joint classifications are as follows:

- **Immovable**. Bones of the skull are an example of an immovable joint. Immovable joints are characterized by the bones being in close contact with each other and little or no movement occurring between the bones.

- **Slightly movable**. In slightly movable joints, the bones are held together by broad flattened disks of cartilage and ligaments (e.g., vertebrae and symphysis pubis).

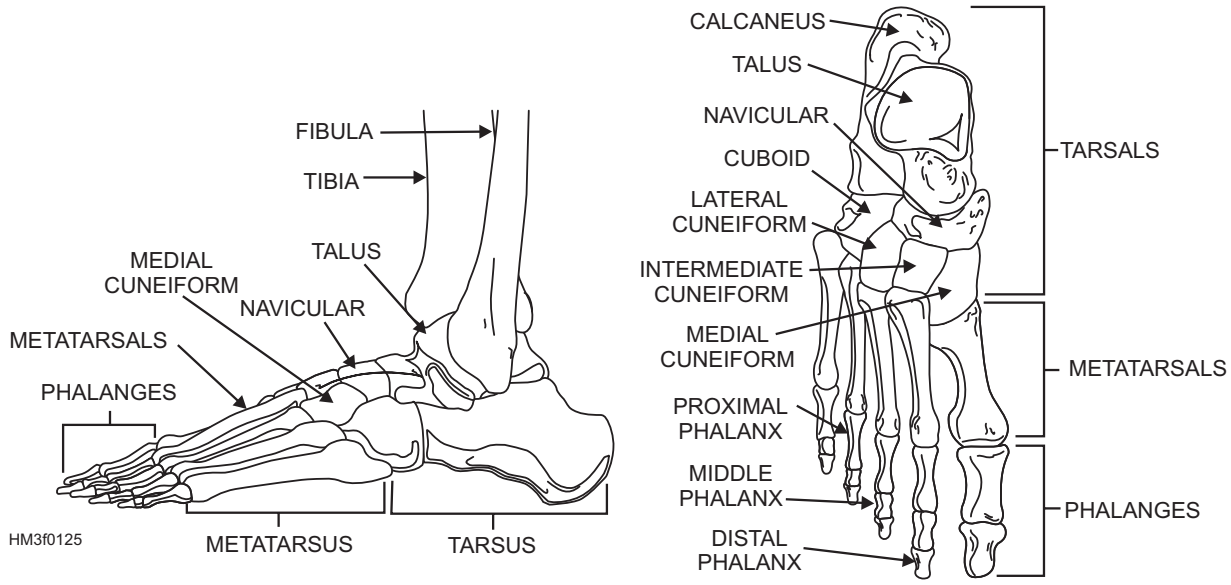


**Figure 1-25.—The foot: A. Lateral view of foot; B. Right foot viewed from above.**

- **Freely movable**. Most joints in the body are freely movable joints. The joint consists of the **joint capsule, articular cartilage, synovial membrane, and synovial (joint) cavity** (fig. 1-26). There are six classifications of freely movable joints: **ball-in-socket, condyloid, gliding, hinge, pivot**, and **saddle joints** (fig. 1-27). These joints have much more complex structures than the immovable and slightly movable joints. The ends of the bones in this type of joint are covered with a smooth layer of cartilage. The whole joint is enclosed in a watertight sac or membrane containing a small amount of lubricating fluid. This lubrication enables the joint to work with little friction. **Ligaments** (cords or sheets of connective tissue) reach across the joints from one bone to another and keep the bone stable. When ligaments are torn, we call the injury a sprain; when bones are out of place, we refer to this as a dislocation; and when bones are chipped or broken, the injury is called a fracture.

## TYPES OF JOINT MOVEMENTS

Joint movements are generally divided into four types: gliding, angular, rotation, and circumduction.

### Gliding

Gliding is the simplest type of motion. It is one surface moving over another without any rotary or angular motion. This motion exists between two adjacent surfaces.

### Angular

Angular motion decreases or increases the angle between two adjoining bones. The more common types of angular motion are as follows:

- **Flexion**—bending the arm or leg.
- **Extension**—straightening or unbending, as in straightening the forearm, leg, or fingers.
- **Abduction**—moving an extremity away from the body.
- **Adduction**—bringing an extremity toward the body.

### Rotation

Rotation is a movement in which the bone moves around a central point without being displaced, such as turning the head from side to side.

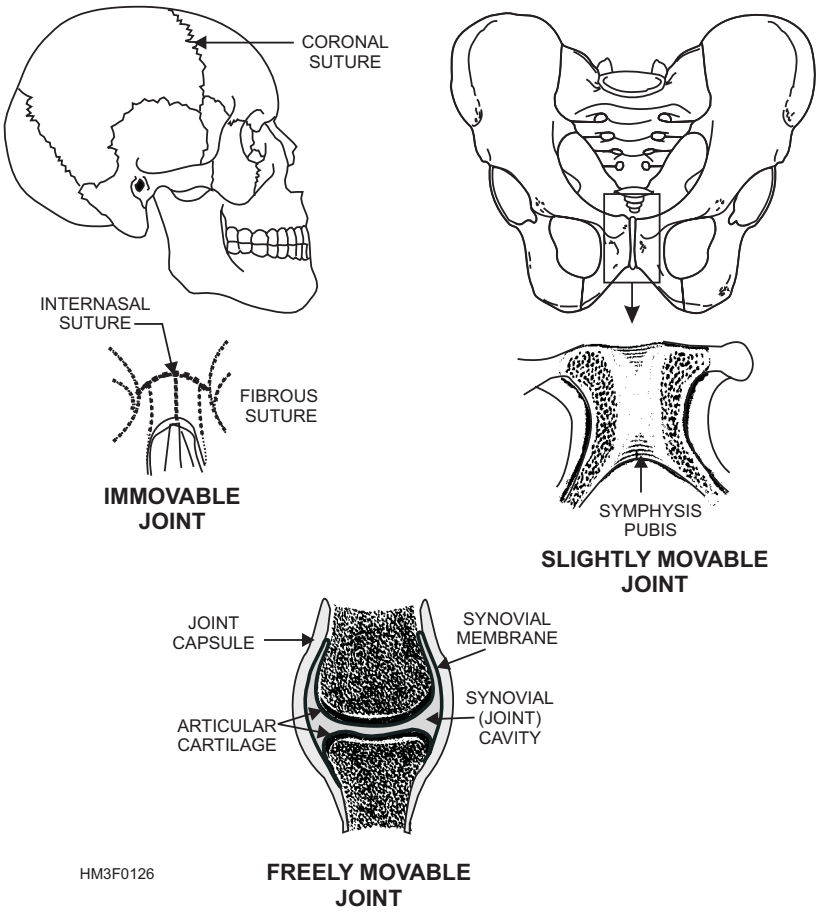


**Figure 1-26.—Example of immovable, slightly movable, and freely movable joints.**

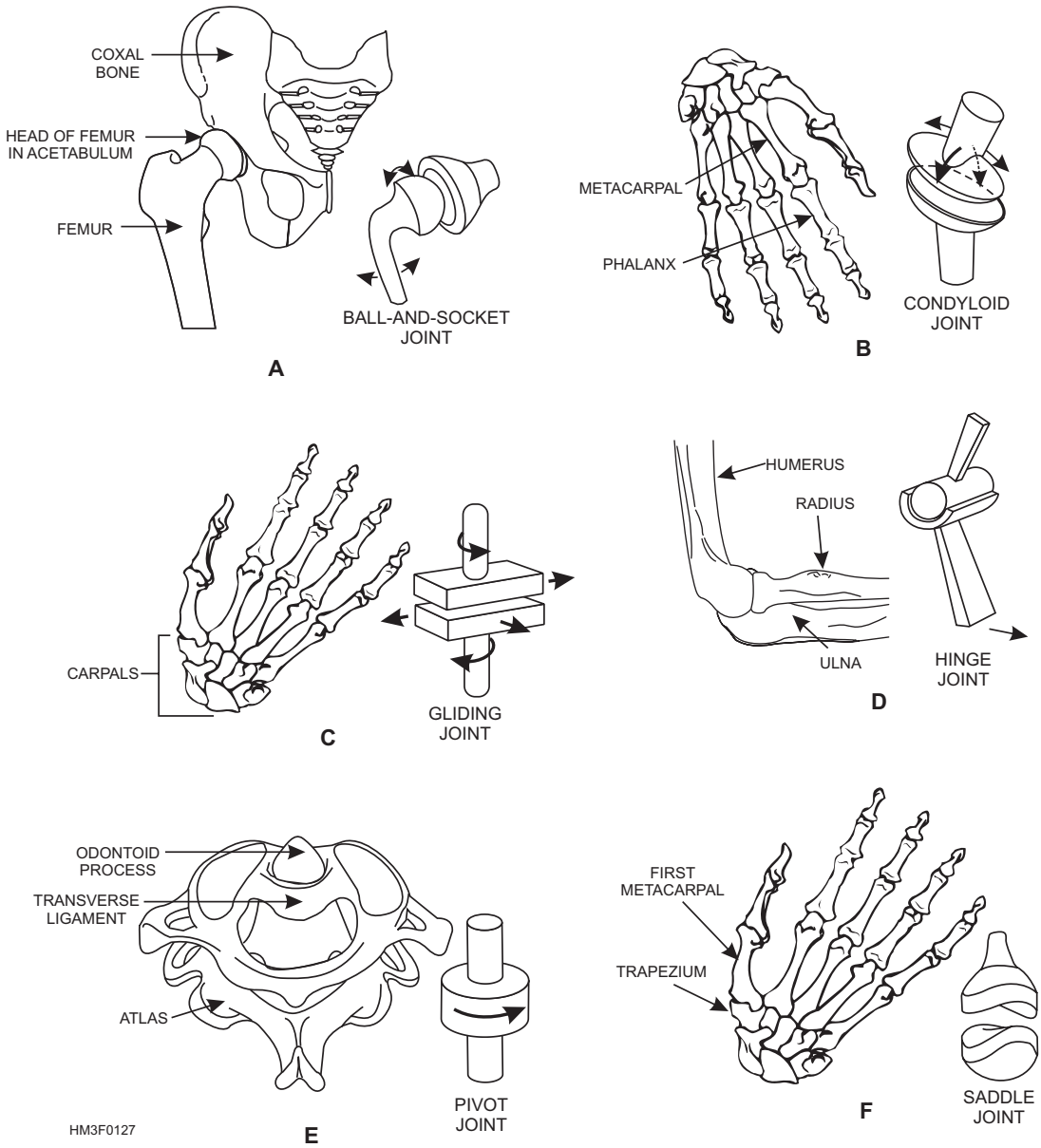


**Figure 1-27.—Types of joints: A. Ball-in-socket joint; B. Condyloid joint; C. Gliding joint; D. Hinge joint; E. Pivot joint; F. Saddle joint.**

### Circumduction

Circumduction is the movement of the hips and shoulders.

### Other Types of Movement

Other types of movement generally used to indicate specific anatomical positions include the following:

- **Supination**—turning upward, as in placing the palm of the hand up.
- **Pronation**—turning downward, as in placing the palm of the hand down.
- **Eversion**—turning outward, as in turning the sole of the foot to the outside.
- **Inversion**—turning inward, as in turning the sole of the foot inward.

## MUSCLES

**LEARNING OBJECTIVE**: *Identify primary muscle functions, muscle characteristics, types of muscle tissue, and important functional muscles.*

Muscles are responsible for many different types of body movements. The action of the muscle is

determined mainly by the kind of joint it is associated with and the way the muscle is attached to the joint. At one end of some muscles are long white **tendons** that attach the muscles to bone. The point of fixed attachment of a muscle to bone is called the **origin**. The more flexible attachments, especially attachments to a movable bone, are termed **insertions**.

Muscles seldom act alone; they usually work in groups held together by sheets of a white fibrous tissue called **fascia**. Muscles make up about one-half of the total body weight. Their main functions are threefold:

- **Providing movement**—including internal functions such as peristalsis (rhythmic waves of muscular contraction within the intestines).
- **Maintaining body posture**—through muscle tone, as in the muscles of the head, neck and shoulders, which keep the head up.
- **Providing heat**—through chemical changes that take place during muscle activity, such as exercise that warms the body.

In addition, muscles are involved in such essential bodily functions as respiration, blood circulation, digestion, and other functions such as speaking and seeing.

## MUSCLE CONTRACTION

Muscle tissue has a highly developed ability to contract. **Contractibility** enables a muscle to become shorter or thicker, and this ability, along with interaction with other muscles, produces movement of internal and external body parts. Muscle contraction in a tissue or organ produces motion and provides power and speed for body activity. A contracting muscle is referred to as a **prime mover**. A muscle that is relaxing while a prime mover is contracting is called the **antagonist**.

## STIMULUS FOR CONTRACTION

All muscles respond to stimulus. This property is called **excitability** or **irritability**. The mechanical muscular action of shortening or thickening (also called contraction) is activated by a stimulus sent through a motor nerve. All muscles are linked to nerve fibers that carry messages from the central nervous system.

## CONTRACTION AND RECOVERY

The chemical action of muscle fibers consists of two stages, **contraction** and **recovery**. In the contraction stage, two protein substances (actin and myosin) react to provide energy through the breakdown of glycogen into lactic acid. In the recovery stage, oxygen reacts with lactic acid to release carbon dioxide and water.

## MUSCLE FATIGUE

When a muscle contracts, it produces chemical waste products (carbon dioxide, lactic acid, and acid phosphate) which make the muscle more irritable. If contraction is continued, the muscle will cramp and refuse to move. This condition is known as **fatigue**. If it is carried too far, the muscle cells will not recover and permanent damage will result. Muscles, therefore, need rest to allow the blood to carry away the waste materials and bring in fresh glucose, oxygen, and protein to restore the muscle protoplasm and the energy that was used.

## TONICITY

Tonicity, or muscular tone, is a continual state of partial contraction that gives muscles a certain firmness. **Isometric** muscle contraction occurs when the muscle is stimulated and shortens, but no movement occurs, as when a person tenses his or her muscles against an immovable object. **Isotonic** muscle contraction occurs when the muscle is stimulated. The muscle shortens and movement occurs. An example would be lifting an object.

## EXTENSIBILITY AND ELASTICITY

Muscles are also capable of stretching when force is applied (**extensibility**) and regaining their original form when that force is removed (**elasticity**).

## MAINTENANCE OF MUSCLE TISSUE

During exercise, massage, or ordinary activities, the blood supply of muscles is increased. This additional blood brings in fresh nutritional material, carries away waste products more rapidly, and enables the muscles to build up and restore their efficiency and tone.

The importance of exercise for normal muscle activity is clear, but excessive muscle strain is damaging. For example, if a gasoline motor stands

idle, it eventually becomes rusty and useless. Similarly, a muscle cell that does not work atrophies, becoming weak and decreasing in size. On the other hand, a motor that is never allowed to stop and is forced to run too fast or to do too much heavy work soon wears out so that it cannot be repaired. In the same way, a muscle cell that is forced to work too hard without proper rest will be damaged beyond repair.

When a muscle dies, it becomes solid and rigid and no longer reacts. This stiffening, which occurs from 10 minutes to several hours after death, is called **rigor mortis**.

## MUSCLE TISSUES

There are three types of muscle tissue: skeletal, smooth, and cardiac. Each is designed to perform a specific function.

### Skeletal

Skeletal, or striated, muscle tissues are attached to the bones and give shape to the body. They are responsible for allowing body movement. This type of muscle is sometimes referred to as **striated** because of the striped appearance of the muscle fibers under a microscope (fig. 1-9). They are also called **voluntary** muscles because they are under the control of our conscious will. These muscles can develop great power.

### Smooth

Smooth, or nonstriated, muscle tissues are found in the walls of the stomach, intestines, urinary bladder, and blood vessels, as well as in the duct glands and in the skin. Under a microscope, the smooth muscle fiber lacks the striped appearance of other muscle tissue (fig. 1-10). This tissue is also called **involuntary** muscle because it is not under conscious control.

### Cardiac

The cardiac muscle tissue forms the bulk of the walls and septa (or partitions) of the heart, as well as the origins of the large blood vessels. The fibers of the cardiac muscle differ from those of the skeletal and smooth muscles in that they are shorter and branch into a complicated network (fig. 1-11). The cardiac muscle has the most abundant blood supply of any muscle in the body, receiving twice the blood flow of the highly vascular skeletal muscles and far more than the smooth muscles. Cardiac muscles contract to pump blood out of the heart and through the cardiovascular system. Interference with the blood supply to the heart can result in a heart attack.

## MAJOR SKELETAL MUSCLES

In the following section, the location, actions, origins, and insertions of some of the major skeletal muscles are covered. In figures 1-28 and 1-29 the superficial skeletal muscles are illustrated. Also note, the names of some of the muscles give you clues to their location, shape, and number of attachments.

### Temporalis

The temporalis muscle is a fan-shaped muscle located on the side of the skull, above and in front of the ear. This muscle's fibers assist in raising the jaw and pass downward beneath the zygomatic arch to the mandible (fig. 1-29). The temporalis muscle's origin is the temporal bone. It is inserted in the coronoid process (a prominence of bone) of the mandible.

### Masseter

The masseter muscle raises the mandible, or lower jaw, to close the mouth (fig. 1-28). It is the chewing muscle in the mastication of food. It originates in the zygomatic process and adjacent parts of the maxilla and is inserted in the mandible.

### Sternocleidomastoid

The sternocleidomastoid muscles are located on both sides of the neck. Acting individually, these muscles rotate the head left or right (figs. 1-28 and 1-29). Acting together, they bend the head forward toward the chest. The sternocleidomastoid muscle originates in the sternum and clavicle and is inserted in the mastoid process of the temporal bone. When this muscle becomes damaged, the result is a common condition known as a “stiff neck.”

### Trapezius

The trapezius muscles are a broad, trapezium-shaped pair of muscles on the upper back, which raise or lower the shoulders (figs. 1-28 and 1-29). They cover approximately one-third of the back. They originate in a large area which includes the 12 thoracic vertebrae, the seventh cervical vertebra, and the occipital bone. They have their insertion in the clavicle and scapula.

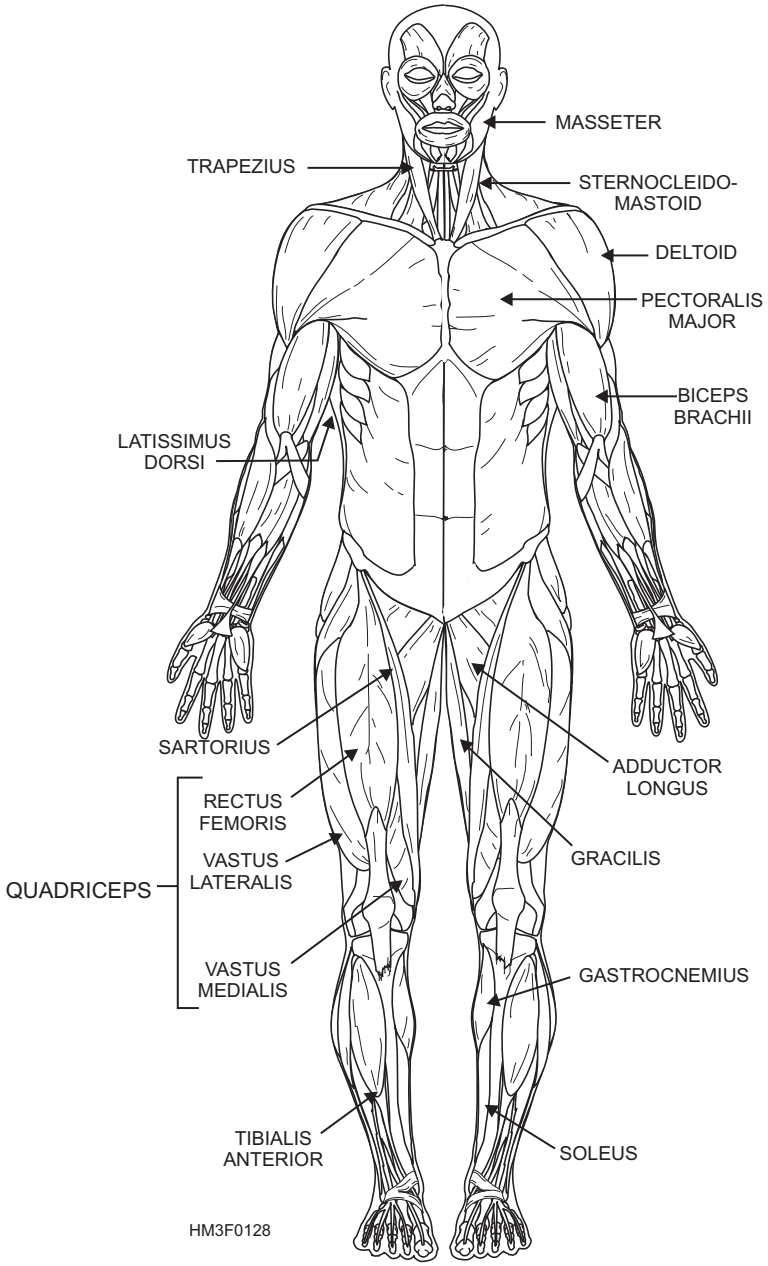


**Figure 1-28.—Anterior view of superficial skeletal muscles.**

### Pectoralis Major

The pectoralis major is the large triangular muscle that forms the prominent chest muscle (fig. 1-28). It rotates the arm inward, pulls a raised arm down toward the chest, and draws the arm across the chest. It originates in the clavicle, sternum, and cartilages of the true ribs, and the external oblique muscle. Its insertion is in the greater tubercle of the humerus.

### Deltoid

The deltoid muscle raises the arm and has its origin in the clavicle and the spine of the scapula (figs. 1-28 and 1-29). Its insertion is on the lateral side of the humerus. It fits like a cap over the shoulder and is a frequent site of intramuscular injections.

### Biceps Brachii

The biceps brachii is the prominent muscle on the anterior surface of the upper arm (fig. 1-28). Its origin is in the outer edge of the glenoid cavity, and its insertion is in the tuberosity of the radius. This muscle rotates the forearm outward (supination) and, with the aid of the brachial muscle, flexes the forearm at the elbow.

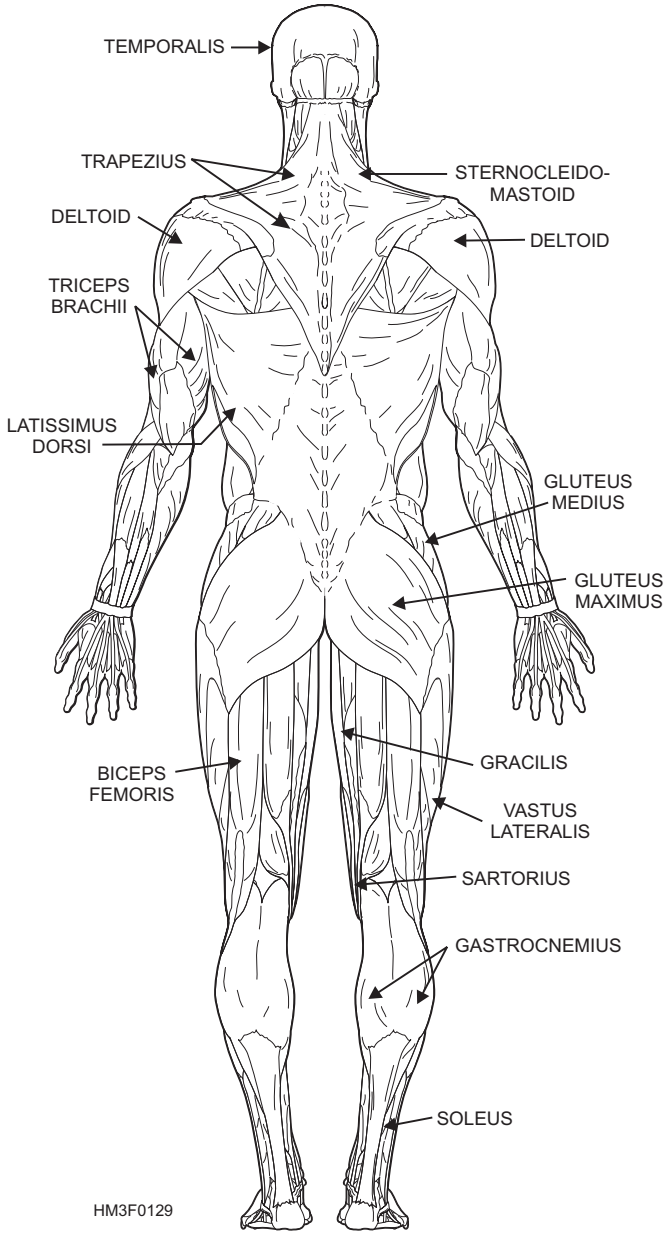


**Figure 1-29.—Posterior view of superficial skeletal muscles.**

### Triceps Brachii

The triceps brachii is the primary extensor of the forearm (the antagonist of the biceps brachii) (fig. 1-29). It originates at two points on the humerus and one on the scapula. These three heads join to form the large muscle on the posterior surface of the upper arm. The point of insertion is the olecranon process of the ulna.

### Latissimus Dorsi

The latissimus dorsi is a broad, flat muscle that covers approximately one-third of the back on each side (figs. 1-28 and 1-29). It rotates the arm inward and draws the arm down and back. It originates from the upper thoracic vertebrae to the sacrum and the posterior portion of the crest of the ilium. Its fibers converge to form a flat tendon that has its insertion in the humerus.

### Gluteus

The gluteus (**maximus**, **minimus** (not shown), and **medius**) are the large muscles of the buttocks, which extend and laterally rotate the thigh, as well as abduct and medially rotate it (fig. 1-29). They arise from the ilium, the posterior surface of the lower sacrum, and the side of the coccyx. Their points of insertion include the greater trochanter and the gluteal tuberosity of the femur. The gluteus maximus is the site of choice for intramuscular injections.

### Quadriceps

The quadriceps is a group of four muscles that make up the anterior portion of the thigh. The four muscles of this group are the **rectus femoris** that originates at the ilium; and the **vastus lateralis**, **v. medialis**, **v. intermedius** (not shown), that originate along the femur (fig. 1-28). All four are inserted into the tuberosity of the tibia through a tendon passing over the knee joint. The quadriceps serves as a strong extensor of the leg at the knee and flexes the thigh. Additionally located in the quadriceps area is the **adductor longus** that adducts, rotates, and flexes the thigh.

### Biceps Femoris

The biceps femoris (often called the hamstring muscle) originates at the tuberosity of the ischium (the lowest portion of the coxal bone, part of the pelvic girdle) and the middle third of the femur (fig. 1-29). It is inserted on the head of the fibula and the lateral condyle of the tibia. It acts, along with other related muscles, to flex the leg at the knee and to extend the thigh at the hip joint.

### Gracilis

The gracilis is a long slender muscle located on the inner aspect of the thigh (figs. 1-28 and 1-29). It adducts the thigh, and flexes and medially rotates the leg. Its origin is in the symphysis pubis, and its insertion is in the medial surface of the tibia, below the condyle.

### Sartorius

The sartorius is the longest muscle in the body. It extends diagonally across the front of the thigh from its origin at the ilium, down to its insertion near the tuberosity of the tibia (fig. 1-29). Its function is to flex the thigh and rotate it laterally, and to flex the leg and rotate it slightly medially.

### Gastrocnemius and Soleus

The gastrocnemius and soleus (together commonly called the calf muscles) extend the foot at the ankle (figs. 1-28 and 1-29). The gastrocnemius originates at two points on the femur; the soleus originates at the head of the fibula and the medial border of the tibia. Both are inserted in a common tendon called the calcaneus, or Achilles tendon.

### Tibialis Anterior

The tibialis anterior originates at the upper half of the tibia and inserts at the first metatarsal and cuneiform bones (fig. 1-28). It flexes the foot.

### Diaphragm

The diaphragm (not shown) is an internal (as opposed to superficial) muscle that forms the floor of the thoracic cavity and the ceiling of the abdominal cavity. It is the primary muscle of respiration, modifying the size of the thorax and abdomen vertically. It has three openings for the passage of nerves and blood vessels.

## THE INTEGUMENTARY SYSTEM

**LEARNING OBJECTIVE:** *Identify skin, its functions, structure, and appendages.*

Organ systems are comprised of tissues grouped together to form organs, and groups of organs with specialized functions. Since the skin acts with hair follicles, sebaceous glands, and sweat glands, these organs together constitute the integumentary system.

### SKIN FUNCTION

The skin covers almost every visible part of the human body. Even the hair and nails are outgrowths from it. It protects the underlying structures from injury and invasion by foreign organisms; it contains the peripheral endings of many sensory nerves; and it has limited excretory and absorbing powers. The skin also plays an important part in regulating body temperature. In addition, the skin is a waterproof covering that prevents excessive water loss, even in very dry climates.

### SKIN STRUCTURE

The skin, or integument, consists of two layers, the epidermis and the dermis, and supporting structures and appendages (fig. 1-30).

### Epidermis

The epidermis is the outer skin layer (fig. 1-30). It is made up of tough, flat, scalelike epithelial cells. Five sublayers or strata of epidermal cells have been identified, and, listed from superficial to deep, they are

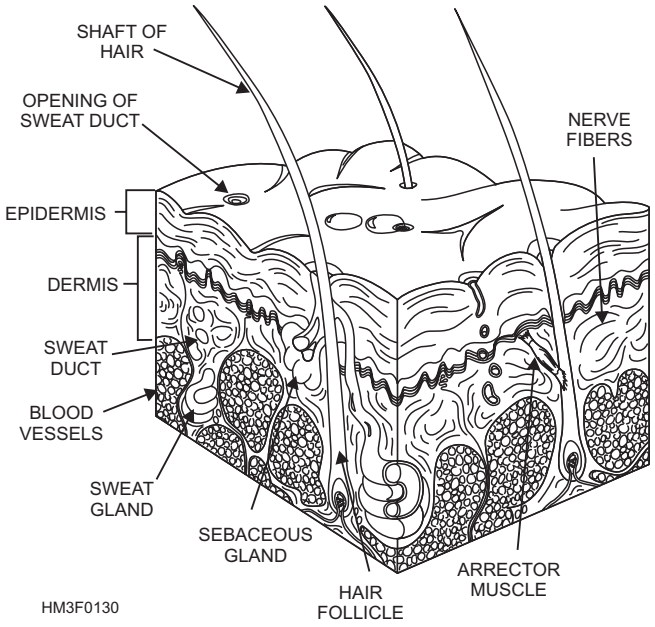


**Figure 1-30.—Cross section of the skin.**

the **stratum corneum**, **stratum lucidum** (not always present), **stratum granulosum**, **stratum spinosum**, and **stratum basale**.

### Dermis

The dermis, or true skin, lies below the epidermis and gradually blends into the deeper tissues (fig. 1-30). It is a wide area of connective tissue that contains blood vessels, nerve fibers, smooth muscles, and skin appendages.

**BLOOD VESSELS**.—The blood vessels of the dermis can dilate to contain a significant portion of the body's blood supply (fig. 1-30). This ability, along with the actions of the sweat glands, forms the body's primary temperature-regulating mechanism. The constriction or dilation of these blood vessels also affects blood pressure and the volume of blood available to the internal organs.

**NERVE FIBERS**.—The skin contains two types of nerve fibers that carry impulses to and from the central nervous system (fig. 1-30). The nerve fibers are distributed to the smooth muscles in the walls of the arteries in the dermis and to the smooth muscles around the sweat glands and hair roots. The first type of nerve fiber carries impulses to the dermal muscles and glands, while the other type carries impulses from sensory receptors (i.e., detecting touch). Both nerve fibers send messages about the external environment to the brain.

**SMOOTH MUSCLES**.—Smooth involuntary muscles are found in the dermis. They are responsible for controlling the skin surface area. When dilated, these muscles allow for maximum skin surface exposure to aid heat loss. When constricted, the skin surface exposure is decreased, thus impeding heat radiation. Repeated muscle contractions (shivering) are also a rapid means of generating body heat.

### Skin Appendages

The appendages of the skin are the nails, hairs, sebaceous glands, sweat glands, and ceruminous glands.

**NAILS**.—The nails are composed of horny epidermal scales and are found on the dorsal surfaces of the fingers and toes. They protect the many sensitive nerve endings at the ends of these digits. New formation of nail will occur in the epithelium of the nail bed. As a new nail is formed, the whole nail moves forward, becoming longer.

**HAIR**.—Hair is an epithelial structure found on almost every part of the surface of the body (fig. 1-30). Its color depends on the type of melanin present. The hair has two components: the root below the surface and the shaft projecting above the skin. The root is embedded in a pit-like depression called the hair follicle. Hair grows as a result of the division of the cells of the root. A small muscle, known as the **arrector** (fig. 1-30), fastens to the side of the follicle and is responsible for the gooseflesh appearance of the skin as a reaction to cold or fear. Each hair follicle is associated with two or more sebaceous glands.

**SEBACEOUS GLANDS**.—Sebaceous glands are found in most parts of the skin except in the soles of the feet and the palms of the hand (fig. 1-30). Their ducts open most frequently into the hair follicles and secrete an oily substance that lubricates the skin and hair, keeping them soft and pliable and preventing bacterial invasion.

**SWEAT GLANDS**.—Sweat glands are found in almost every part of the skin (fig. 1-30). They are control mechanisms to reduce the body's heat by evaporating water from its surface. The perspiration secreted is a combination of water, salts, amino acids, and urea. Normally, about one liter of this fluid is excreted daily. However, the amount varies with atmospheric temperature and humidity and the amount of exercise taken. When the outside temperature is high, or upon exercise, the glands secrete large amounts to cool the body through evaporation. When

evaporation does not remove all the sweat that has been excreted, the sweat collects in beads on the surface of the skin.

**CERUMINOUS GLANDS**.—Ceruminous glands are modified sweat glands found only in the auditory canal. They secrete a yellow, waxy substance called **cerumen** that protects the eardrum.

## THE CIRCULATORY SYSTEM

**LEARNING OBJECTIVE:** *Identify the parts of the circulatory system, and recognize their major components and functions.*

The circulatory system, also called the **vascular system**, consists of blood, heart, and blood vessels. The circulatory system is close circuited (i.e., there is no opening to external environment of the body). The function of this system is to move blood between the cells and the organs of the integumentary, digestive, respiratory, and urinary system that communicate with the external environment of the body. This function is facilitated by the heart pumping blood through blood vessels. The blood travels throughout the body transporting nutrients and wastes, and permitting the exchange of gases (carbon dioxide and oxygen).

### BLOOD

Blood is fluid tissue composed of formed elements (i.e., cells) suspended in plasma. It is pumped by the heart through arteries, capillaries, and veins to all parts of the body. Total blood volume of the average adult is 5 to 6 liters.

#### Plasma

Plasma is the liquid part of blood (fig. 1-31). Plasma constitutes 55 percent of whole blood (plasma and cells). It is a clear, slightly alkaline, straw-colored liquid consisting of about 92 percent water. The remainder is made up mainly of proteins. One of these proteins, **fibrinogen**, contributes to coagulation.

#### Blood Cells

The blood cells suspended in the plasma constitute 45 percent of whole blood. Its cells, which are formed mostly in red bone marrow, include red blood cells (RBCs) and white blood cells (WBCs). The blood also contains cellular fragments called blood platelets.

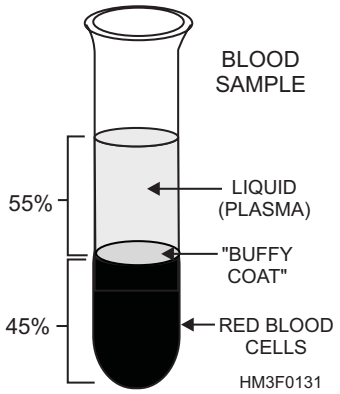


**Figure 1-31.—Blood sample illustrating blood components.**

When blood components are separated, the WBCs and platelets form a thin layer, called the **buffy coat**, between the layers of plasma and RBCs. These layers are illustrated in figure 1-31.

**RED BLOOD CELLS**.—Red blood cells, or **erythrocytes**, are small, biconcave, nonnucleated disks, formed in the red bone marrow (fig. 1-32). Blood of the average man contains 5 million red cells per cubic millimeter. Women have fewer red cells, 4.5 million per cubic millimeter. Emotional stress, strenuous exercise, high altitudes, and some diseases may cause an increase in the number of RBCs.

During the development of the red blood cell, a substance called **hemoglobin** is combined with it. Hemoglobin is the key of the red cell's ability to carry oxygen and carbon dioxide. Thus, the main function of erythrocytes is the transportation of respiratory gases. The red cells deliver oxygen to the body tissues, holding some oxygen in reserve for an emergency. Carbon dioxide is picked up by the same cells and discharged via the lungs.

The color of the red blood cell is determined by the hemoglobin content. Bright red (arterial) blood is due to the combination of oxygen and hemoglobin. Dark

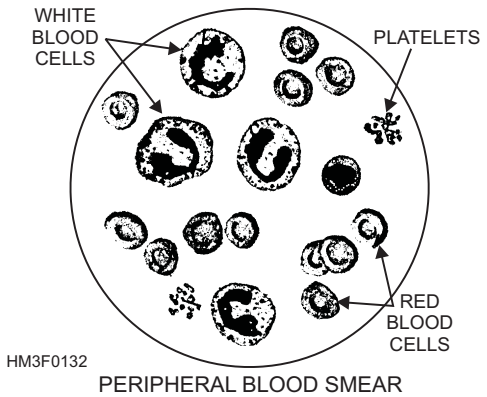


**Figure 1-32.—A blood smear showing red blood cells, white blood cells, and platelets.**

red (venous) blood is the result of hemoglobin combining with carbon dioxide.

Red blood cells live only about 100 to 120 days in the body. There are several reasons for their short life span. These delicate cells have to withstand constant knocking around as they are pumped into the arteries by the heart. These cells travel through blood vessels at high speed, bumping into other cells, bouncing off the walls of arteries and veins, and squeezing through narrow passages. They must adjust to continual pressure changes. The spleen is the "graveyard" where old, worn out cells are removed from the blood stream. Fragments of red blood cells are found in the spleen and other body tissues.

**WHITE BLOOD CELLS**.—White blood cells, or **leukocytes**, are almost colorless, nucleated cells originating in the bone marrow and in certain lymphoid tissues of the body (fig. 1-32). There is only one white cell to every 600 red cells. Normal WBC count is 6,000 to 8,000 per cubic millimeter, although the number of white cells may be 15,000 to 20,000 or higher during infection.

Leukocytes are important for the protection of the body against disease. Leukocytes can squeeze between the cells that form blood cell walls. This movement, called **diapedesis**, permits them to leave the blood stream through the capillary wall and attack pathogenic bacteria. They can travel anywhere in the body and are often named "the wandering cells." They protect the body tissues by engulfing disease-bearing bacteria and foreign matter, a process called **phagocytosis**. When white cells are undermanned, more are produced, causing an increase in their number and a condition known as **leukocytosis**. Another way WBC's protect the body from disease is by producing **bacteriolysins** that dissolve the foreign bacteria. The secondary function of WBCs is to aid in blood clotting.

**BLOOD PLATELETS**.—Blood platelets, or **thrombocytes**, are irregular- or oval-shaped discs in the blood that contain no nucleus, only cytoplasm (fig. 1-32). They are smaller than red blood cells and average about 250,000 per cubic millimeter of blood. Blood platelets play an important role in the process of blood coagulation, clumping together in the presence of jagged, torn tissue.

### Blood Coagulation

To protect the body from excessive blood loss, blood has its own power to coagulate, or clot. If blood components and linings of vessels are normal, circulating blood will not clot. Once blood escapes from its vessels, however, a chemical reaction begins that causes it to become solid. Initially a blood clot is a fluid, but soon it becomes thick and then sets into a soft jelly that quickly becomes firm enough to act as a plug. This plug is the result of a swift, sure mechanism that changes one of the soluble blood proteins, **fibrinogen**, into an insoluble protein, **fibrin**, whenever injury occurs.

Other necessary elements for blood clotting are calcium salts; a substance called **prothrombin**, which is formed in the liver; blood platelets; and various factors necessary for the completion of the successive steps in the coagulation process. Once the fibrin plug is formed, it quickly enmeshes red and white blood cells and draws them tightly together. **Blood serum**, a yellowish clear liquid, is squeezed out of the clot as the mass shrinks. Formation of the clot closes the wound, preventing blood loss. A clot also serves as a network for the growth of new tissues in the process of healing. Normal clotting time is 3 to 5 minutes, but if any of the substances necessary for clotting are absent, severe bleeding will occur.

**Hemophilia** is an inherited disease characterized by delayed clotting of the blood and consequent difficulty in controlling hemorrhage. Hemophiliacs can bleed to death as a result of minor wounds.

## THE HEART

The heart is a hollow, muscular organ, somewhat larger than the closed fist, located anteriorly in the chest and to the left of the midline. It is shaped like a cone, its base directed upward and to the right, the apex down and to the left. Lying obliquely in the chest, much of the base of the heart is immediately posterior to the sternum.

### Heart Composition

The heart is enclosed in a membranous sac, the **pericardium**. The smooth surfaces of the heart and pericardium are lubricated by a serous secretion called **pericardial fluid**. The inner surface of the heart is lined with a delicate serous membrane, the **endocardium**, similar to and continuous with that of the inner lining of blood vessels.

The interior of the heart (fig. 1-33) is divided into two parts by a wall called the **interventricular septum**. In each half is an upper chamber, the **atrium**, which receives blood from the veins, and a lower chamber, the **ventricle**, which receives blood from the

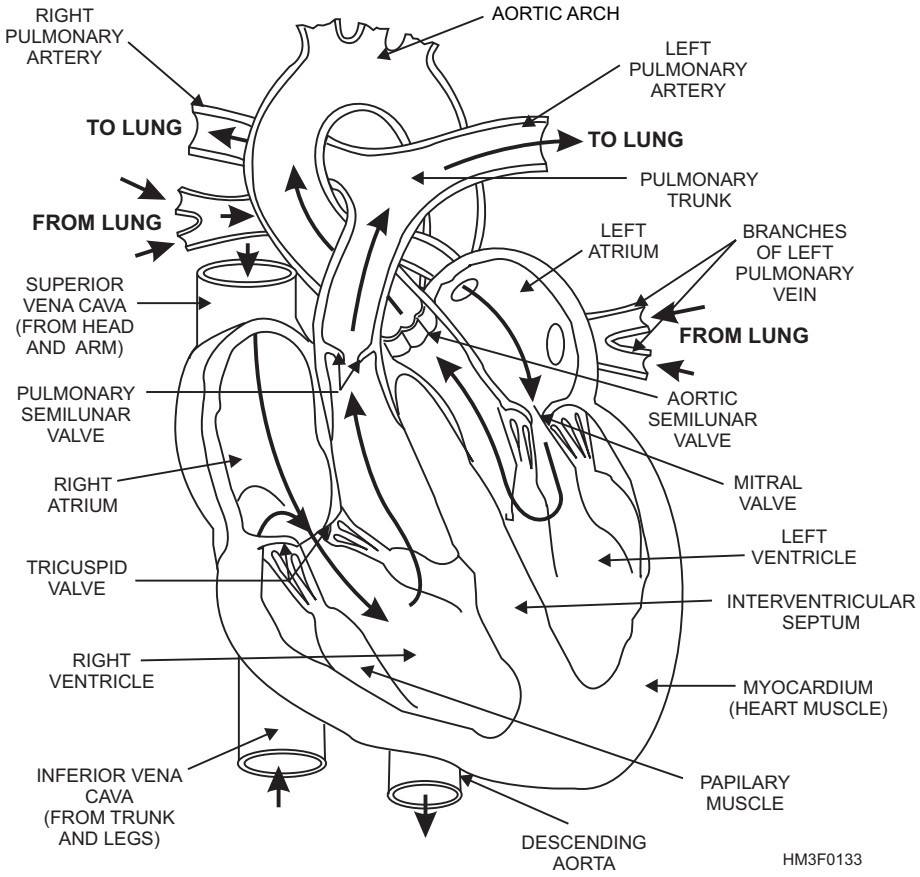


**Figure 1-33.—Frontal view of the heart—arrows indicate blood flow.**

atrium and pumps it out into the arteries. The openings between the chambers on each side of the heart are separated by flaps of tissue that act as valves to prevent backward flow of blood. The valve on the right has three flaps, or cusps, and is called the **tricuspid valve**. The valve on the left has two flaps and is called the **mitral**, or **bicuspid**, **valve**. The outlets of the ventricles are supplied with similar valves. In the right ventricle, the **pulmonary valve** is at the origin of the pulmonary artery. In the left ventricle, the **aortic valve** is at the origin of the aorta. See figure 1-33 for valve locations.

The heart muscle, the **myocardium**, is striated like the skeletal muscles of the body, but involuntary in action, like the smooth muscles. The walls of the atria are thin with relatively little muscle fiber because the blood flows from the atria to the ventricles under low pressure. However, the walls of the ventricles, which comprise the bulk of the heart, are thick and muscular. The wall of the left ventricle is considerably thicker than that of the right, because more force is required to pump the blood into distant or outlying locations of the circulatory system than into the lungs located only a short distance from the heart.

## Heart Functions

The heart acts as four interrelated pumps. The right atrium receives deoxygenated blood from the body via the **superior** and **inferior vena cava**. It pumps the deoxygenated blood through the tricuspid valve to the right ventricle. The right ventricle pumps the blood past the pulmonary valve through the **pulmonary artery** to the lungs, where it is oxygenated. The left atrium receives the oxygenated blood from the lungs through four **pulmonary veins** and pumps it to the left ventricle past the mitral valve. The left ventricle pumps the blood to all areas of the body via the aortic valve and the **aorta**.

The heart's constant contracting and relaxing forces blood into the arteries. Each contraction is followed by limited relaxation or dilation. Cardiac muscle never completely relaxes: It always maintains a degree of tone. Contraction of the heart is called **systole** or "the period of work." Relaxation of the heart is called **diastole** or "the period of rest." A complete cardiac cycle is the time from onset of one contraction, or heart beat, to the onset of the next.

## Cardiac Cycle

The cardiac cycle is coordinated by specialized tissues that initiate and distribute electrical (cardiac) impulses (fig. 1-34). The contractions of the heart are stimulated and maintained by the **sinoatrial (SA) node**, commonly called the **pacemaker** of the heart. The SA node is an elongated mass of specialized muscle tissue located in the upper part of the right atrium. The SA node sets off cardiac impulses, causing both atria to contract simultaneously. The normal heart rate, or number of contractions, is about 70 to 80 beats per minute.

This same cardiac impulse continues to travel to another group of specialized tissue called the **atrioventricular (AV) node**. The AV node is located in the floor of the right atrium near the septum that separates the atria. The cardiac impulse to the AV node is slowed down by **junctional fibers**. The junctional fibers conduct the cardiac impulse to the AV node; however, these fibers are very small in diameter, causing the impulse to be delayed. This slow arrival of the impulse to the AV node allows time for the atria to empty and the ventricles to fill with blood.

Once the cardiac impulse reaches the far side of the AV node, it quickly passes through a group of large fibers which make up the AV bundle (also called the bundle of His). The AV bundle starts at the upper part of the interventricular septum and divides into right and left branches. About halfway down the interventricular septum, the right and left branches terminate into **Purkinje fibers**. The Purkinje fibers spread from the interventricular septum into the papillary muscles, which project inward from the ventricular walls. As the cardiac impulse passes through the Purkinje fibers, these fibers in turn stimulate the cardiac muscle of the ventricles. This stimulation of the cardiac muscles causes the walls of the ventricles to contract with a twisting motion. This action squeezes the blood out of the ventricular chambers and forces it into the arteries. This is the conclusion of one cardiac cycle.

## Blood Pressure

Blood pressure is the pressure the blood exerts on the walls of the arteries. The highest pressure is called **systolic** pressure, because it is caused when the heart is in systole, or contraction. A certain amount of blood pressure is maintained in the arteries even when the heart is relaxed. This pressure is the **diastolic** pressure, because it is present during diastole, or relaxation of the heart. The difference between systolic and diastolic pressure is known as **pulse pressure**.

Normal blood pressure can vary considerably with an individual's age, weight, and general condition. For young adults, the systolic pressure is normally between 120 and 150 mm of mercury, and the diastolic pressure is normally between 70 and 90 mm of mercury. On average, women have lower blood pressure than men.

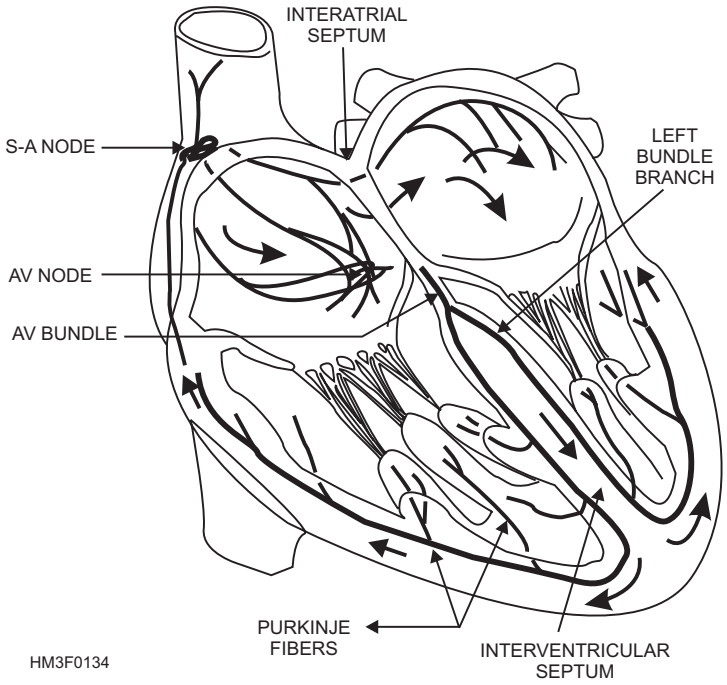


**Figure 1-34.—Cardiac cycle.**

## BLOOD VESSELS

Blood vessels form a closed circuit of tubes that transport blood between the heart and body cells. The several types of blood vessels include arteries, arterioles, capillaries, venules, and veins.

### Blood Vessel Classifications

The blood vessels of the body fall into three classifications:

- **Arteries and arterioles**—distributors
- **Capillaries**—exchangers
- **Veins and venules**—collectors

### Arteries and Arterioles

Arteries are elastic tubes constructed to withstand high pressure. They carry blood away from the heart to all parts of the body. The smallest branches of the arteries are called **arterioles**. The walls of arteries and arterioles consist of layers of endothelium, smooth muscle, and connective tissue. The smooth muscles of arteries and arterioles constrict and dilate in response to electrical impulses received from the autonomic nervous system.

### Capillaries

At the end of the arterioles is a system of minute vessels that vary in structure, but which are spoken of collectively as capillaries. It is from these capillaries that the tissues of the body are fed. There are approximately 60,000 miles of capillaries in the body. As the blood passes through the capillaries, it releases oxygen and nutritive substances to the tissues and takes up various waste products to be carried away by **venules**. Venules continue from capillaries and merge to form veins.

### Veins and Venules

Veins and venules form the venous system. The venous system is comprised of vessels that collect blood from the capillaries and carry it back to the heart. Veins begin as tiny venules formed from the capillaries. Joining together as tiny rivulets, veins connect and form a small stream. The force of muscles contracting adjacent to veins aids in the forward propulsion of blood on its return to the heart. Valves, spaced frequently along the larger veins, prevent the backflow of blood. The walls of veins are similar to arteries, but are thinner and contain less muscle and elastic tissue.

### Arterial System

Arterial circulation is responsible for taking freshly oxygenated blood from the heart to the cells of the body (fig. 1-35). To take this oxygenated blood from the heart to the entire body, the arterial system begins with the contraction of blood from the left ventricle into the aorta and its branches.

**AORTA**.—The aorta, largest artery in the body, is a large tube-like structure arising from the left ventricle of the heart. It arches upward over the left lung and then down along the spinal column through the thorax and the abdomen, where it divides and sends arteries down both legs (fig. 1-35).

**KEY BRANCHES OF THE AORTA**.—Key arterial branches of the aorta are the coronary, innominate (brachiocephalic), left common carotid, and left subclavian. The coronary arteries are branches of what is called the **ascending aorta**. The coronary arteries supply the heart with blood. There are three large arteries that arise from the aorta as it arches over the left lung. First is the **innominate artery**, which divides into the **right subclavian artery** to supply the right arm, and the **right common carotid** to supply the right side of the head. The second branch is the **left common carotid**, which supplies the left side of the head. The third branch is the **left subclavian**, which supplies the left arm.

**ARTERIES OF THE HEAD, NECK, AND BRAIN**.—The **carotid arteries** divide into internal and external branches, the external supplying the muscle and skin of the face and the internal supplying the brain and the eyes.

**ARTERIES OF THE UPPER EXTREMITIES**.—The **subclavian arteries** are so named because they run underneath the clavicle. They supply the upper extremities, branching off to the back, chest, neck, and brain through the spinal column (fig. 1-35).

The large artery going to the arm is called the **axillary**. The axillary artery becomes the **brachial artery** as it travels down the arm and divides into the **ulnar** and **radial arteries**. The radial artery is the artery at the wrist that you feel when you take the pulse of your patient (fig. 1-35).

**ARTERIES OF THE ABDOMEN**.—In the abdomen, the aorta gives off branches to the abdominal viscera, including the stomach, liver, spleen, kidneys,

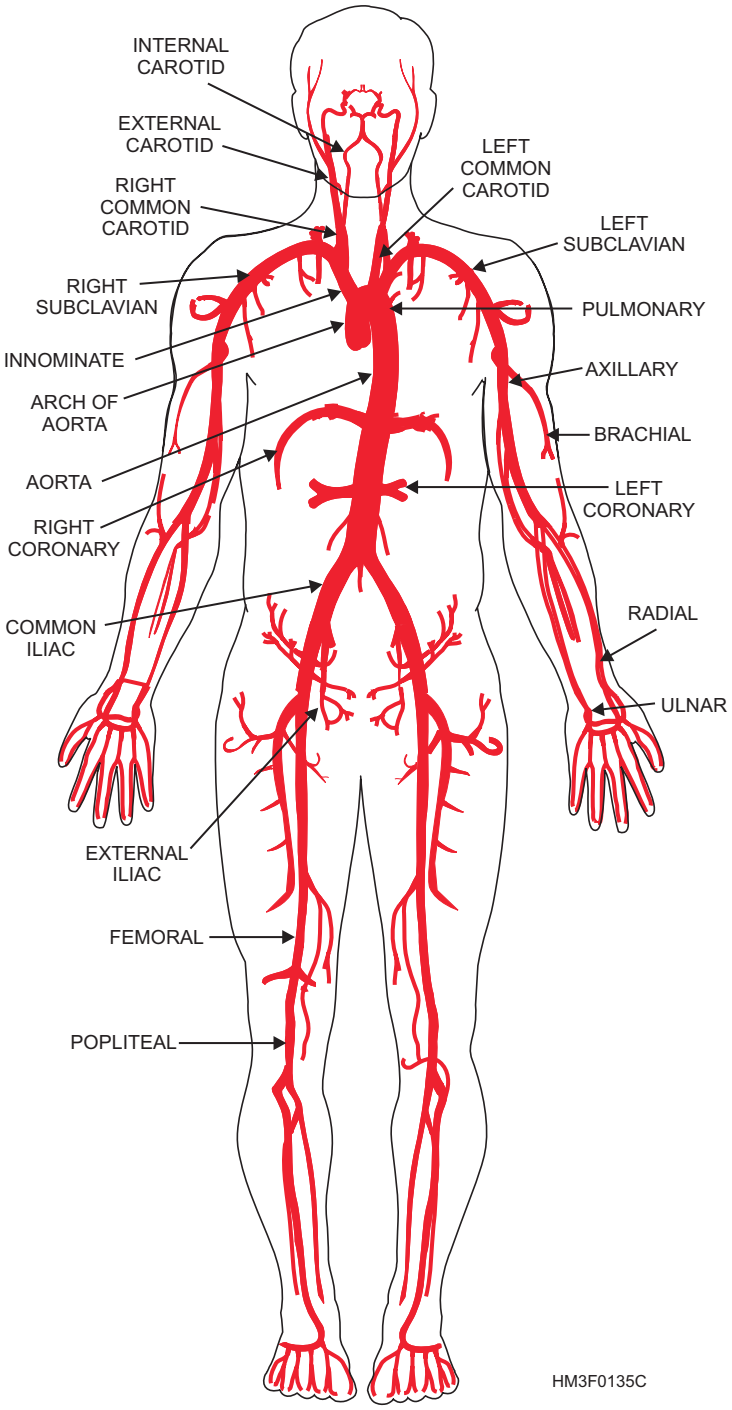


**Figure 1-35.—Principal vessels of the arterial system.**

and intestines. The aorta later divides into the **left** and **right common iliacs**, which supply the lower extremities (fig. 1-35).

**ARTERIES OF THE LOWER EXTREMITIES**.—The left and right common iliacs, upon entering the thigh, become the **femoral artery**. At the knee, this same vessel is named the **popliteal artery** (fig. 1-35).

### Venous System

Venous circulation is responsible for returning the blood to the heart after exchanges of gases, nutrients, and wastes have occurred between the blood and body cells (fig. 1-36). To return this blood to the heart for reoxygenation, the venous system begins with the merging of capillaries into venules, venules into small veins, and small veins into larger veins. The blood vessel paths of the venous system are difficult to

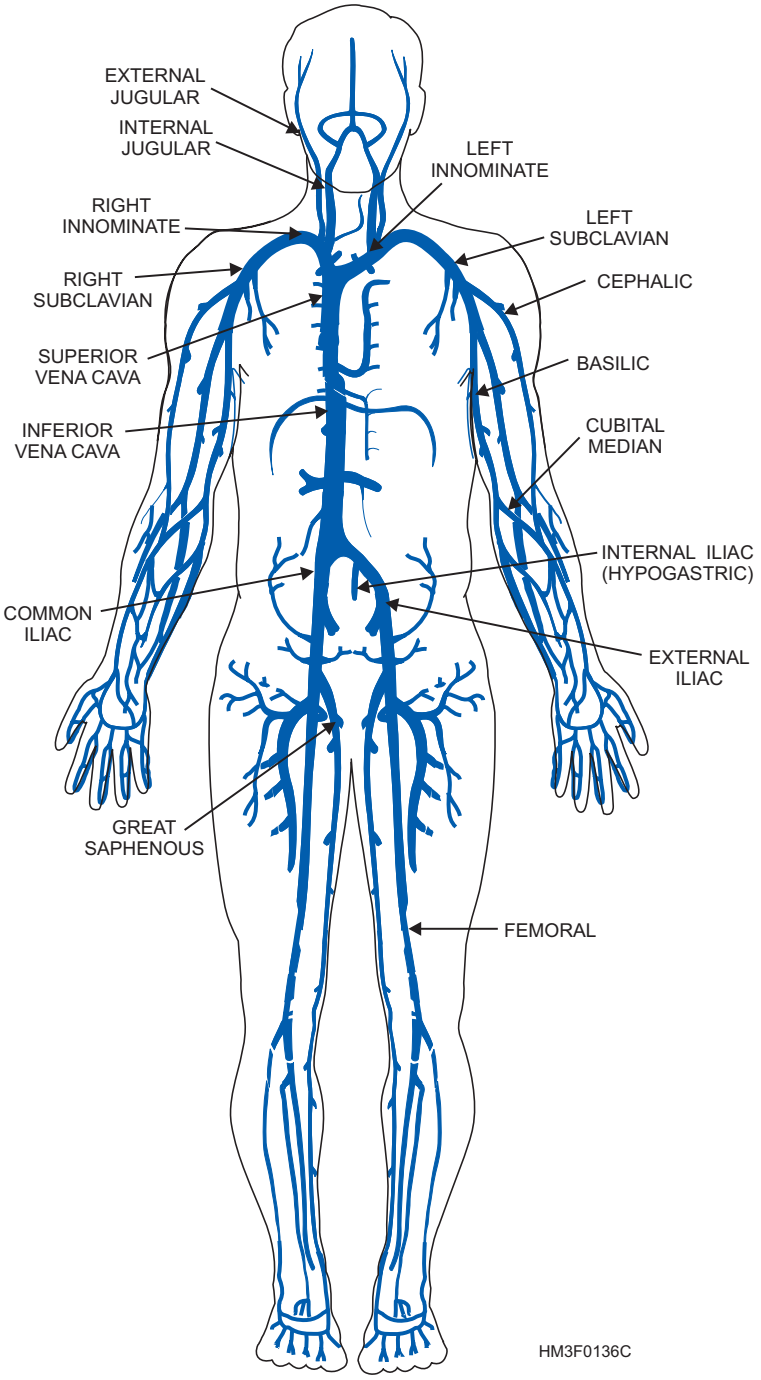


**Figure 1-36.—Principal vessels of the venous system.**

follow, unlike the arterial system. However, the larger veins are commonly located parallel to the course taken by their counterpart in the arterial system. For instance, the renal vein parallels the renal artery, the common iliac vein parallels the common iliac artery, and so forth.

**THREE PRINCIPAL VENOUS SYSTEMS**.—The three principal venous systems in the body are the **pulmonary, portal**, and **systemic**.

- The **pulmonary system** is composed of four vessels, two from each lung, which empty into the left atrium. These are the only veins in the body that carry freshly oxygenated blood.

- The **portal system** consists of the veins that drain venous blood from the abdominal part of the digestive tract—the spleen, pancreas, and gallbladder, but not the lower rectum—and deliver it to the liver. There, it is distributed by a set of venous capillaries. The blood in the portal system conveys absorbed substances from the intestinal tract to the liver for storage,

alteration, or detoxification. From the liver the blood flows through the hepatic vein to the inferior vena cava.

- The **systemic system** is divided into the deep and superficial veins. The superficial veins lie immediately under the skin, draining the skin and superficial structures. The deep veins, usually located in the muscle or deeper layers, drain the large muscle masses and various other organs. Deep veins commonly lie close to the large arteries that supply the various organs of the body and typically have the same name as the artery they accompany.

**VEINS OF THE HEAD, NECK, AND BRAIN**.—The superficial veins of the head unite to form the **external jugular veins**. The external jugular veins drain blood from the scalp, face, and neck, and finally empty into the **subclavian veins**.

The veins draining the brain and internal facial structures are the **internal jugular veins**. These combine with the subclavian veins to form the **innominate veins**, which empty into the **superior vena cava** (fig. 1-36).

**VEINS OF THE UPPER EXTREMITIES**.—The veins of the upper extremities begin at the hand and extend upward. A vein of great interest to you is the **median cubital**, which crosses the anterior surface of the elbow. It is the vein most commonly used for venipuncture. Also found in this area are the **basilic** and **cephalic veins,** which extend from the midarm to the shoulder.

The deep veins of the upper arm unite to form the **axillary vein**, which unites with the superficial veins to form the subclavian vein. This vein later unites with other veins to form the innominate and eventually, after union with still more veins, the superior vena cava (fig. 1-36).

**VEINS OF THE ABDOMEN AND THORACIC REGION**.—The veins from the abdominal organs, with the exception of those of the portal system, empty directly or indirectly into the **inferior vena cava**, while those of the thoracic region eventually empty into the superior vena cava (fig. 1-36).

**VEINS OF THE LOWER EXTREMITIES**.—In the lower extremities (fig. 1-36), a similar system drains the superficial areas. The **great saphenous vein** originates on the inner aspect of the foot and extends up the inside of the leg and thigh to join the **femoral vein** in the upper thigh. The great saphenous vein is used for intravenous injections at the ankle.

The veins from the lower extremities unite to form the femoral vein in the thigh, which becomes the **external iliac vein** in the groin. Higher in this region, external iliac unites the **internal iliac** (hypogastric) **vein** from the lower pelvic region to form the **common iliac veins**. The right and left common iliac veins unite to form the inferior vena cava.

## THE LYMPHATIC SYSTEM

**LEARNING OBJECTIVE**: *Identify the parts of the lymphatic system and their function.*

All tissue cells of the body are continuously bathed in **interstitial fluid**. This fluid is formed by leakage of blood plasma through minute pores of the capillaries. There is a continual interchange of fluids of the blood and tissue spaces with a free interchange of nutrients and other dissolved substances. Most of the tissue fluid returns to the circulatory system by means of capillaries, which feed into larger veins. Large protein molecules that have escaped from the arterial capillaries cannot reenter the circulation through the small pores of the capillaries. However, these large molecules, as well as white blood cells, dead cells, bacterial debris, infected substances, and larger particulate matter, can pass through the larger pores of the lymphatic capillaries and, thus, enter the lymphatic circulatory system with the remainder of the tissue fluid.

The lymphatic system also helps defend the tissues against infections by supporting the activities of the **lymphocytes**, which give immunity, or resistance, to the effects of specific disease-causing agents.

### PATHWAYS OF THE LYMPHATIC SYSTEM

The lymphatic pathway begins with lymphatic capillaries. These small tubes merge to form lymphatic vessels, and the lymphatic vessels in turn lead to larger vessels that join with the veins in the thorax.

#### Lymphatic Capillaries

Lymphatic capillaries are closed-ended tubes of microscopic size (fig. 1-37). They extend into interstitial spaces, forming complex networks that parallel blood capillary networks. The lymphatic capillary wall consists of a single layer of squamous epithelial cells. This thin wall makes it possible for interstitial fluid to enter the lymphatic capillary. Once

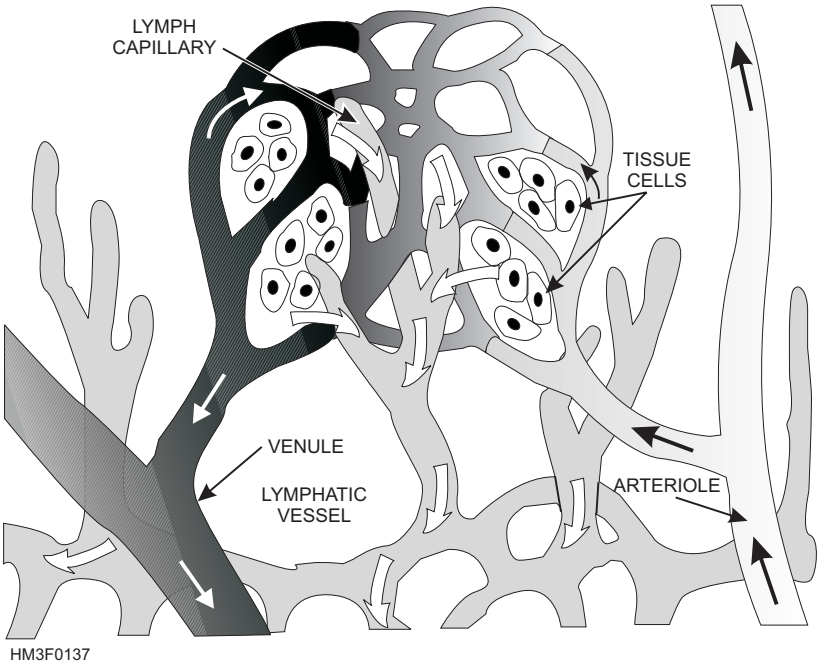


**Figure 1-37.—Lymphatic capillary and vessel.**

the interstitial fluid enters the lymphatic capillaries, the fluid is called **lymph**.

### Lymphatic Vessels

Lymphatic vessels are formed from the merging of lymphatic capillaries (fig. 1-37). Lymphatic vessels, also known simply as **lymphatics**, are similar to veins in structure. The vessel walls are composed of three layers: an inner layer of endothelial tissue, a middle layer of smooth muscle and elastic fibers, and an outer layer of connective tissue. Like a vein, the lymphatic vessel has valves to prevent backflow of lymph. The larger lymphatic vessels lead to specialized organs called lymph nodes. After leaving these structures, the vessels merge to form still larger lymphatic trunks.

### Lymphatic Trunks and Ducts

Lymphatic trunks drain lymph from large regions in the body. The lymphatic trunks are usually named after the region they serve, such as the subclavian trunk that drains the arm. There are many lymphatic trunks through out the body. These lymphatic trunks then join one of two collecting ducts, the **thoracic duct** and the **right lymphatic duct** (fig. 1-38).

Lymphatic trunks from the upper half of the right side of the body converge to form the right lymphatic duct, which empties into the right subclavian vein. Drainage from the remainder of the body is by way of the thoracic duct, which empties into the left subclavian vein.

## LYMPH NODES

Lymph nodes, which are frequently called glands but are not true glands, are small bean-shaped bodies of lymphatic tissue found in groups of two to fifteen along the course of the lymph vessels (fig. 1-38). Major locations of lymph nodes are in the following regions: cervical, axillary, inguinal, pelvic cavity, abdominal cavity, and thoracic cavity. Lymph nodes vary in size and act as filters to remove bacteria and particles from the lymph stream. Lymph nodes produce lymphocytes, which help defend the body against harmful foreign particles, such as bacteria, cells, and viruses. Lymph nodes also contain **macrophages**, which engulf and destroy foreign substances, damaged cells, and cellular debris.

## THE RESPIRATORY SYSTEM

**LEARNING OBJECTIVE:** *Identify the location and function of each part of the respiratory system, and recall the process of respiration.*

Respiration is the exchange of oxygen and carbon dioxide between the atmosphere and the cells of the body. There are two phases of respiration:

- **Physical**, or **mechanical**, **respiration** involves the motion of the diaphragm and rib cage. The

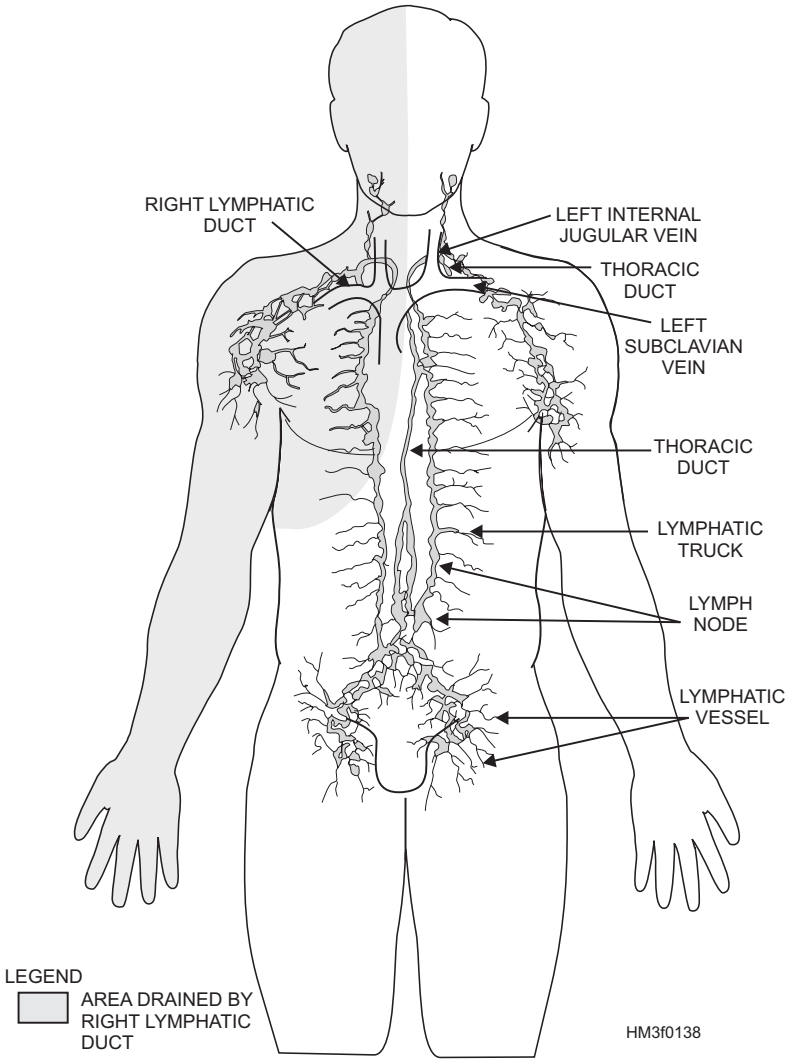


**Figure 1-38.—Pathway of right lymphatic duct and thoracic duct.**

musculoskeletal action, which resembles that of a bellows, causes air to be inhaled or exhaled.

- **Physiological respiration** involves an exchange of gases, oxygen and carbon dioxide, at two points in the body. The first is the transfer that occurs in the lungs between the incoming oxygen and the carbon dioxide present in the capillaries of the lungs (external respiration). The second transfer occurs when oxygen brought into the body replaces carbon dioxide build up in the cellular tissue (internal respiration).

Normally, oxygen and carbon dioxide exchange in equal volumes; however, certain physiological conditions may throw this balance off. For example, heavy smokers will find that the ability of their lungs to exchange gases is impaired, leading to shortness of breath and fatigue during even slight physical exertion. This debilitating situation is the direct result of their inability to draw a sufficient amount of oxygen into the body to replace the carbon dioxide build-up and sustain further muscular exertion. On the other hand, hyperventilation brings too much oxygen into the body, overloading the system with oxygen, and depleting the carbon dioxide needed for balance.

## ANATOMY OF THE RESPIRATORY SYSTEM

Air enters the nasal chambers and the mouth, then passes through the pharynx, larynx, trachea, and bronchi into the bronchioles. Each bronchiole is surrounded by a cluster of alveoli (fig. 1-39).

### Nasal Cavity

Air enters the nasal cavity through the nostrils (**nares**). Lining the nasal passages are hairs, which, together with the mucous membrane, entrap and filter out dust and other minute particles that could irritate the lungs. Incoming air is warmed and moistened in the

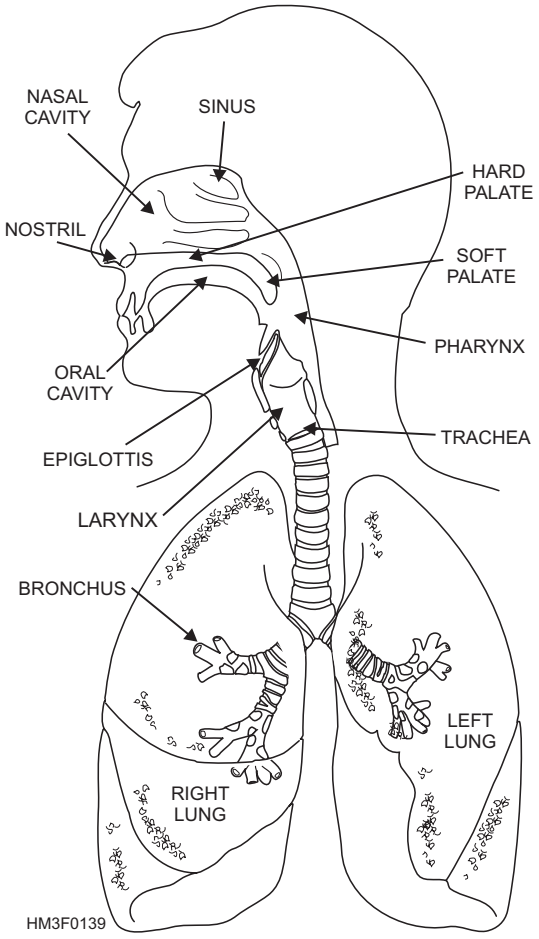


**Figure 1-39.—Organs of the respiratory system.**

chambers of the nasal cavity to prevent damage to the lungs. The nasal and oral cavities are separated by the **palate.** The anterior, rigid portion is called the **hard palate**, and the posterior fleshy part is called the **soft palate.** The mouth and nose serve as secondary respiratory structures.

### Pharynx

The pharynx, or throat, serves both the respiratory and digestive systems and aids in speech. It has a mucous membrane lining that traps microscopic particles in the air and aids in adjusting temperature and humidifying inspired (inhaled) air. The pharynx connects with the mouth and nasal chambers posteriorly. According to its location, the pharynx is referred to as the **nasopharynx** posterior to the nasal chambers), the **oropharynx** (posterior to the mouth), or the **laryngopharynx** (posterior to the pharynx).

### Epiglottis

The epiglottis is a lidlike, cartilaginous structure that covers the entrance to the larynx and separates it from the pharynx. It acts as a trap door to deflect food particles and liquids from the entrance to the larynx and trachea.

### Larynx

The larynx, or voice box, is a triangular cartilaginous structure located between the tongue and the trachea. It is protected anteriorly by the thyroid cartilage (commonly called the Adam's apple), which is usually larger and more prominent in men than in women. During the act of swallowing, it is pulled upward and forward toward the base of the tongue. The larynx is responsible for the production of vocal sound (voice). This sound production is accomplished by the passing of air over the vocal cords. The ensuing vibrations can be controlled to produce the sounds of speech or singing. The nose, mouth, throat, bone sinuses, and chest serve as resonating chambers to further refine and individualize the voice.

### Trachea

The trachea, or windpipe, begins at the lower end of the larynx and terminates by dividing into the right and left bronchi. It is a long tube composed of 16 to 20 C-shaped cartilaginous rings, embedded in a fibrous membrane, that support its walls, preventing their collapse (fig. 1-39).

The trachea has a ciliated mucous membrane lining that entraps dust and foreign material. It also propels secretions and exudates from the lungs to the pharynx, where they can be expectorated.

### Bronchi

The bronchi are the terminal branches of the trachea, which carry air to each lung and further divide into the bronchioles.

### Bronchioles

The bronchioles are much smaller than the bronchi and lack supporting rings of cartilage. They terminate at the alveoli (fig. 1-40).

### Alveoli

The alveoli are thin, microscopic air sacs within the lungs (fig. 1-40). They are in direct contact with the pulmonary capillaries. It is here that fresh oxygen exchanges with carbon dioxide by means of a diffusion process through the alveolar and capillary cell walls

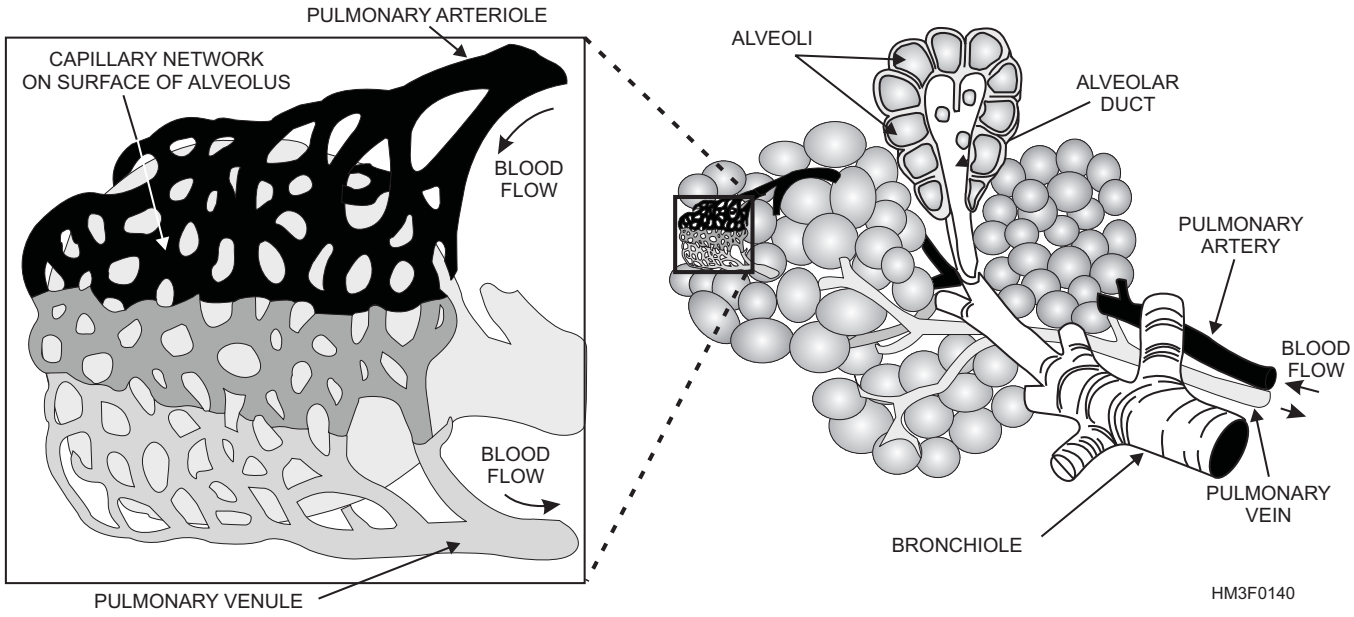


**Figure 1-40.—Bronchiole and alveoli.**

(fig. 1-41). The **lungs** are cone-shaped organs that lie in the thoracic cavity. Each lung contains thousands of alveoli with their capillaries. The right lung is larger than the left lung and is divided into superior, middle, and inferior lobes. The left lung has two lobes, the superior and the inferior.

### Pleurae

The pleurae are airtight membranes that cover the outer surface of the lungs and line the chest wall. They secrete a serous fluid that prevents friction during movements of respiration.

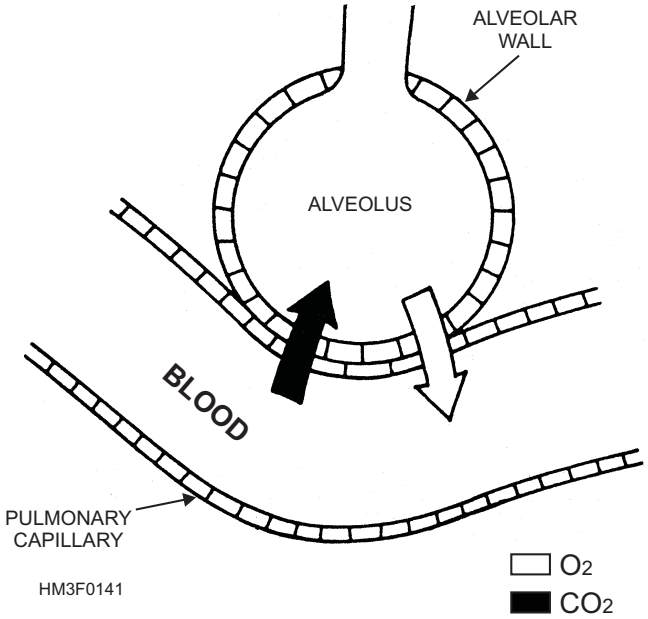


**Figure 1-41.—Pulmonary exchange at alveolus.**

### Mediastinum

The mediastinum is the tissue and organs of the thoracic cavity that form a septum between the lungs. It extends from the sternum to the thoracic vertebrae and from the fascia of the neck to the diaphragm. The mediastinum contains the heart, the great blood vessels, the esophagus, a portion of the trachea, and the primary bronchi.

### Diaphragm

The diaphragm is the primary muscle of respiration. It is a dome-shaped muscle and separates the thoracic and abdominal cavities. Contraction of this muscle flattens the dome and expands the vertical diameter of the chest cavity.

### Intercostal Muscles

The intercostal muscles are situated between the ribs. Their contraction pulls the ribs upward and outward, resulting in an increase in the transverse diameter of the chest (chest expansion).

**Inhalation** is the direct result of the expansion caused by the action of the diaphragm and intercostal muscles. The increase in chest volume creates a negative (lower than atmospheric) pressure in the pleural cavity and lungs. Air rushes into the lungs through the mouth and nose to equalize the pressure. **Exhalation** results when the muscles of respiration relax. Pressure is exerted inwardly as muscles and

bones return to their normal position, forcing air from the lungs.

### THE PROCESS OF RESPIRATION

The rhythmical movements of breathing are controlled by the respiratory center in the brain. Nerves from the brain pass down through the neck to the chest wall and diaphragm. The nerve that controls the diaphragm is called the **phrenic nerve**; the nerve that controls the larynx is the **vagus nerve**; and the nerves that control the muscles between the ribs are the **intercostal nerves**.

The respiratory center is stimulated by chemical changes in the blood. When too much carbon dioxide accumulates in the blood stream, causing the blood to become acidic, the respiratory center signals the lungs to breathe faster to get rid of the carbon dioxide.

The respiratory center can also be stimulated or depressed by a signal from the brain. For example, changes in one's emotional state can alter respiration through laughter, crying, emotional shock, or panic.

The muscles of respiration normally act automatically, with normal respiration being 14 to 18 cycles per minute. The lungs, when filled to capacity, hold about 6,500 ml of air, but only 500 ml of air is exchanged with each normal respiration. This exchanged air is called **tidal air**. The amount of air left in the lungs after forceful exhalation is about 1,200 ml and is known as **residual air**.

## THE NERVOUS SYSTEM

**LEARNING OBJECTIVE:** *Identify the components and function of a neuron, recall the process of impulse transmission, and identify the components and functions of the central and peripheral nervous systems.*

The activities of the widely diverse cells, tissues, and organs of the body must be monitored, regulated, and coordinated to effectively support human life. The interaction of the nervous and endocrine systems provides the needed control.

The nervous system is specifically adapted to the rapid transmission of impulses from one area of the body to another. On the other hand, the endocrine system, working at a far slower pace, maintains body metabolism at a fairly constant level.

In this section, you will study the **neuron**, the basic functional unit of the nervous system. Also, you will study the components and functions of the different divisions of the nervous system. The nervous system is divided into two major groups, the **central nervous system** (CNS) and the **peripheral nervous system** (PNS). Another division of the nervous system is the **autonomic nervous system** (ANS), which is further subdivided into the **sympathetic** and **parasympathetic nervous systems**.

### THE NEURON

The structure and functional unit of the nervous system is the nerve cell, or neuron, which can be classified into three types. The first is the **sensory** neuron, which conveys sensory impulses inward from the receptors. The second is the **motor** neuron, which carries command impulses from a central area to the responding muscles or organs. The third type is the **interneuron**, which links the sensory neurons to the motor neurons.

The neuron is composed of dendrites, a cyton, and an axon (fig. 1-42). The **dendrites** are thin receptive branches, and vary greatly in size, shape, and number with different types of neurons. They serve as receptors, conveying impulses toward the **cyton**. The cyton is the cell body containing the nucleus. The single, thin extension of the cell outward from the cyton is called the **axon**. It conducts impulses away from the cyton to its **terminal branches**, which transmit the impulses to the dendrites of the next neuron.

Large axons of the peripheral nerves are commonly enclosed in a sheath, called **neurilemma**, composed of **Schwann cells** (fig. 1-42). Schwann cells wrap around the axon and act as an electrical insulator.

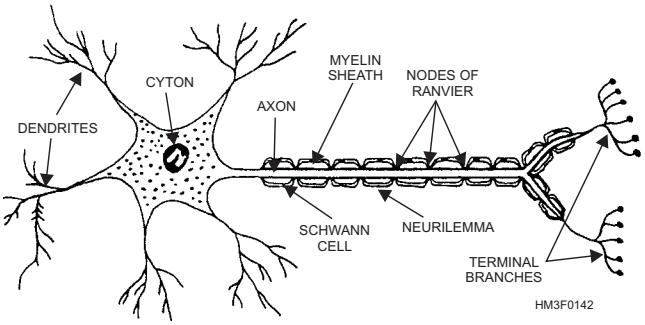


**Figure 1-42.—The neuron and its parts.**

The membranes of the Schwann cell are composed largely of a lipid-protein called **myelin**, which forms a **myelin sheath** on the outside of an axon. The myelin sheath has gaps between adjacent Schwann cells called **nodes of Ranvier**. Nerve cells without Schwann cells also lack myelin and neurilemma sheaths.

## IMPULSE TRANSMISSION

When dendrites receive a sufficiently strong stimulus, a short and rapid change in electrical charge, or polarity, of the neuron is triggered. Sodium ions rush through the plasma membrane into the cell, potassium ions leave, and an electrical impulse is formed, which is conducted toward the cyton. The cyton receives the impulse and transmits it to the terminal filaments of the axon. At this point a chemical transmitter such as acetylcholine is released into the **synapse**, a space between the axon of the activated nerve and the dendrite receptors of another neuron. This chemical transmitter activates the next nerve. In this manner, the impulse is passed from neuron to neuron down the nerve line to a central area at approximately the speed of a bullet.

Almost immediately after being activated, the chemical transmitter in the synapse is neutralized by the enzyme acetylcholinesterase, and the first neuron returns to its normal state by pumping out the sodium ions and drawing potassium ions back in through the plasma membrane. When these actions are completed, the nerve is ready to be triggered again. A particularly strong stimulus will cause the nerve to fire in rapid succession, or will trigger many other neurons, thus giving a feeling of intensity to the perceived sensation.

## NERVES

A nerve is a cordlike bundle of nerve fibers held together with connective tissue. Each nerve fiber is an extension of a neuron. Nerves that conduct impulses into the brain or the spinal cord are called **sensory nerves**, and those that carry impulses to muscles and glands are termed **motor nerves**. Most nerves, however, include both sensory and motor fibers, and they are called **mixed nerves**.

## CENTRAL NERVOUS SYSTEM

The central nervous system (CNS) consists of the brain and spinal cord. The brain is almost entirely enclosed in the skull, but it is connected with the spinal cord, which lies in the canal formed by the vertebral column.

### Brain

The brain has two main divisions, the **cerebrum** and the **cerebellum**. The cerebrum is the largest and most superiorly situated portion of the brain. It occupies most of the cranial cavity. The outer surface is called the **cortex**. This portion of the brain is also called "gray matter" because the nerve fibers are unmyelinated (not covered by a myelin sheath), causing them to appear gray. Beneath this layer is the **medulla**, often called the white matter of the brain because the nerves are myelinated (covered with a myelin sheath), giving them their white appearance.

**CEREBRUM**.—The cortex of the cerebrum is irregular in shape. It bends on itself in folds called **convolutions**, which are separated from each other by grooves, also known as **fissures**. The deep **sagittal cleft**, a longitudinal fissure, divides the cerebrum into two hemispheres. Other fissures further subdivide the cerebrum into lobes, each of which serves a localized, specific brain function (fig. 1-43). For example, the **frontal lobe** is associated with the higher mental processes such as memory, the **parietal lobe** is concerned primarily with general sensations, the **occipital lobe** is related to the sense of sight, and the **temporal lobe** is concerned with hearing.

**CEREBELLUM**.—The cerebellum is situated posteriorly to the brain stem (which is made up of the pons, mid-brain, and medulla oblongata) and inferior to the occipital lobe. The cerebellum is concerned chiefly with bringing balance, harmony, and coordination to the motions initiated by the cerebrum.

**PONS AND MEDULLA OBLONGATA**.— Two smaller divisions of the brain vital to life are the pons and the medulla oblongata. Together, the pons and medulla form the **brain stem** (fig. 1-43). The pons consists chiefly of a mass of white fibers connecting the other three parts of the brain (the cerebrum, cerebellum, and medulla oblongata).

The medulla oblongata is the inferior portion of the brain, the last division before the beginning of the spinal cord. It connects to the spinal cord at the upper level of the first cervical vertebra (C-1). In the medulla oblongata are the centers for the control of heart action, breathing, circulation, and other vital processes such as blood pressure.

**MENINGES**.—The outer surface of the brain and spinal cord is covered with three layers of membranes called the meninges. The **dura mater** is the strong outer layer; the **arachnoid membrane** is the delicate

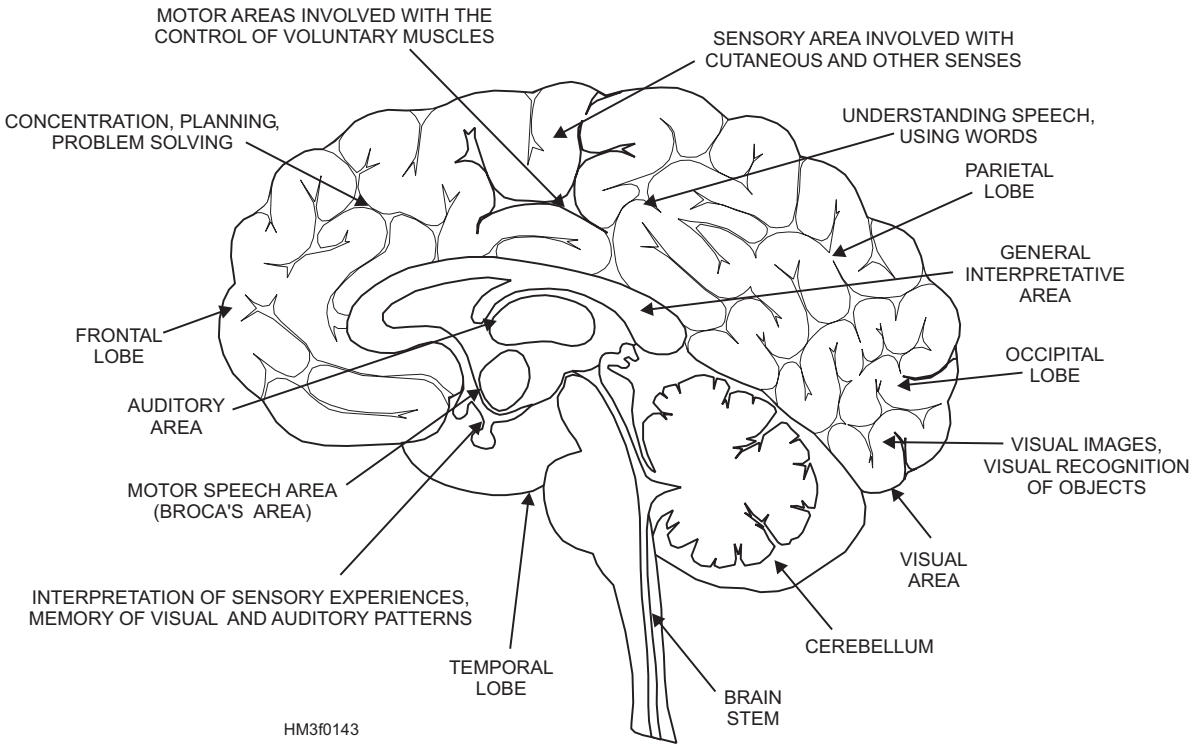


**Figure 1-43.—Functional areas of the brain.**

middle layer; and the **pia mater** is the vascular inner-most layer that adheres to the surface of the brain and spinal cord. Inflammation of the meninges is called meningitis. The type of meningitis contracted depends upon whether the brain, spinal cord, or both are affected, as well as whether it is caused by viruses, bacteria, protozoa, yeasts, or fungi.

**CEREBROSPINAL FLUID**.—Cerebrospinal fluid is formed by a plexus, or network, of blood vessels in the central ventricles of the brain. It is a clear, watery solution similar to blood plasma. The total quantity of spinal fluid bathing the spinal cord is about 75 ml. This fluid is constantly being produced and reabsorbed. It circulates over the surface of the brain and spinal cord and serves as a protective cushion as well as a means of exchange for nutrients and waste materials.

### Spinal Cord

The spinal cord is continuous with the medulla oblongata and extends from the foramen magnum, through the atlas, to the lower border of the first lumbar vertebra, where it tapers to a point. The spinal cord is surrounded by the bony walls of the vertebral canal (fig. 1-44). Ensheathed in the three protective meninges and surrounded by fatty tissue and blood vessels, the cord does not completely fill the vertebral canal, nor does it extend the full length of it. The nerve roots serving the lumbar and sacral regions must pass some distance down the canal before making their exit. The **sympathetic trunk** contains the **paravertebral ganglia** (*sing.* ganglion), knotlike masses of nerve cell bodies (fig. 1-44).

A cross section of the spinal cord shows white and gray matter (fig. 1-45). The outer white matter is composed of bundles of myelinated nerve fibers arranged in functionally specialized tracts. It establishes motor communication between the brain and the body parts. The inner gray unmyelinated

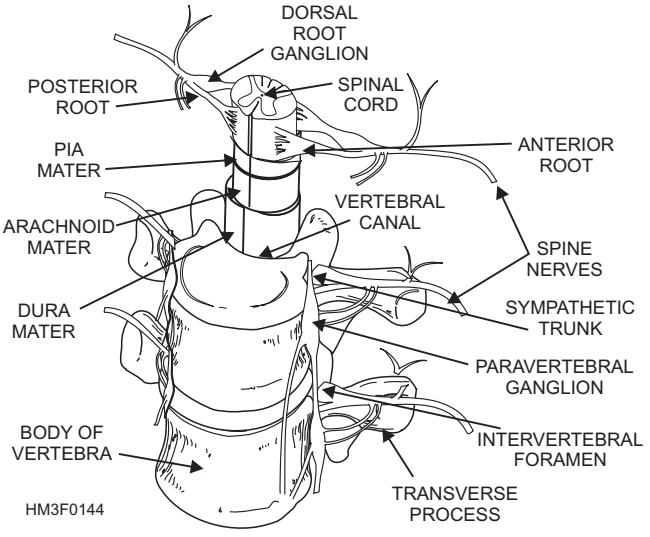


**Figure 1-44.—Spinal cord.**

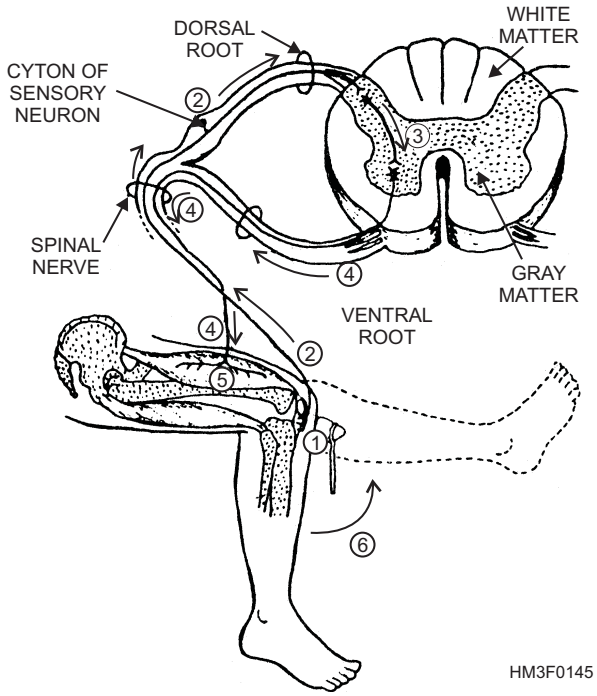


**Figure 1-45.—Cross section of the spinal cord and reflex arc—arrows and numbers show impulse pathway.**

matter is shaped roughly like the letter H. It establishes sensory communication between the brain and the spinal nerves, conducting sensory impulses from the body parts.

The spinal cord may be thought of as an electric cable containing many wires (nerves) that connect parts of the body with each other and with the brain. Sensations received by a sensory nerve are brought to the spinal cord, and the impulse is transferred either to the brain or to a motor nerve. The majority of impulses go to the brain for action. However, a system exists for quickly handling emergency situations. It is called the **reflex arc**.

If you touch a hot stove, you must remove your hand from the heat source immediately or the skin will burn very quickly. But the passage of a sense impulse to the brain and back again to a motor nerve takes too much time. The reflex arc responds instantaneously to emergency situations like the one just described. The sensation of heat travels to the spinal cord on a sensory nerve. When the sensation reaches the spinal cord, it is picked up by an interneuron in the gray matter. This reception then triggers the appropriate nerve to stimulate a muscle reflex drawing the hand away. An illustrated example of the reflex arc is shown in figure 1-45.

The reflex arc works well in simple situations requiring no action of the brain. Consider, however, what action is involved if the individual touching the stove pulls back and, in so doing, loses balance and has to grab a chair to regain stability. Then the entire spinal cord is involved. Additional impulses must travel to the brain, then down to the muscles of the legs and arms to enable the individual to maintain balance and to hold on to a steadying object. While all this activity is going on, the stimulus is relayed through the sympathetic autonomic nerve fibers to the adrenal glands, causing adrenalin to flow, which stimulates heart action. The stimulus then moves to the brain, making the individual conscious of pain. In this example, the spinal cord has functioned not only as a center for spinal relaxes, but also as a conduction pathway for other areas of the spinal cord to the autonomic nervous system and to the brain.

## PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system (PNS) consists of the nerves that branch out from the CNS and connect it to the other parts of the body. The PNS includes 12 pairs of cranial nerves and 31 pairs of spinal nerves. Cranial and spinal nerves carry both voluntary and involuntary impulses.

### Cranial Nerves

The 12 pairs of cranial nerves are sensory, motor, or mixed (sensory and motor). Table 1-3 shows the 12 cranial nerves and parts of the body they service.

### Spinal Nerves

There are 31 pairs of spinal nerves that originate from the spinal cord. Although spinal nerves are not named individually, they are grouped according to the level from which they arise, and each nerve is numbered in sequence. Thus, there are 8 pairs of **cervical** nerves, 12 pairs of **thoracic** nerves, 5 pairs of **lumbar** nerves, 5 pairs of **sacral** nerves, and 1 pair of **coccygeal** nerves. See figure 1-46.

Spinal nerves (mixed) send fibers to sensory surfaces and muscles of the trunk and extremities. Nerve fibers are also sent to involuntary smooth muscles and glands of the gastrointestinal tract, urogenital system, and cardiovascular system.

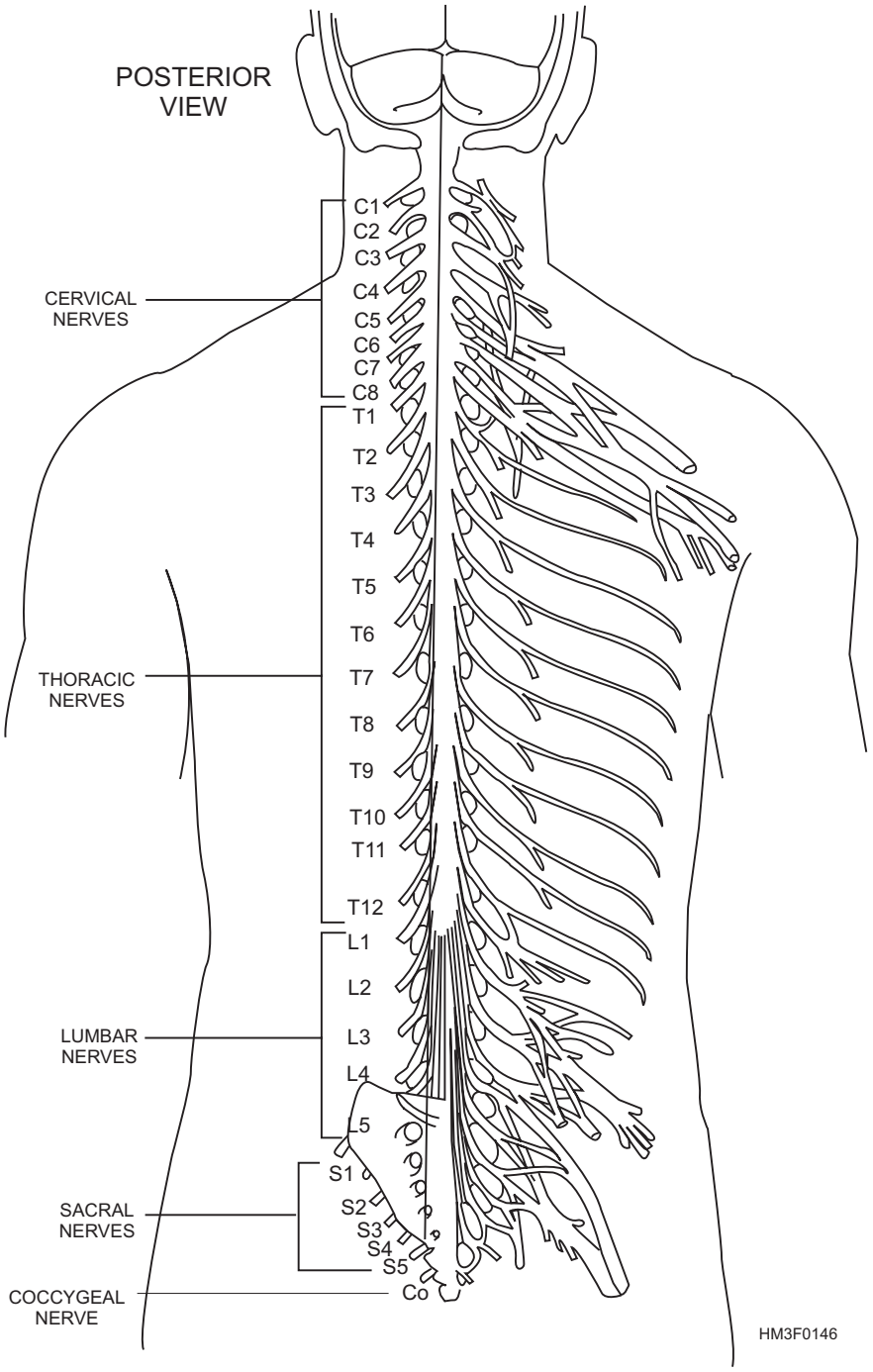


**Figure 1-46.—Spinal nerves.**

## AUTONOMIC NERVOUS SYSTEM

The autonomic nervous system (ANS) is the portion of the PNS that functions independently, automatically, and continuously, without conscious effort. It helps to regulate the smooth muscles, cardiac muscle, digestive tube, blood vessels, sweat and digestive glands, and certain endocrine glands. The autonomic nervous system is not directly under the control of the brain but usually works in harmony with the nerves that are under the brain's control. The autonomic nervous system includes two subdivisions (the sympathetic and parasympathetic nervous systems) that act together.

The sympathetic nervous system's primary concern is to prepare the body for energy-expending, stressful, or emergency situations. On the other hand, the parasympathetic nervous system is most active under routine, restful situations. The parasympathetic system also counterbalances the effects of the sympathetic system, and restores the body to a resting

Table 1-3.—Cranial Nerves

| CRANIAL NERVE | FUNCTION(S) |
|---|---|
| Olfactory | Sense of smell. |
| Optic | Vision. |
| Oculomotor | Eye movement, size of pupil, and eye focus. |
| Trochlear | Eye movements. |
| Trigeminal | Sensations of head and face and chewing movements. |
| Abducens | Abduction of eye (muscles that turn eye outward). |
| Facial | Facial expressions, secretion of saliva, and sense of taste. |
| Acoustic | Sense of hearing and balance or equilibrium sense. |
| Glossopharyngeal | Taste and other sensations of the tongue, swallowing movements, secretion of saliva. |
| Vagus | Sensations of movement (e.g., decrease in heart rate, increase in peristalsis, and contracting of muscles for voice production). |
| Accessory | Shoulder movements, turning movements of the head, and voice production. |
| Hypoglossal | Tongue movements. |

state. For example, during an emergency the body's heart and respiration rate increases. After the emergency, the parasympathetic system will decrease heart and respiration rate to normal. The sympathetic and parasympathetic systems counterbalance each other to preserve a harmonious balance of body functions and activities.

## THE ENDOCRINE SYSTEM

**LEARNING OBJECTIVE:** *Identify endocrine glands and the hormone(s) they produce, and determine the effect each hormone has on the body.*

Homeostasis, the self-balancing of the body's internal environment, is achieved and maintained by the endocrine system and the nervous systems. These systems work alone and together to perform similar functions in the body: communication, integration, and control. Their communication capabilities provide the means for controlling and integrating the many different functions performed by organs, tissues, and cells. The endocrine system, however, performs these functions by different mechanisms than the nervous system.

The endocrine system sends messages by way of chemical messengers called **hormones**. Minute amounts of these hormones are secreted from endocrine gland cells into the blood and distributed by the circulatory system. Endocrine glands secrete hormones directly into the blood, because they have no duct system. The glands of this system are often called **ductless glands**. Cells that are affected by the hormone are referred to as **target organ cells**.

Today, many hormones can be extracted from the glands of animals or produced synthetically. Medical officers may prescribe these naturally derived or synthetic hormones for patients who are deficient in them or who might otherwise benefit from their use. For example, oxytocin (the hormone which stimulates uterine contractions during pregnancy) has been synthesized and is used during the delivery process for women who are deficient in this hormone.

The hormone-producing glands include the hypothalamus, pituitary, thyroid, parathyroids, adrenals, pancreas, and gonads (the testes and ovaries) (fig. 1-47).

### HYPOTHALAMUS

The hypothalamus, a structure in the brain, synthesizes chemicals that are secreted to the pituitary

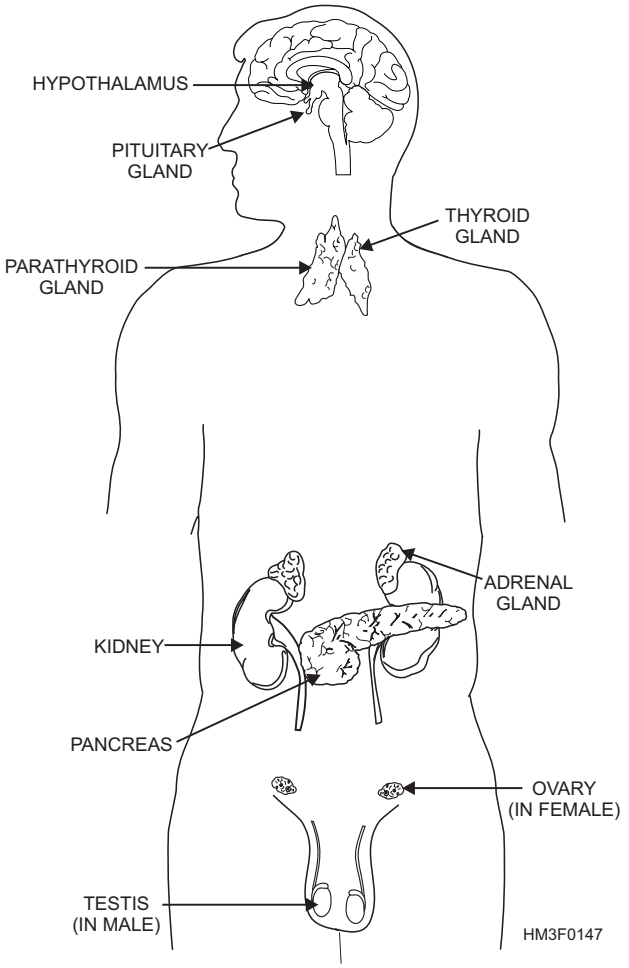


**Figure 1-47.—Major endocrine glands.**

gland to stimulate the release of its hormones and to help regulate body temperature (fig. 1-47).

## PITUITARY GLAND

The pituitary is a small, pea-sized gland located at the base of the brain in the sella turcica, the saddle-shape depression of the sphenoid bone (fig. 1-47). It is often called the master gland of the body because it influences many other endocrine glands. Although the pituitary looks like just one gland, it actually consists of two separate glands, the anterior pituitary gland and the posterior pituitary gland.

### Anterior Pituitary Gland

The anterior pituitary gland plays the more important role in influencing body functions. The hormones produced by the anterior pituitary gland have a broad and significant range of effects.

**SOMATOTROPIN**.—Somatotropin, the growth hormone, influences body growth and development. During the growth years, an overproduction of somatotropin causes giantism, while the lack of it causes dwarfism. An overproduction after the growth years causes **acromegaly**, which is characterized by the development of abnormally large hands, feet, and jaw.

**THYROTROPIN**.—Thyrotropin, or the thyroid-stimulating hormone (TSH), influences the growth, development, and secreting activities of the thyroid gland.

**GONADOTROPIN**.—Gonadotropin influences the gonads and is essential for the normal development and functioning of both male and female reproductive systems.

**ADRENOCORTICOTROPIN**.—The adrenocorticotropin hormone (ACTH) acts primarily on the adrenal cortex (the outer portion of the adrenal glands), stimulating its growth and its secretion of corticosteroids. Corticosteroid hormones affect every cell in the body and are discussed in more detail later in this section.

### Posterior Pituitary Gland

The posterior pituitary gland produces two hormones, antidiuretic hormone (ADH) and oxytocin.

**ANTIDIURETIC**.—The ADH hormone, promotes the conservation of water by the kidney. When ADH is not produced in adequate amounts, the daily urine volume is between 10 and 15 liters instead of the normal 1.5 liters. This condition is known as diabetes insipidus.

**OXYTOCIN**.—Oxytocin stimulates contraction of the muscles of the uterus, particularly during pregnancy. It also plays an important role in the production of milk in the mammary glands of nursing mothers.

## THYROID GLAND

The thyroid gland, shaped like a butterfly, lies in the anterior part of the neck, below the larynx (fig. 1-47). It consists of two lobes, one on each side of the upper trachea, connected by a strip of tissue called the isthmus. The thyroid secretes the iodine containing hormone **thyroxin**, which controls the rate of cell metabolism. Excessive secretion of thyroxin raises the metabolic rate and causes hyperthyroidism. This condition is characterized by a fast pulse rate, dizziness, increased basal metabolism, profuse sweating, tremors, nervousness, and a tremendous appetite coupled with a loss of weight.

Iodine is essential for the formation of thyroxin. **Simple goiter**, a diffuse and painless enlargement of the thyroid gland, was once common in areas of the United States where the iodine content of the soil and water was inadequate. In simple goiter, the gland enlarges to compensate for the lack of iodine. To prevent formation of a simple goiter, iodine-containing foods, such as vegetables, iodized salt, and seafood, should be eaten.

A condition known as **hypothyroidism** is caused by an insufficient secretion of thyroxin. The patient exhibits a decrease in basal metabolism, and sweating is almost absent. There may be a weight gain and constant fatigue. The heart rate may be slow, and a simple goiter may form. There may also be personality changes characterized by slow, lethargic mental functioning. Hypothyroidism during childhood can lead to the development of **cretinism**. Cretinism is a condition characterized by retarded mental and physical development.

## PARATHYROID GLANDS

Parathyroid glands are four small round bodies located just posterior to the thyroid gland (fig. 1-47). Their hormone, **parathormone** (PTH), regulates the calcium and phosphorus content of the blood and bones. The amount of calcium is important in certain tissue activities, such as bone formation, coagulation of blood, maintenance of normal muscular excitability, and milk production in the nursing mother. Diminished function or removal of the parathyroid glands results in a low calcium level in the blood. In extreme cases death may occur, preceded by strong contraction of the muscles (tetany) and convulsions.

**Hyperparathyroidism**, an excess of parathyroid hormone in the blood, causes calcium levels in the blood to become elevated by the withdrawal of calcium from the bones, leaving the skeleton demineralized and subject to spontaneous fractures. The excess calcium may be deposited as stones in the kidneys.

## ADRENAL GLANDS

The adrenal glands are located on the superior surface of each kidney, fitting like a cap (fig. 1-47). They consist of an outer portion, the cortex, and an inner portion, the medulla.

### Adrenal Cortex

Specialized cells in the outer layer of the adrenal cortex produce three types of steroid hormones that are of vital importance.

**MINERALOCORTICOIDS**.—Mineralocorticoids are regulators of fluid and electrolyte balance. They are sometimes called salt and water hormones because they regulate the excretion and absorption of sodium, chlorine, potassium, and water.

**GLUCOCORTICOIDS**.—Glucocorticoids are essential to metabolism. They increase certain liver functions and have an anti-inflammatory effect. Clinically, they are used to suppress inflammatory reactions, to promote healing, and to treat rheumatoid arthritis.

**ANDROGENS AND ESTROGENS**.—The adrenal cortex also produces sex hormones, some with male characteristics (**androgens**), others with female characteristics (**estrogens**). These hormones appear in different concentrations in both men and women.

### Adrenal Medulla

The adrenal medulla secretes **epinephrine** (**adrenalin**) in the presence of emotional crises, hypoglycemia (low blood sugar), or low blood pressure. Epinephrine causes powerful contractions of many arterioles (especially in the skin, mucous membranes, and kidneys), but it dilates other arterioles (such as those of the coronary system, skeletal muscles, and lungs). Heart rate, respiration rate and depth, blood pressure, blood sugar levels, and metabolism are all increased by epinephrine. It also stimulates the production of other adrenal cortical hormones.

**Norepinephrine** is also produced in the adrenal medulla. It is a chemical precursor to epinephrine. Its effects are similar to those of epinephrine, but its action differs.

Despite these marked influences, the medullary tissue of the adrenal gland is not essential to life, because its various functions can be assumed by other regulatory mechanisms.

## PANCREAS

The pancreas contains two types of secretory tissues. The first secretory tissue secretes digestive juice through a duct to the small intestine, while the other tissue releases hormones into body fluids. The

endocrine portion of the pancreas consists of cells arranged in groups, called "**islands (islets) of Langerhans**." The islands (islets) of Langerhans contain three types of endocrine cells: alpha, beta, and delta. The **alpha cells** secrete the hormone glucagon. **Glucagon** causes a temporary rise in blood sugar levels. The **beta cells** secrete insulin, which is essential for carbohydrate metabolism. **Insulin** lowers blood sugar levels by increasing tissue utilization of glucose and stimulating the formation and storage of glycogen in the liver. Together, glucagon and insulin act to regulate sugar metabolism in the body. **Delta cells** produce the hormone **somatostatin**. Somatostatin helps regulate carbohydrates by inhibiting the secretion of glucagon.

When the islet cells are destroyed or stop functioning, the sugar absorbed from the intestine remains in the blood and excess sugar is excreted by the kidneys into the urine. This condition is called **diabetes mellitus**, or sugar diabetes. Insulin, a synthetic hormone, is given to patients having this disease as part of their ongoing treatment.

## GONADS (TESTES AND OVARIES)

The term **gonads** refers to the primary sex organs of the reproductive system (male and female).

### Testes

The male gonad is the testis (*pl.* testes), and the existence of the testes is the primary male sex characteristic (fig. 1-47). The testes produce and secrete the male hormone **testosterone**, which influences the development and maintenance of the male accessory sex organs and the secondary sex characteristics of the male. The male **accessory sex organs** include two groups of organs: the internal sex organs and the external sex organs. See section titled "Male Reproductive System" for more information on the male accessory sex organs.

### Male Secondary Sex Characteristics

Male secondary sex characteristics influenced by the hormone testosterone are as follows:

- Increased growth of hair, particularly in the areas of the face, chest, axilla, and pubic region.
- Enlargement of the larynx (Adam's apple) and thickening of the vocal cords, which produces a lower-pitched voice.
- Thickening of the skin.
- Increased muscle growth, broadening of the shoulder and narrowing of the waist.
- Thickening and strengthening of the bones.

### Ovaries

The female gonads, the ovaries, produce the hormones **estrogen** and **progesterone** (fig. 1-47). Estrogen influences the development and maintenance of the female accessory sex organs and the secondary sex characteristics, and promotes changes in the mucous lining of the uterus (endometrium) during the menstrual cycle. Progesterone prepares the uterus for the reception and development of the fertilized ovum and maintains the lining during pregnancy.

Today, progesterone and estrogen hormones (naturally derived) are incorporated into oral contraceptives or birth control pills. The combination of hormones released through this monthly series of pills fools the body into not preparing (building-up of uterine lining) for implantation of an embryo. Because the uterus has not prepared for implantation, pregnancy cannot occur.

Female accessory sex organs are also divided into internal and external accessory sex organs. See section titled "Female Reproductive System" for more information on the female accessory sex organs.

### Female Secondary Sex Characteristics

Female secondary sex characteristics influenced by the hormone estrogen are listed below.

- Development of the breasts and the ductile system of the mammary glands within the breasts.
- Increased quantities of fatty (or adipose) tissue in the subcutaneous layer, especially in the breasts, thighs, and buttocks.
- Increased vascularization of the skin.

## THE SENSORY SYSTEM

**LEARNING OBJECTIVE:** *Recognize the senses of the body, and identify their physical characteristics.*

The sensory system informs areas of the cerebral cortex of changes that are taking place within the body or in the external environment. The special sensory receptors respond to special individual stimuli such as sound waves, light, taste, smell, pressure, heat, cold, pain, or touch. Positional changes, balance, hunger, and thirst sensations are also detected and passed on to the brain.

### SMELL

Odor is perceived upon stimulation of the receptor cells in the **olfactory** membrane of the nose. The olfactory receptors are very sensitive, but they are easily fatigued. This tendency explains why odors that are initially very noticeable are not sensed after a short time. Smell is not as well developed in man as it is in other mammals.

### TASTE

The taste buds are located in the tongue. The sensation of taste is limited to **sour, sweet, bitter**, and **salty**. Many foods and drinks tasted are actually smelled, and their taste depends upon their odor. (This interdependence between taste and smell can be demonstrated by pinching the nose shut when eating onions.) Sight can also affect taste. Several drops of green food coloring in a glass of milk will make it all but unpalatable, even though the true taste has not been affected.

### SIGHT

The eye, the organ of sight, is a specialized structure for the reception of light. It is assisted in its function by accessory structures, such as the eye brows, eyelashes, eyelids, and **lacrimal apparatus**. The lacrimal apparatus consists of structures that produce tears and drains them from the surface of the eyeball.

#### Structure of the Eye

Approximately five-sixths of the eyeball lies recessed in the orbit, protected by a bony socket. Only the small anterior surface of the eyeball is exposed. The eye is not a solid sphere but contains a large interior cavity that is divided into two cavities, anterior and posterior. The anterior cavity is further subdivided into anterior and posterior chambers (fig. 1-48).

The **anterior cavity** of the eye lies in front of the lens. The **anterior chamber** of the anterior cavity is the space anterior to the iris, but posterior to the cornea. The **posterior chamber** of the anterior cavity consists of a small space directly posterior to the iris, but anterior to the lens. Both chambers of the anterior cavity are filled with a clear, watery fluid called **aqueous humor**. Aqueous humor helps to give the cornea its curved shape.

The **posterior cavity** of the eye is larger than the anterior cavity, since it occupies all the space posterior to the lens, suspensory ligaments, and ciliary body. The posterior cavity contains a substance, with the consistency similar to soft gelatin, called **vitreous humor**. Vitreous humor helps maintain sufficient pressure inside the eye to prevent the eyeball from collapsing.

The eyeball is composed of three layers. From the outside in, they are the sclera, choroid, and retina (fig. 1-48).

**OUTER LAYER**.—The outer layer of the eye is called the **sclera**. The sclera is the tough, fibrous, protective portion of the globe, commonly called the white of the eye. Anteriorly, the outer layer is transparent and is called the **cornea**, or the window of the eye. It permits light to enter the globe. The exposed sclera is covered with a mucous membrane, the conjunctiva, which is a continuation of the inner lining of the eyelids. The **lacrimal gland** produces tears that constantly wash the front part of the eye and the conjunctiva. The tear gland secretions that do not

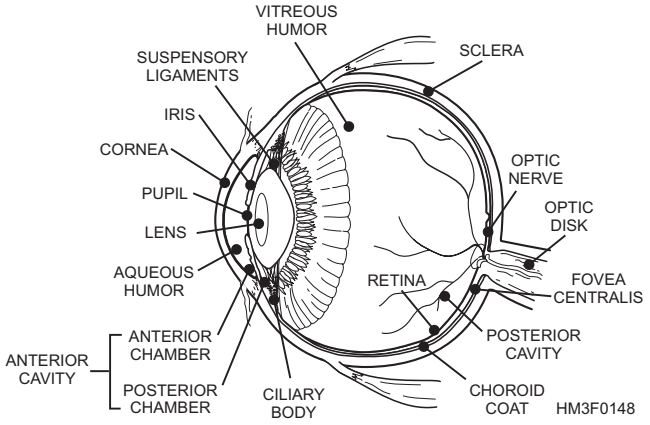


**Figure 1-48.—Transverse section of the eye.**

evaporate flow toward the inner angle of the eye, where they drain down ducts into the nose.

**MIDDLE LAYER**.—The middle layer of the eye is called the **choroid**. This layer is a highly vascular, pigmented tissue that provides nourishment to the inner structures. Continuous with the choroid is the **ciliary body**. The ciliary body is formed by a thickening of the choroid and fits like a collar into the area between the retina and iris. Attached to the ciliary the body are the **suspensory ligaments**, which blend with the elastic capsule of the lens and holds it in place.

**Iris**.—The iris is continuous with the ciliary body. The iris is a circular, pigmented muscular structure that gives color to the eye. The iris separates the anterior cavity into anterior and posterior chambers. The opening in the iris is called the **pupil** (fig. 1-49). The amount of light entering the pupil is regulated through the constriction of radial and circular muscles in the iris. When strong light is flashed into the eye, the circular muscle fibers of the iris contract, reducing the size of the pupil. If the light is dim, the pupil dilates to allow as much of the light in as possible. The size and reaction of the pupils of the eyes are an important diagnostic tool.

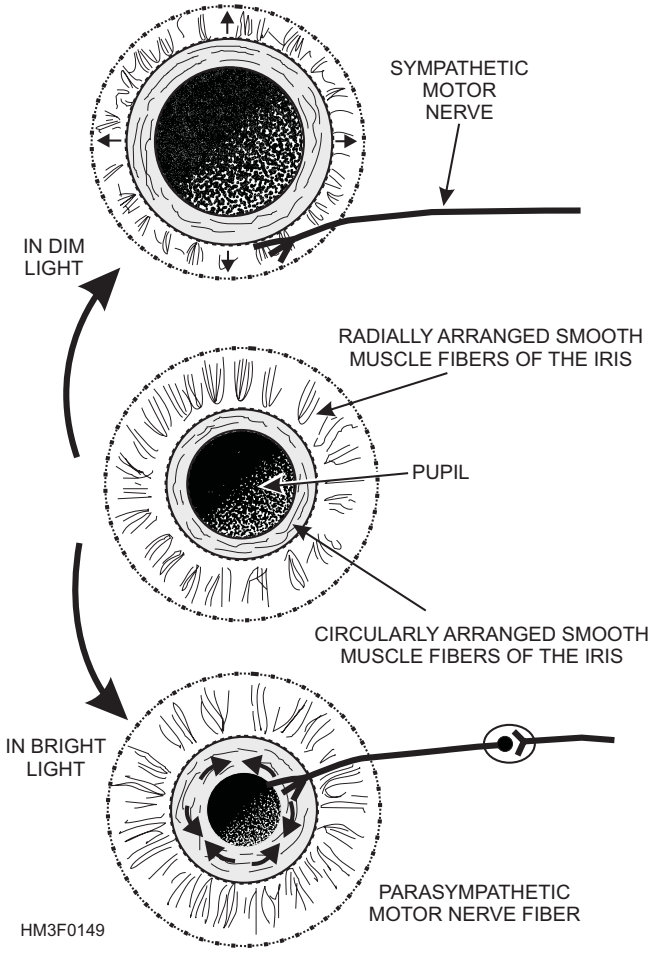


**Figure 1-49.—Anterior view of the eye.**

**Lens**.—The lens is a transparent, biconvex (having two convex surfaces) structure suspended directly behind the iris. The optic globe posterior to the lens is filled with a jellylike substance called vitreous humor, which helps to maintain the shape of the eyeball by maintaining intraocular pressure. The lens separates the eye into anterior and posterior cavities.

**INNER LAYER**.—The inner layer of the eye is called the **retina** (fig. 1-48). It contains layers of the nerve cells, **rods**, and **cones** that are the receptors of the sense of vision. The retina is continuous with the **optic nerve**, which enters the back of the globe and carries visual impulses received by the rods and cones to the brain. The area where the optic nerve enters the eyeball contains no rods and cones and is called the **optic disc** (blind spot) (fig. 1-50).

**Rods**.—Rods respond to low intensities of light and are responsible for night vision. They are located in all areas of the retina, except in the small depression called the **fovea centralis**, where light entering the eye is focused, and which has the clearest vision.

**Cones**.—Cones require higher light intensities for stimulation and are most densely concentrated in the fovea centralis. The cones are responsible for daytime vision.

### Vision Process

The vision process begins with rays of light from an object passing through the cornea. The image is then received by the lens, by way of the iris. Leaving the lens, the image falls on the rods and cones in the retina. The image then is carried to the brain for interpretation by the optic nerve (fig. 1-51). Note the image received by the retina is upside down, but the brain turns it right-side up.

**REFRACTION**.—Deflection or bending of light rays results when light passes through substances of varying densities in the eye (cornea, aqueous humor, lens, and vitreous humor). The deflection of light in the eye is referred to as **refraction**.

**ACCOMMODATION**.—Accommodation is the process by which the lens increases or decreases its curvature to refract light rays into focus on the fovea centralis.

**CONVERGENCE**.—The movement of the globes toward the midline, causes a viewed object to come into focus on corresponding points of the two

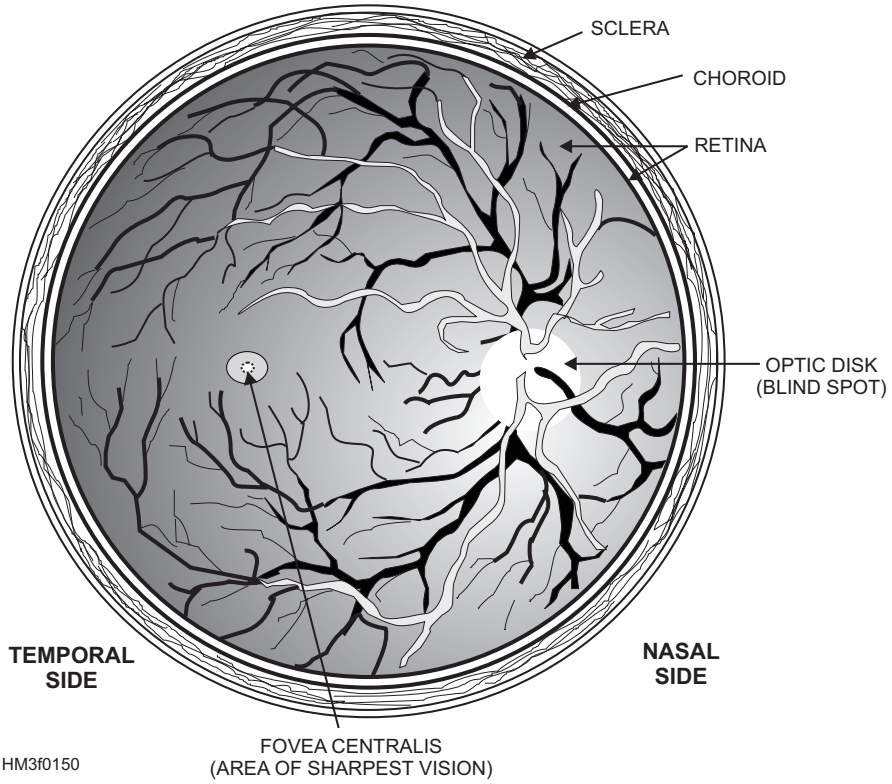


**Figure 1-50.—Ophthalmoscope view of the eye.**

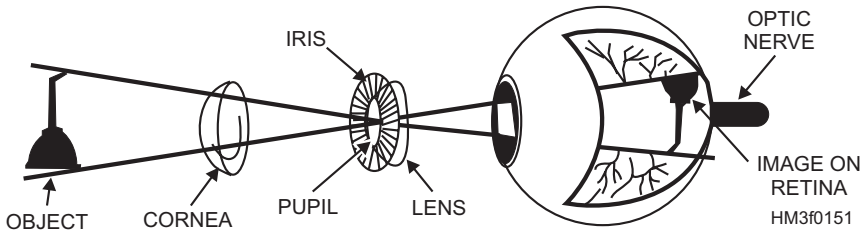


**Figure 1-51.—The vision process.**

retinas. This process, called **convergence**, produces clear, three-dimensional vision.

## HEARING

The ear is the primary organ of hearing. Its major parts are illustrated in figure 1-52. The ear is divided into three parts: the external, middle, and inner ear.

### External Ear

The external (outer) ear is composed of two parts, the **auricle** and the **external auditory canal** (fig. 1-52). The auricle, or pinna, is a cartilaginous structure located on each side of the head. The auricle collects sound waves from the environment, which are then conducted by the external auditory canal to the eardrum. The lining of the external auditory canal contains glands that secrete a wax-like substance called **cerumen**. Cerumen aids in protecting the eardrum against foreign bodies and microorganisms.

The **tympanic membrane**, or eardrum, is an oval sheet of fibrous epithelial tissue that stretches across the inner end of the external auditory canal. The eardrum separates the outer and middle ear. The sound waves cause the eardrum to vibrate, and this vibration transfers the sounds from the external environment to the auditory ossicles.

### Middle Ear

The middle ear is a cavity in the temporal bone, lined with epithelium. It contains three **auditory ossicles**—the malleus (hammer), the incus (anvil), and the stapes (stirrup)—which transmit vibrations from the tympanic membrane to the fluid in the inner ear

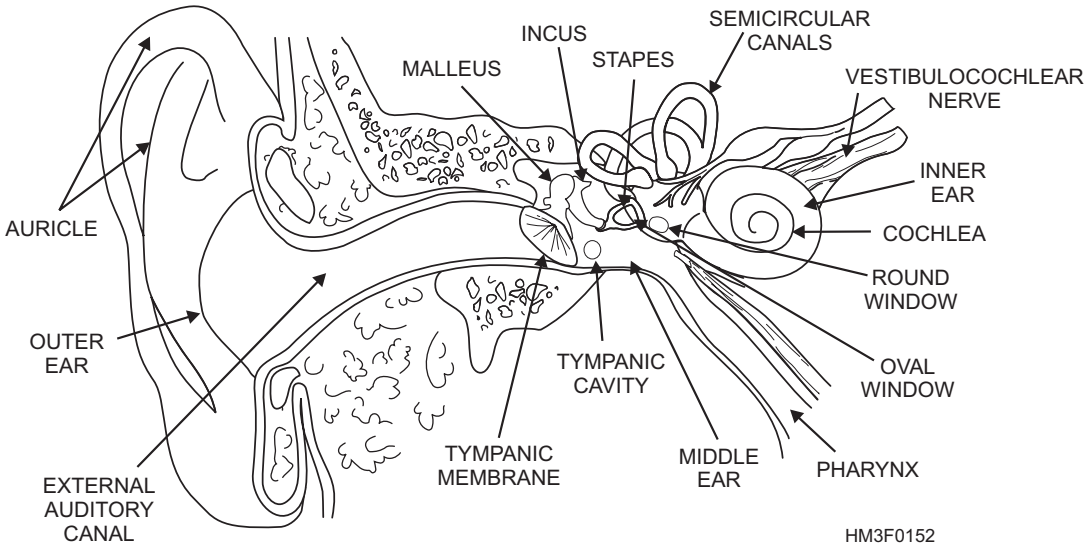


**Figure 1-52.—Major parts of the ear.**

(fig. 1-52). The **malleus** is attached to the inner surface of the eardrum and connects with the **incus**, which in turn connects with the **stapes**. The base of the stapes is attached to the **fenestra ovalis** (oval window), the membrane-covered opening of the inner ear. These tiny bones, which span the middle ear, are suspended from bony walls by ligaments. This arrangement provides the mechanical means for transmitting sound vibrations to the inner ear.

The **eustachian tube**, or auditory tube, connects the middle ear with the pharynx. It is lined with a mucous membrane and is about 36 mm long. Its function is to equalize internal and external air pressure. For example, while riding an elevator in a tall building, you may experience a feeling of pressure in the ear. This condition is usually relieved by swallowing, which opens the eustachian tube and allows the pressurized air to escape and equalize with the area of lower pressure. Divers who ascend too fast to allow pressure to adjust may experience rupture of their eardrums. The eustachian tube can also provide a pathway for infection of the middle ear.

### Inner Ear

The inner ear is filled with a fluid called **endolymph**. Sound vibrations that cause the stapes to move against the oval window create internal ripples that run through the endolymph. These pressurized ripples move to the **cochlea**, a small snail-shaped structure housing the **organ of Corti**, the hearing organ (fig. 1-52). The cells protruding from the organ of Corti are stimulated by the ripples to convert these mechanical vibrations into nerve impulses, and these impulses are relayed through the vestibulocochlear (8th cranial) nerve to the auditory area of the cortex in the temporal lobe of the brain. There they are interpreted as the sounds we hear.

Another structure located in the inner ear is composed of the **three semicircular canals**, situated perpendicular to each other. Movement of the endolymph within the canals, caused by general body movements, stimulates nerve endings, which report these changes in body position to the brain, which in turn uses the information to maintain equilibrium.

The **fenestra rotunda** (round window) is another membrane-covered opening of the inner ear. It contracts the middle ear and flexes to accommodate the inner ear ripples caused by the stapes.

## TOUCH

Until the beginning of the last century, touch (feeling) was treated as a single sense. Thus, warmth or coldness, pressure, and pain, were thought to be part of a single sense of touch or feeling. It was discovered that different types of nerve ending **receptors** are widely and unevenly distributed in the skin and mucous membranes. For example, the skin of the back possesses relatively few touch and pressure receptors while the fingertips have many. The skin of the face has relatively few cold receptors, and mucous membranes have few heat receptors. The cornea of the eye is sensitive to pain, and when pain sensation is abolished by a local anesthetic, a sensation of touch can be experienced.

Receptors are considered to be sensory organs. They provide the body with the general senses of touch, temperature, and pain. In addition, these receptors initiate reactions or reflexes in the body to maintain homeostasis. For example, receptors in the skin perceive cold, resulting in goosebumps. This reaction is the body's attempt to maintain internal warmth.

Receptors are classified according to location, structure, and types of stimuli activating them. Classified according to location, the three types of receptors are as follows: **superficial receptors** (exteroceptors), **deep receptors** (proprioceptors), and **internal receptors** (visceroceptors). See table 1-4 for receptor locations and the senses resulting from the stimulation of these receptors.

## THE DIGESTIVE SYSTEM

**LEARNING OBJECTIVE:** *Identify the location and function of each part of the digestive system.*

The digestive system includes the organs that digest and absorb food substances, and eliminate the unused residuals. The digestive system consists of the **alimentary canal** and several accessory organs. The accessory organs release secretions into the canal. These secretions assist in preparing food for absorption and use by the tissues of the body. Table 1-5 illustrates principal digestive juices (secretions) produced by alimentary and accessory organs.

Digestion is both mechanical and chemical. Mechanical digestion occurs when food is chewed, swallowed, and propelled by a wave-like motion called **peristalsis**. When peristalsis occurs, a ring of contraction appears in the walls of the alimentary canal. At the same time, the muscular wall just ahead of the ring relaxes. This phenomenon is called **receptive relaxation**. As the wave moves along, it pushes the canal's contents ahead of it. Chemical digestion consists of changing the various food substances, with the aid of digestive enzymes, into solutions and simple compounds. Carbohydrates (starches and sugars) change into simple sugars (glucose); fats change into fatty acids; and proteins change into amino acids. Once the food substances have been broken down into simple compounds, the cells of the body can absorb and use them.

### THE ALIMENTARY CANAL

The alimentary canal (tract) is 9 meters in length, tubular, and includes the mouth, pharynx, esophagus, stomach, small intestine, and large intestine (fig. 1-53).

#### Mouth

The mouth, which is the first portion of the alimentary canal, is adapted to receive food and prepare it for digestion (fig. 1-53). The mouth mechanically reduces the size of solid particles and mixes them with saliva. This process is called **mastication**. Saliva, produced by the **salivary gland**, moistens food making it easier to chew. Saliva also lubricates the food mass to aid swallowing. The tongue assists with both mastication and swallowing.

#### Pharynx

The pharynx (covered earlier in "The Respiratory System") is the passageway between the mouth and the esophagus and is shared with the respiratory tract (fig. 1-53). The **epiglottis** is a cartilaginous flap that

**Table 1-4.—Types of Receptors, Their Location, and Affected Sense**

| TYPES | LOCATIONS | SENSES |
|---|---|---|
| Superficial receptors | At or near surface of body | Touch, pressure, heat, cold, and pain |
| Deep receptors | In muscles, tendons, and joints | Sense of position and movement |
| Internal receptors | In the internal organs and blood vessel walls | Usually none (except hunger, nausea, pain from stimuli such as chemicals (e.g., aspirin) and distension (e.g., stomach expansion from gas)) |

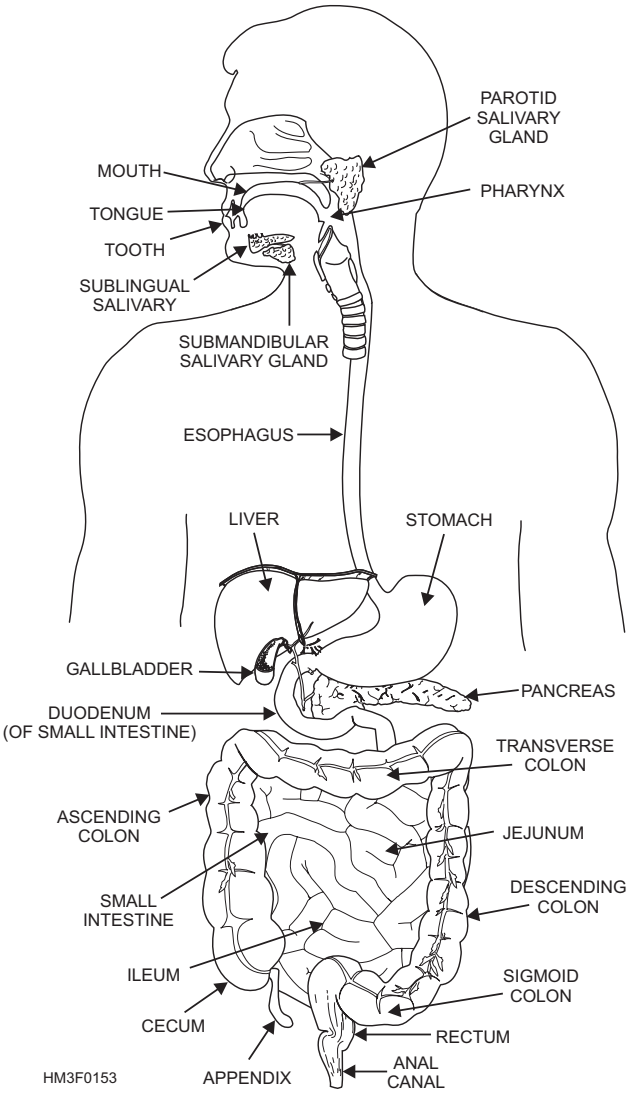


**Figure 1-53.—The digestive system.**

**Table 1-5.—Principal Digestive Juices**

| Digestive Juice | Source | Substance Acted Upon | Product |
|---|---|---|---|
| Amylase | Salivary glands and pancreas | Starch | Complex sugars (maltose) |
| Hydrochloric acid | Gastric glands | Pepsinogen (Proteins) | Pepsin (Split proteins) |
| Bile | Liver | Fats | Emulsified fats |
| Proteinase | Pancreas | Proteins and split proteins | Peptides and polypeptides |
| Lipase | Pancreas | Fats (triglycerides) | Fatty acids and glycerol |
| Carbohydrase | Intestinal glands | Complex sugars (maltose, sucrose, and lactose) | Simple sugars (glucose, fructose, and galactose) |
| Peptidase | Intestinal glands | Peptides and polypeptides | Amino acids |

closes the opening to the larynx when food is being swallowed down the pharynx. Food is deflected away from the trachea to prevent particle aspiration (inhalation).

### Esophagus

The esophagus is a muscular tube about 25 cm (10 inches) long (fig. 1-53). It is the passageway between the pharynx and the stomach. By means of peristalsis, food is pushed along this tube to the stomach. When peristalsis is reversed, vomiting occurs.

### Stomach

The stomach acts as an initial storehouse for swallowed material and helps in the chemical breakdown of food substances. The stomach is a saccular enlargement of the gastrointestinal tube and lies in the left upper quadrant of the abdomen (fig. 1-53). It connects the lower end of the esophagus with the first portion of the small intestine (the duodenum). The stomach is divided into the **cardiac, fundic, body**, and **pyloric** regions (fig. 1-54). At each end of the stomach, muscular rings (or sphincters) form valves to close off the stomach. The sphincters prevent the stomach's contents from escaping in either direction while food substances are being mixed by peristaltic muscular contractions of the stomach wall. The sphincter at the esophageal end is the **cardiac sphincter**; at the duodenal end it is the **pyloric sphincter**.

The chemical breakdown of food in the stomach is accomplished through the production of digestive juices (**enzymes**) by small (**gastric**) glands in the wall of the stomach. The principal digestive enzymes produced by the gastric glands are **hydrochloric acid** and **pepsinogen**. Hydrochloric acid activates pepsin from pepsinogen, kills bacteria that enter the stomach, inhibits the digestive action of amylase, and helps regulate the opening and closing of the pyloric sphincter. **Pepsin** is a protein-splitting enzyme capable of beginning the digestion of nearly all types of dietary protein.

Most food absorption takes place in the small intestine. In general, food is not absorbed in the stomach. An exception is alcohol, which is absorbed directly through the stomach wall. It is for this reason that intoxication occurs quickly when alcohol is taken on an empty stomach.

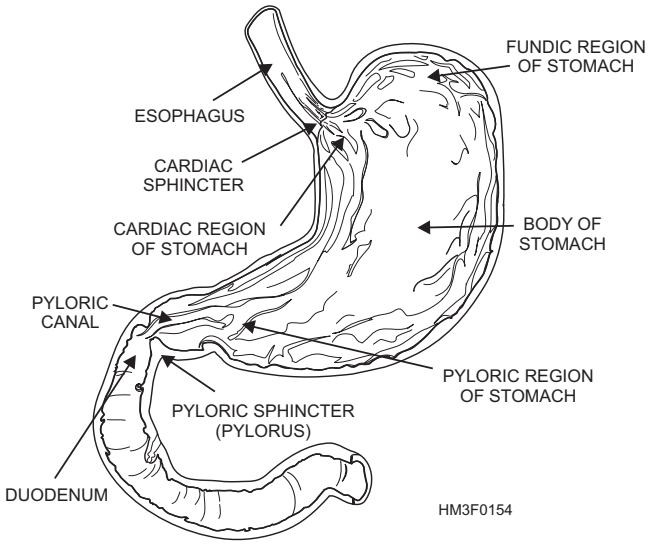


**Figure 1-54.—Major regions of the stomach.**

### Abdominal Cavity

The stomach and intestines are enclosed in the abdominal cavity, the space between the diaphragm and the pelvis. This cavity is lined with serous membrane called the **peritoneum**. The peritoneum covers the intestines and the organs and, by secreting a serous fluid, prevents friction between adjacent organs. The **mesentery** (double folds of peritoneum) extends from the cavity walls to the organs of the abdominal cavity, suspending them in position and carrying blood vessels to the organs.

### Small Intestine

The small intestine is a muscular, convoluted, coiled tube, about 7 meters (23 feet) long and attached to the posterior abdominal wall by its mesentery (fig. 1-53).

The small intestine is divided into three contiguous parts: the duodenum, jejunum, and ileum. It receives digestive juices from three accessory organs of digestion: the pancreas, liver, and gallbladder.

**DUODENUM.**—The duodenum is approximately 25 cm (10 inches) long and forms a C-shaped curve around the head of the pancreas, posterior to the liver. It is lined with a mucous membrane that contains small glands. These glands secrete intestinal juices containing the enzymes carbohydrase, peptidase, and lipase.

**JEJUNUM**.—The jejunum is the middle part of the small intestine and is approximately 2.5 meters (8.2 feet) long. Its enzymes continue the digestive process.

**ILEUM**.—The ileum is the last and longest part of the small intestine. It is approximately 3.5 meters (11.5 feet) long. Most of the absorption of food occurs in the ileum, where fingerlike projections (**villi**) provide a large absorption surface. After ingestion, it takes 20 minutes to 2 hours for the first portion of the food to pass through the small intestine to the beginning of the large intestine.

### Large Intestine

The large intestine is so called because it is larger in diameter than the small intestine (fig. 1-53). It is considerably shorter, however, being about 1.5 meters (5 feet) long. It is divided into three distinct parts: the cecum, colon, and rectum.

**CECUM AND COLON**.—The unabsorbed food or waste material passes through the **cecum** into the **ascending colon**, across the **transverse colon**, and down the **descending colon** through the **sigmoid colon** to the rectum. Twelve hours after the meal, the waste material passes slowly through the colon, building in mass and reaching the rectum 24 hours after the food is ingested.

The **appendix**, a long narrow tube with a blind end, is a pouchlike structure of the cecum located near the junction of the ileum and the cecum (fig. 1-53). There is no known function of this structure. Occasionally, the appendix becomes infected, causing inflammation to develop. This inflammation of the appendix is known as **appendicitis**.

**RECTUM**.—The rectum is approximately 12.5 cm (5 inches) long and follows the contour of the sacrum and coccyx until it curves back into the short (2.5 to 4 cm) anal canal. The **anus** is the external opening at the lower end of the digestive system. Except during bowel movement (defecation), it is kept closed by a strong muscular ring, the **anal sphincter**.

## ACCESSORY ORGANS OF DIGESTION

The accessory organs of digestion include the salivary glands, pancreas, liver, and gallbladder. As stated earlier, during the digestive process, the accessory organs produce secretions that assist the organs of the alimentary canal.

### Salivary Glands

The salivary glands are located in the mouth (fig. 1-53). Within the salivary glands are two types of secretory cells, serous cells and mucous cells. The serous cells produce a watery fluid that contains a digestive juice called **amylase**. Amylase splits starch and glycerol into complex sugars. The mucous cells secrete a thick, sticky liquid called **mucus**. Mucus binds food particles together and acts to lubricate during swallowing. The fluids produced by the serous and mucous cells combine to form **saliva**. Approximately 1 liter of saliva is secreted daily.

### Pancreas

The pancreas is a large, elongated gland lying posteriorly to the stomach (fig. 1-53). As discussed earlier in "The Endocrine System," the pancreas has two functions: It serves both the endocrine system and the digestive system. The digestive portion of the pancreas produces digestive juices (amylase, proteinase, and lipase) that are secreted through the pancreatic duct to the duodenum. These digestive juices break down carbohydrates (amylase), proteins (proteinase), and fats (lipase) into simpler compounds.

### Liver

The liver is the largest gland in the body. It is located in the upper abdomen on the right side, just under the diaphragm and superior to the duodenum and pylorus (fig. 1-53).

Of the liver's many functions, the following are important to remember:

- It metabolizes carbohydrates, fats, and proteins preparatory to their use or excretion.
- It forms and excretes bile salts and pigment from bilirubin, a waste product of red blood cell destruction.
- It stores blood; glycogen; vitamins A, D, and $B_{12}$; and iron.
- It detoxifies the end products of protein digestion and drugs.
- It produces antibodies and essential elements of the blood-clotting mechanism.

### Gallbladder

The gallbladder is a pear-shaped sac, usually stained dark green by the bile it contains. It is located in the hollow underside of the liver (fig. 1-53). Its duct, the **cystic duct,** joins the **hepatic duct** from the liver to form the **common bile duct**, which enters the duodenum. The gallbladder receives bile from the liver and then concentrates and stores it. It secretes bile

when the small intestine is stimulated by the entrance of fats.

## THE URINARY SYSTEM

**LEARNING OBJECTIVE:** *Recall the parts of the urinary system and their function(s).*

The urinary system is the primary filtering system of the body (fig. 1-55). This system is composed of two main organs, the **kidneys** and **urinary bladder**. The kidneys produce urine, which is drained from the kidneys by two tubes called **ureters**. Urine flows down both ureters to the bladder. The urinary bladder is a large reservoir where the urine is temporarily stored before excretion from the body. A tube called the **urethra** carries the urine from the bladder to the outside of the body. All these parts, except the length of the urethra, are the same in both sexes.

### KIDNEYS

The importance of the kidney can be realized only when its structure and functions are understood. The bladder, ureters, and urethra store and pass the products of the kidneys.

The kidneys are two large, bean-shaped organs designed to filter waste materials from the blood (figs. 1-55 and 1-56). They also assist in controlling the rate of red blood cell formation, and in the regulation of blood pressure, the absorption of calcium ions, and the volume, composition, and pH of body fluids. The kidneys are located in the upper posterior part of the abdominal cavity, one on each side of the spinal column. The upper end of each kidney reaches above the level of the 12th rib. The suprarenal (adrenal) gland sits like a cap on top of each kidney. The kidneys are protected by a considerable amount of fat and supported by connective tissue and the peritoneum. Attached to the hollow side of each kidney is the dilated upper end of the ureter, forming the **renal pelvis**.

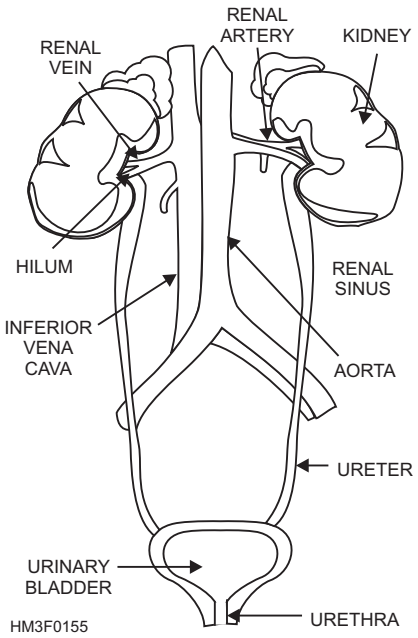


**Figure 1-55.—The urinary system.**

#### Structure

The lateral surface of the kidneys is convex in shape, and the medial side is deeply concave. The medial side of each kidney possesses a depression that leads to a hollow chamber called the **renal sinus** (fig. 1-55). The entrance of the renal sinus is referred to as the **hilum** (fig. 1-55). Blood vessels, nerves, lymphatic vessels, and the ureters pass through the hilum.

The superior end of the ureter forms a funnel-shaped sac called the **renal pelvis** (fig. 1-56). The renal pelvis is divided into two or three tubes, called **major calyces**. The major calyces (*sing.* calyx) are further subdivided into **minor calyces**.

There are groups of elevated projections in the walls of the renal pelvis. These projections are called **renal papillae**. The renal papillae connect to the minor calyces, through tiny openings in the minor calyces.

The principal portion of the kidney is divided into two distinct regions: an inner medulla and outer cortex (fig. 1-56). The **renal medulla** is composed of pyramid-shaped masses of tubes and tubules called **renal pyramids**. **Renal pyramids** drain the urine to the renal pelvis. The **renal cortex** forms a shell over the renal medulla. Renal cortex tissue dips down, like fingers, between the renal pyramids, and forms what are called **renal columns**. The cortex possesses very small tubes associated with **nephrons**. Nephrons are the functional units of the kidneys.

**RENAL BLOOD VESSELS**.—The **renal artery** supplies blood to the kidneys (fig. 1-56). The renal artery enters the kidneys through the hilum, and sends off branches to the renal pyramids. These arterial branches are called **interlobar arteries**. At the border between the medulla and cortex, the interlobar arteries branch to form the **arciform arteries**. The arciform arteries branch also and form the **interlobular arteries**.

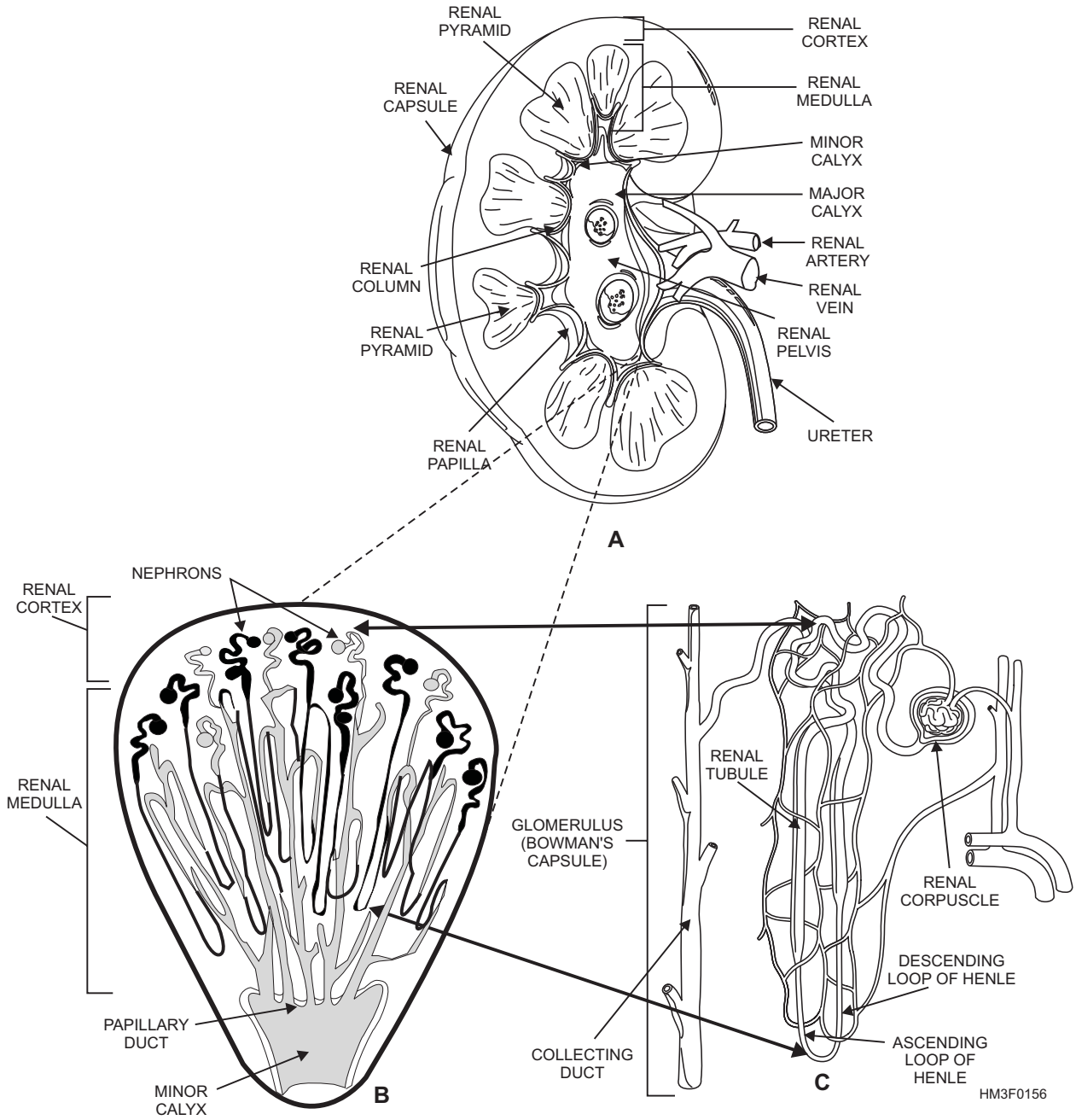


**Figure 1-56.—Principal parts of the kidney: A. Longitudinal section of a kidney; B. A renal pyramid containing nephrons; C. A single nephron.**

The venous system of the kidneys generally follow the same paths as the arteries. Venous blood passes through the interlobular, arciform, interlobar, and renal veins (fig. 1-56).

**NEPHRONS**.—The functional units of the kidneys are called nephrons. There are about 1 million nephrons in each kidney. Each nephron consists of a renal corpuscle and a renal tubule (fig. 1-56, view C).

The **renal corpuscle** (**Malpighian corpuscle**) is composed of a tangled cluster of blood capillaries called a **glomerulus**. The glomerulus is surrounded by a sac-like structure referred to as the **glomerulus capsule** or **Bowman's capsule** (figs. 1-56, view C, and 1-57).

Leading away from the glomerulus is the renal tubule. The initial portion of the renal tubule is coiled and called the **proximal convoluted** (meaning coiled or twisted) **tubule**. The proximal convoluted tubule dips down to become the **descending loop of Henle**. The tubule then curves upward toward the renal corpuscle and forms the **ascending loop of Henle**.

Once the ascending limb reaches the region of the renal corpuscle, it called the distal convoluted tubule. Several distal convoluted tubules merge in the renal

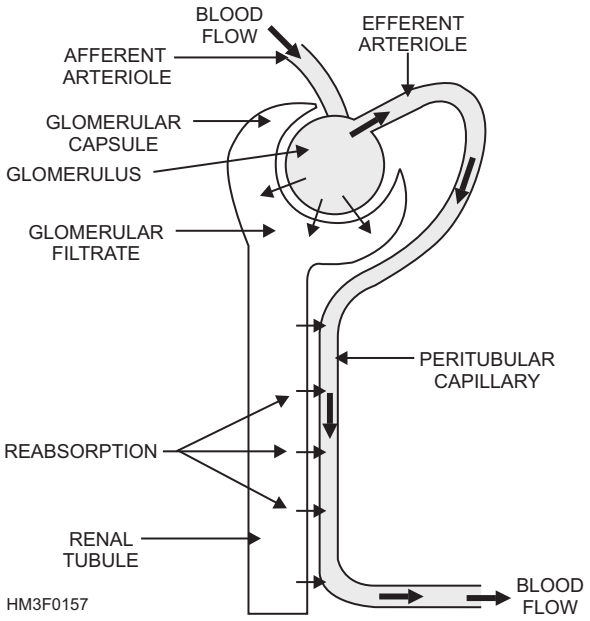


**Figure 1-57.—The reabsorption process.**

cortex to form a **collecting duct**. The collecting duct begins to merge within the renal medulla. The collecting ducts become increasingly larger as they are joined by other collecting ducts. The resulting tube is called the **papillary duct**. The papillary duct empties into the minor calyx through an opening in the renal papilla.

### Function

The kidneys are effective blood purifiers and fluid balance regulators. In addition to maintaining a normal pH of the blood (acid-base balance), the kidneys keep the blood slightly alkaline by removing excess substances from the blood. The end product of these functions is the formation of **urine**, which is excreted from the body.

Urine is formed through a series of processes in the nephron. These processes are filtration, reabsorption, and secretion.

**FILTRATION**.—Urine formation begins when water and various dissolved substances are filtered out of blood plasma from a glomerular capillary into the glomerular capsule. The filtered substance (glomerular filtrate) leaves the glomerular capsule and enters the renal tubule.

**REABSORPTION**.—As glomerular filtrate passes through the renal tubule, some of the filtrate is reabsorbed into the blood of the **peritubular capillary** (fig. 1-57). The filtrate entering the peritubular capillary will repeat the filtration cycle. This process of reabsorption changes the composition of urine. For instance, the filtrate entering the renal tubule is high in sugar content, but because of the reabsorption process, urine secreted from the body does not contain sugar.

**SECRETION**.—Secretion is the process by which the peritubular capillary transports certain substances directly into the fluid of the renal tubule (fig. 1-58). These substances are transported by similar mechanisms as used in the reabsorption process, but done in reverse. For example, certain organic compounds, such as penicillin and histamine, are secreted directly from the proximal convoluted tubule to the renal tubule. Also, large quantities of hydrogen ions are secreted in this same manner. The secretion of hydrogen ions plays an important role in regulating pH of body fluids.

The glomerulus filters gallons of blood each day. It is estimated that 2,500 gallons of blood pass through the kidneys in 24 hours, and about 80 gallons of glomerular filtrate. All the water from this filtrate is reabsorbed in the renal tubules except that containing the concentrated waste products.

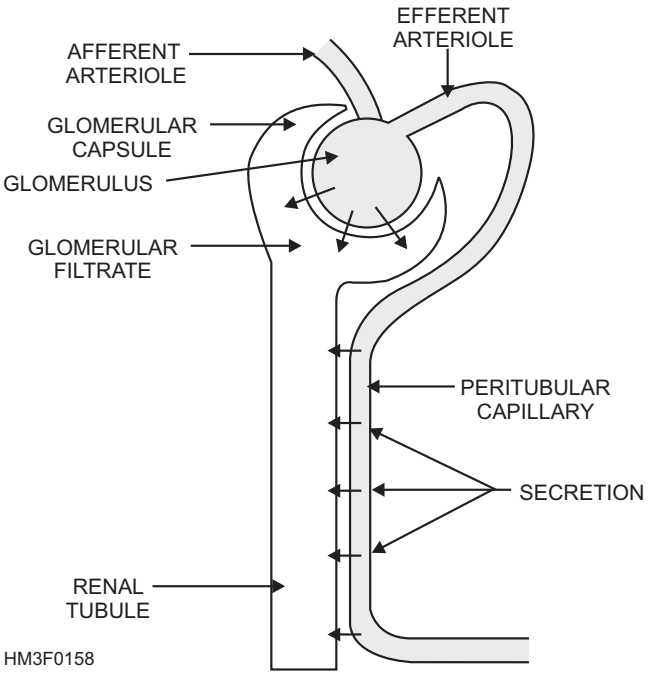


**Figure 1-58.—The secretion process.**

The average amount of urine an adult excretes varies from 1,000 to 1,500 ml per day. However, the amount of urine excreted varies greatly with temperature, water intake, and state of health. No matter how much water one drinks, the blood will always remain at a constant concentration, and the excess water will be excreted by the kidneys. A large water intake does not put a strain on the kidneys. Instead it eases the load of concentration placed on the kidneys.

## URETERS

The ureters' only function is to carry urine from each kidney to the urinary bladder. The ureters are two membranous tubes 1 mm to 1 cm in diameter and about 25 cm in length. Urine is transported through the ureters by peristaltic waves (produced by the ureter's muscular walls).

## URINARY BLADDER

The urinary bladder functions as a temporary reservoir for urine. The bladder possesses features that enable urine to enter, be stored, and later be released for evacuation from the body.

### Structure

The bladder is a hollow, expandable, muscular organ located in the pelvic girdle (fig. 1-59). Although the shape of the bladder is spherical, its shape is altered by the pressures of surrounding organs. When it is empty, the inner walls of the bladder form folds. But as the bladder fills with urine, the walls become smoother.

The internal floor of the bladder includes a triangular area called the **trigone** (fig. 1-59). The trigone has three openings at each of its angles. The ureters are attached to the two posterior openings. The anterior opening, at the apex of the trigone, contains a funnel-like continuation called the **neck** of the bladder. The neck leads to the urethra.

The wall of the bladder consists of four bundles of smooth muscle fibers. These muscle fibers, interlaced, form the **detrusor muscle** (which surrounds the bladder neck) and comprise what is called the **internal urethral sphincter**. The internal urethral sphincter prevents urine from escaping the bladder until the pressure inside the bladder reaches a certain level. Parasympathetic nerve fibers in the detrusor muscle function in the micturition (urination) process. The

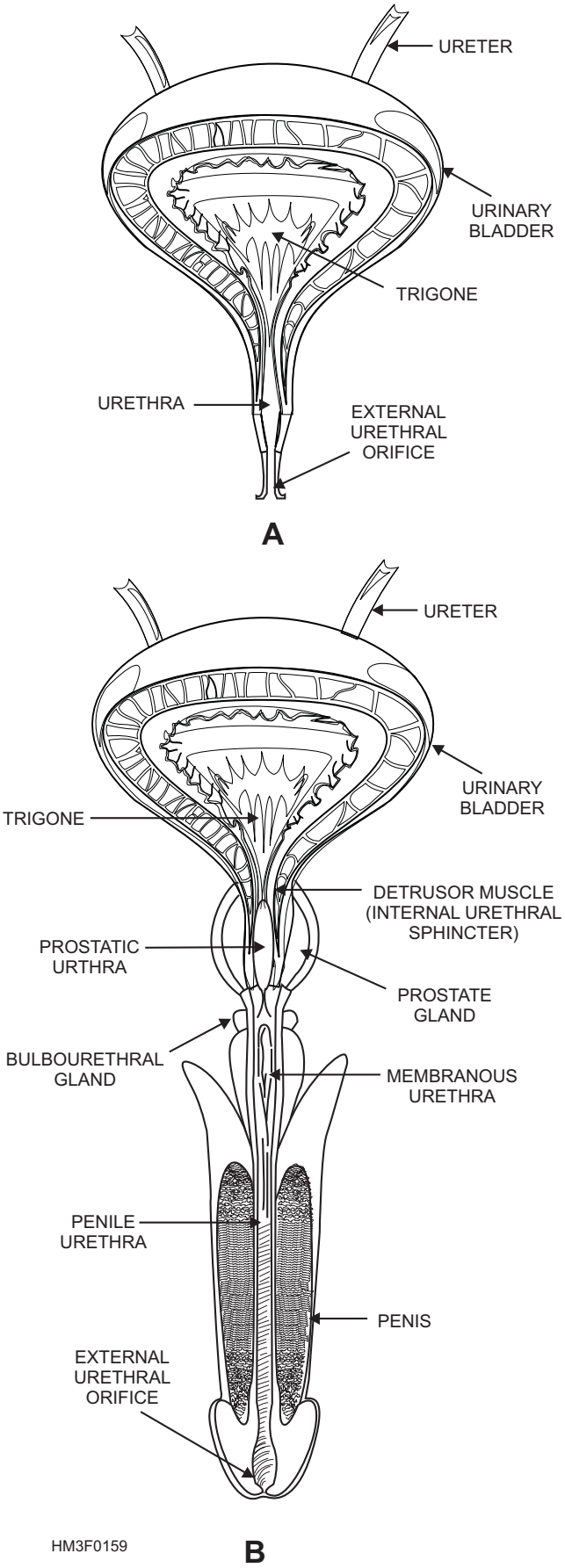


**Figure 1-59.—Urinary bladder and urethra:**
**A. Frontal section of the female urinary bladder and urethra;**
**B. Frontal section of the male urinary bladder and urethra.**

outer layer (**serous coat**) of the bladder wall consists of two types of tissue, **parietal peritoneum** and **fibrous connective tissue**.

### Micturition (Urination)

Micturition is the process by which urine is expelled from the bladder. It involves the contraction of the detrusor muscle, and pressure from surrounding structures. Urination also involves the relaxation of the **external urethral sphincter**. The external urethral sphincter surrounds the urethra about 3 centimeters from the bladder, and is composed of voluntary muscular tissue.

Urination is usually stimulated by the distention of the bladder as it fills with urine. When the walls of the bladder contract, nerve receptors are stimulated, and the urination reflex is triggered. The urination reflex causes the internal urethral sphincter to open and the external urethral sphincter to relax. This relaxation allows the bladder to empty. The bladder can hold up to 600 ml of urine. The desire to urinate may not occur until the bladder contains 250-300 ml.

## URETHRA

The urethra is the tube that carries urine from the bladder to the outside of the body (fig. 1-59, views A and B). The **urinary meatus** is the external urethral orifice. In the male, the urethra is common to the urinary and reproductive systems; in the female, it belongs only to the urinary system.

### Female Urethra

The female urethra is about 4 cm long, extending from the bladder to the external orifice, (fig. 1-59, view A).

### Male Urethra

The male urethra is about 20 cm long and is divided into three parts: the prostatic, membranous, and penile portions. See view B of figure 1-59 for an illustration of the male urethra.

**PROSTATIC URETHRA**.—The prostatic urethra is surrounded by the prostate gland; it contains the orifices of the prostatic and ejaculatory ducts. This portion of the male urethra is about 2.5 cm long.

**MEMBRANOUS URETHRA**.—The membranous urethra is about 2 cm in length and is surrounded by the external urethral sphincter.

**PENILE URETHRA**.—The penile urethra, the longest portion, is about 15 cm long. It lies in the ventral portion of the penis. The urethra terminates with the external orifice at the tip of the penis.

## MALE REPRODUCTIVE SYSTEM

**LEARNING OBJECTIVE**: *Recall the parts of the male reproductive system and their function(s).*

The organs of the male and female reproductive systems are concerned with the process of reproducing offspring, and each organ is adapted to perform specialized tasks. The primary male sex organs of the reproductive system are the testes. The other structures of the male reproductive system are termed accessory reproductive organs. The accessory organs include both internal and external reproductive organs. See figure 1-60 for an illustration of the male reproductive system.

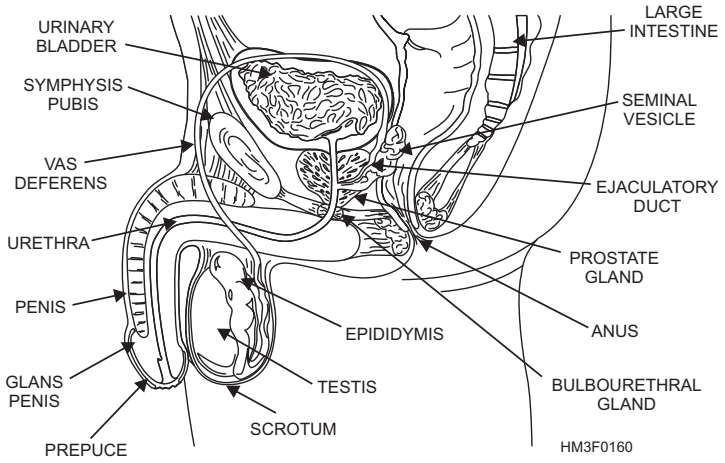


**Figure 1-60.—The male reproductive system.**

## TESTES

The testes, as stated earlier, are the primary male reproductive organs. They produce sperm cells (spermatozoa) and male hormones, both necessary for reproduction.

### Structure

The testes are oval glands suspended inside a sac (the scrotum) by a **spermatic cord**. The spermatic cords are formed by the vas deferens, arteries, veins, lymphatics, and nerves, all bound together by connective tissue.

Each testis is encapsulated by a tough, white, fibrous tissue called the tunica albuginea. The interior of the testis is divided into 250 lobules (small lobes). Each lobule contains 1 to 4 highly coiled, convoluted tubules called **seminiferous tubules**. These tubules unite to form a complex network of channels called the **rete testis**. The rete testis give rise to several ducts that join a tube called the **epididymis** (fig. 1-60).

### Functions

The testes perform two functions: to produce sperm cells and to secrete male sex hormones. The process by which sperm cells are produced is called **spermatogenesis**. Spermatogenesis occurs in the seminiferous tubules of the testes. Once the sperm cells are formed, they collect in the lumen of each seminiferous tubule. When the sperm cells are ready, they pass through the rete testis to the epididymis, where they remain for a time to mature. The production of sperm cells occurs continually throughout the reproductive life of a male.

The male hormone **testosterone** is produced in the testes. This hormone is initially responsible for the formation of the male reproductive organs. During puberty, testosterone stimulates the enlargement of the testes and various other accessory reproductive organs. It also causes the development of the male secondary sexual characteristics. Refer to the section titled “The Endocrine System” for more detailed discussion on male secondary sexual characteristics.

Other actions of testosterone include increasing the production of red blood cells. As a result, the average number of red blood cells in blood is usually greater in males than in females.

## INTERNAL ACCESSORY ORGANS

The internal accessory organs of the male reproductive system include the epididymis, vas deferens, ejaculatory ducts, seminal vesicle, urethra, prostate gland, bulbourethral glands, and semen (fig. 1-60).

### Epididymis

Each epididymis is a tightly coiled, thread-like tube that is approximately 6 meters long. This tube is connected to the ducts within the testis. The epididymis covers the top of the testis, runs down the testis' posterior surface, and then courses upward to form the vas deferens.

The epididymis secretes the hormone glycogen, which helps sustain the lives of stored sperm cells and promotes their maturation. When immature sperm cells enter the epididymis, they are not mobile. However, as the sperm cells travel through the epididymis, they mature and become mobile. Once the sperm cells are mature, they leave the epididymis and enter the vas deferens.

### Vas Deferens

The vas deferens is a small tube that connects the epididymis and ejaculatory duct. It ascends as part of the spermatic cord through the inguinal canal of the lower abdominal wall into the pelvic cavity, and transmits the sperm to the ejaculatory ducts.

### Ejaculatory Ducts

The vas deferens and the seminal vesicles converge, just before the entrance of the prostate gland, to form the ejaculatory ducts (fig. 1-60). The ejaculatory ducts open into the prostatic urethra. Its function is to convey sperm cells to the urethra.

### Seminal Vesicles

The seminal vesicles are two pouches that are attached to the vas deferens near the base of the urinary bladder. The lining of the inner walls of the seminal vesicles secrete a slightly alkaline fluid. This fluid is thought to help regulate the pH of the tubular contents as sperm cells are conveyed to the outside. The secretion produced by the seminal vesicles also contains a variety of nutrients, such as fructose (simple sugar), that provides the sperm cells an energy source.

At the time of ejaculation, the contents of the seminal vesicles are emptied into the ejaculatory ducts. This action greatly increases the volume of fluid that is discharged by the vas deferens.

### Urethra

The urethra is an important organ of both the urinary and reproductive systems. The role of the urethra, in the reproductive system, is to transport sperm through the penis to outside the body. See "The Urinary System" section for information on the structure of the urethra.

### Prostate Gland

The prostate gland, made of smooth muscle and glandular tissue, surrounds the first part of the urethra. It resembles a chestnut in shape and size, and secretes an alkaline fluid to keep the sperm mobile, protecting it from the acid secretions of the female vagina. This substance is discharged into the urethra as part of the ejaculate, or semen, during the sexual act.

### Bulbourethral Glands

Bulbourethral glands, also known as **Cowper's glands**, are two pea-sized bodies located below the prostate gland and lateral to the membranous urethra. These glands are enclosed by fibers of the external urethral sphincter. They release a mucous-like fluid in response to sexual stimulation and provide lubrication to the end of the penis in preparation for sexual intercourse.

### Semen

Semen is composed of sperm and secretions from the seminal vesicles, prostate, and bulbourethral glands. It is discharged as the ejaculate during sexual intercourse. There are millions of sperm cells in the semen of each ejaculation, but only one is needed to fertilize the ovum. It is generally considered that fertilization of the ovum occurs while it is still in the fallopian tubes. Therefore, it is apparent that sperm cells can move actively in the seminal fluid deposited in the vagina and through the layers of the secretion lining the uterus and fallopian tubes.

## EXTERNAL ACCESSORY ORGANS

The external accessory organs of the male reproductive system include the scrotum and penis (fig. 1-60).

### Scrotum

The scrotum is a cutaneous pouch containing the testes and part of the spermatic cord. Immediately beneath the skin is a thin layer of muscular fibers (the cremaster), which is controlled by temperature and contracts or relaxes to lower or raise the testes in relation to the body. This muscular activity of the scrotum is necessary to regulate the temperature of the testes, which is important in the maturation of sperm cells.

### Penis

The penis is a cylindrical organ that conveys urine and semen through the urethra to the outside. The penis is composed of three columns of spongy cavernous tissue, bound together by connective tissue and loosely covered by a layer of skin. Two of the columns, the **corpora cavernosa**, lie superiorly side by side; the third column, the **corpus spongiosum**, lies below the other two columns. The urethra is located in the corpus spongiosum. The dilated distal end of the corpus spongiosum is known as the **glans penis** (fig. 1-60). The urethra terminates at the glans penis.

The cavernous tissue becomes greatly distended with blood during sexual excitement, causing an erection of the penis. The loose skin of the penis folds back on itself at the distal end (forming the **prepuce**, or foreskin) and covers the glans. The prepuce is sometimes removed by a surgical procedure called a **circumcision.**

## FEMALE REPRODUCTIVE SYSTEM

**LEARNING OBJECTIVE**: *Recall the parts of the female reproductive system and their function(s).*

The organs of the female reproductive system are specialized to produce and maintain the female sex cells, or egg cells; to transport these cells to the site of fertilization; to provide an environment for a developing offspring; to move the offspring outside; and to produce female sex hormones. The primary female reproductive organs are the ovaries. The other structures of the female reproductive system are considered accessory reproductive organs. The

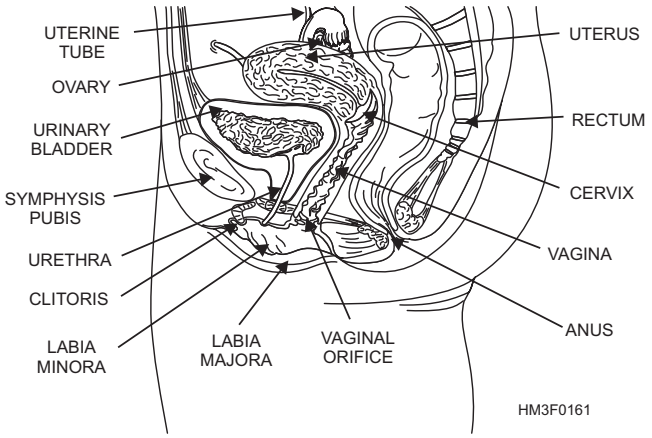


**Figure 1-61.—The female reproductive system.**

accessory organs include both internal and external reproductive organs (fig. 1-61).

## OVARIES

The ovaries, as stated earlier, are the primary female reproductive organs, producing the female sex cells and sex hormones (fig. 1-61).

### Structure

The ovaries, or female gonads, are two almond-shaped glands suspended by ligaments in the upper pelvic cavity. There is one ovary on each side of the uterus. The ligaments that suspend the ovaries contain ovarian blood vessels and nerves.

The tissues of an ovary are divided into two regions, an inner **medulla** and an outer **cortex**. The ovarian medulla is largely composed of loose connective tissue, numerous blood vessels, lymph vessels, and nerves. The ovarian cortex is composed of compact tissue containing tiny masses of cells called **ovarian** (**primordial**) **follicles**. The follicles contain the female sex cells or **ova**. The external surface of the ovary is covered by a layer of cuboidal epithelium cells. Beneath the epithelium is a layer of dense connective tissue.

### Primordial Follicle

In the outer region of the ovarian cortex, microscopic groups of cells are referred to as primordial follicles. The primordial follicles consist of a single large cell, called an **oocyte**, which is surrounded by a layer of flattened epithelial cells called **follicular cells**. The oocyte is an immature egg cell. Follicular cells surround a developing egg cell and secrete female sex hormones. There are approximately 400,000 primordial follicles at puberty. Of these, probably fewer than 500 will be released from the ovary during the reproductive life of a female.

At puberty, the anterior pituitary gland secretes increased amounts of FSH (follicle-stimulating hormone). In response, the ovaries enlarge and many of the primordial follicles begin to mature. During this maturation process, the oocyte enlarges and the follicle cells multiply until there are 6 to 12 layers. Fluid-filled spaces begin to appear among the follicle cells. These spaces join to form a single cavity called the antrum. Ten to fourteen days after this process begins, the primordial follicle reaches maturity. The mature primordial follicle (preovulatory or graafian follicle) and its fluid-filled cavity bulges outward on the surface of the ovary, like a blister.

### Ovulation

Ovulation is the process by which the mature oocyte is released from the primordial follicle (fig. 1-62). Ovulation is stimulated by hormones from the anterior pituitary gland. These hormones cause the mature follicle to swell rapidly and its walls to weaken. Eventually the wall ruptures, permitting the oocyte and 1 or 2 layers of follicle cells to be released from the ovary's surface.

After ovulation, the oocyte is usually propelled to the opening of a nearby fallopian tube. If the oocyte is not fertilized by a sperm cell within a relatively short time, it will degenerate.

This process of ovulation occurs once a month. Each ovary normally releases an ovum every 56 days. The right and left ovary alternately discharge an ovum approximately every 28 days. The menstrual cycle in most women is therefore approximately 28 days.

### Female Sex Hormones

Female sex hormones are produced by the ovaries and various other tissues, such as the adrenal glands, pituitary gland, and placenta (during pregnancy). These female sex hormones are **estrogen** and **progesterone**.

The primary source for estrogen is the ovaries. At puberty, estrogen stimulates enlargement of various accessory organs, which include the vagina, uterus, fallopian tubes, and external structures. Estrogen is also responsible for the development and maintenance

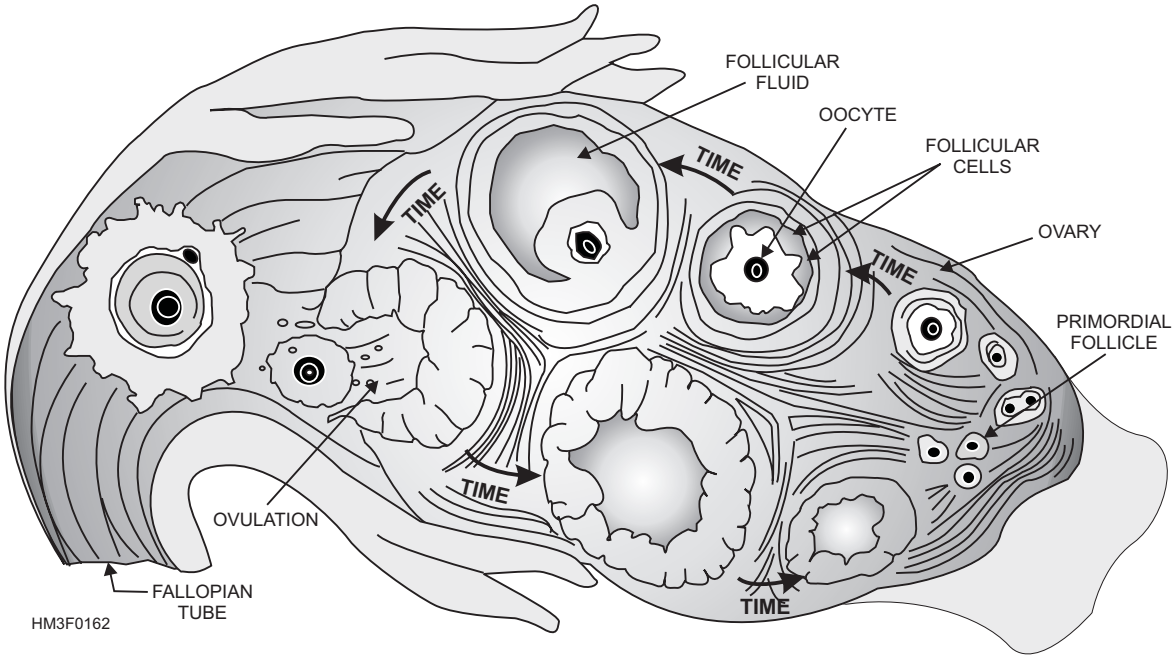


**Figure 1-62.—Ovulation process.**

of female secondary sexual characteristics. See section titled "Endocrine System" for listing of secondary female sexual characteristics.

The ovaries are also the primary source of progesterone (in a nonpregnant female). This hormone promotes changes that occur in the uterus during the female reproductive cycle. In addition, progesterone stimulates the enlargement of mammary glands and ducts, and increases fat deposits in female breasts during puberty.

## INTERNAL ACCESSORY ORGANS

The internal accessory organs of the female reproductive system include a pair of fallopian tubes, the uterus, and the vagina (fig. 1-61).

### Fallopian Tubes

The fallopian tubes, also known as uterine tubes, serve as ducts for the ovaries, providing a passageway to the uterus. The fallopian tubes are composed of three tissue layers. These tissue layers include an inner mucosal layer, a middle muscular layer, and an outer serous layer, and they are continuous with the layers of the uterus. The fallopian tubes are in contact with the ovaries but are not continuous with them. Their funnel-shaped openings, called **free openings**, are fringed with fingerlike processes that pick up an ovum and draw it into the fallopian tubes. Once the ovum enters the fallopian tubes, it is transported to the uterus by peristalsis and gravity. Fertilization of an ovum normally takes place in the fallopian tubes.

### Uterus

The function of the uterus is to receive the embryo that results from the fertilization of an egg cell, and to sustain its life during development. The uterus, or womb, is a hollow, pear-shaped organ with thick, muscular walls. The uterus is divided into two main regions, the **body** and **cervix** (fig. 1-61). The body of the uterus consists of the upper two-thirds of the uterus. The cervix is the lower one-third portion of the uterus that projects into the upper part of the vagina. The cervical opening into the vagina is called the **external os.**

The uterine wall is composed of three layers: the endometrium, the myometrium, and the perimetrium. The inner lining consists of specialized epithelium, called **endometrium**, which undergoes partial destruction approximately every 28 days in the nonpregnant female. The middle layer, the **myometrium**, consists of bundles of interlaced muscular fibers. The muscular layer produces powerful rhythmic contractions that are important in the expulsion of the fetus at birth. The **perimetrium** consists of an outer serosal layer that covers the body of the uterus and part of the cervix. The uterus also has three openings: superiorly and laterally, two openings connect the fallopian tubes to the uterus, and inferiorly, an opening leading to the vagina.

### Vagina

The vagina is the organ that receives the male sperm during intercourse. It also forms the lower portion of the birth canal, stretching widely during delivery. In addition, it serves as an excretory duct for uterine secretions and menstrual flow.

The vagina is a fibromuscular tube capable of great distention. The canal is approximately 9 cm long and extends from the uterus to the outside. The vaginal orifice is partially closed by a thin membrane of tissue called the **hymen**. The wall of the vagina consists of three layers. The inner **mucosal layer** does not have mucous glands; the mucous found in the vagina comes from the glands of the cervix. The middle **muscular layer** consists mainly of smooth muscles fibers. At the lower end of the vagina is a thin band of smooth muscle that helps close the vaginal opening. The outer **fibrous layer** consists of dense fibrous connective tissue interlaced with elastic fibers. These fibers attach the vagina to the surrounding organs.

## EXTERNAL ACCESSORY ORGANS

Many of the external accessory organs of the female reproductive system are referred to collectively as the **vulva**. The vulva includes the labia majora, the labia minora, the clitoris, and the vestibular glands (fig. 1-63). The mammary glands are also considered an accessory organ of the female reproductive system.

### Labia Majora

The function of the labia majora is to enclose and protect the other external reproductive organs. The labia majora are composed of two round folds of fat tissue and a thin layer of smooth muscle, covered by skin. On the outer portion of the labia majora, the skin has numerous hairs, sweat glands, and sebaceous glands. The inner portion of skin is thin and hairless. The labia majora extend from the mons pubis anteriorly to the perineum (the region between the vaginal orifice and the anus). The **mons pubis** is the pad of fatty tissue beneath the skin, which overlies the symphysis pubis.

### Labia Minora

Within the labia majora folds are two smaller folds, called the labia minora. The labia minora extend from the clitoris to either side of the vaginal orifice.

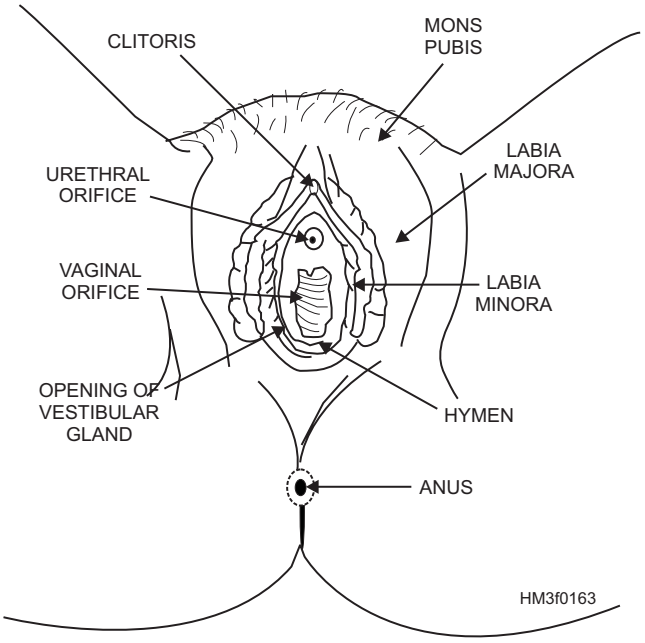


**Figure 1-63.—External reproductive organs.**

### Clitoris

The clitoris is a small projectile at the anterior end of the vulva between the labia minora. It is richly endowed with sensory nerves that are associated with the feeling of pleasure during sexual stimulation.

### Vestibule

The vestibule is the area enclosed by the labia minora that includes that vaginal and urethral openings. The vestibule contains a pair of vestibular glands, more commonly known as the **Bartholin's glands**. The Bartholin's glands lay on each side of the vaginal opening. The ducts of these glands secrete fluid that moistens and lubricates the vestibule.

### Mammary Glands

The mammary glands, or breasts, are accessory organs of the female reproductive system. They develop during puberty under the influence of the hormones estrogen and progesterone. The breasts are responsible for the secretion of milk (**lactation**) for the nourishment of newborn infants.

Structurally, the breasts resemble sweat glands. At the center is a nipple containing 15 to 20 depressions into which ducts from the lobes of the gland empty. During pregnancy, placental estrogen and progesterone stimulate further development of the mammary glands

in preparation for lactation. After childbirth, hormones secreted by the anterior lobe of the pituitary gland stimulate production for 6 to 9 months.

## FEMALE REPRODUCTIVE CYCLE

Females around age 11 begin to experience the female reproductive cycle and continue into middle age, after which it ceases. The female reproductive cycle, or menstrual cycle, is characterized by regular, recurring changes in the uterine lining, resulting in menstrual bleeding (**menses**). The first phase of the recurring reproductive cycle is menstrual bleeding. Menstrual bleeding begins when the endometrial lining starts to slough off from the walls of the uterus, and it is characterized by bleeding from the vagina. This is day 1 of the cycle, and this phase usually lasts through day 5. The time between the last day of the menses and ovulation is known as the postmenstrual phase. It lasts from day 6 through day 13 or 14 and is characterized by proliferation of endometrial cells in the uterus, which develop under the influence of the hormone estrogen. Ovulation, as discussed earlier in this section, is the rupture of a primordial follicle with the release of a mature ovum into the fallopian tubes. It usually occurs on day 14 or 15 of the cycle. The postovulatory (premenstrual) phase is the time between ovulation and the onset of the menstrual bleeding and normally lasts 14 days. During this phase the ovum travels through the fallopian tubes to the uterus. If the ovum becomes fertilized during this passage, it will become implanted in and nurtured by the newly developed endometrial lining. However, if fertilization does not take place, the lining deteriorates and eventually sloughs off, marking day 1 of the next cycle.

## SUMMARY

In this chapter, you have learned about the basic structures of the cell to the many complex systems of the human body. In addition, you have acquired the understanding of how each body system functions and how each system is interdependent upon each other. You will use this knowledge of human anatomy and physiology throughout your career in the medical services. For example, the anatomical terminology will be used in describing location of injuries or conditions. Also, when you perform patient assessments, a clear and thorough understanding of anatomy and physiology is essential. Patient assessment and documentation procedures will be discussed in the next chapter, entitled “Fundamentals of Patient Care.”

# CHAPTER 2

# FUNDAMENTALS OF PATIENT CARE

Twentieth century advances in the medical and technological sciences have made a significant impact on the methods of marketing healthcare services. The numbers and kinds of healthcare providers have expanded greatly. Patients have become more informed about both their healthcare needs and expectations. Additionally, patients have become more vocal, seeking answers for the "what's" and "why's" of the entire spectrum of healthcare services.

The goal of this chapter is to give the Hospital Corpsman basic theory concerning the multidisciplinary aspects of patient care. This chapter is an introduction to some of the critical basic concepts for providing care to individuals seeking healthcare services.

## HEALTH AND ILLNESS

**LEARNING OBJECTIVE:** *Recognize the concepts of health and illness.*

To intelligently and skillfully discharge your duties as a member of the Navy Medical Department healthcare team, you must first understand the concepts of health and illness.

The concept of health includes the physical, mental, and emotional condition of human beings that provide for the normal and proper performance of one's vital functions. Not only is health the absence of disease or disability; health is also a state of soundness of the body, mind, and spirit. Conversely, the concept of illness includes conditions often accompanied by pain or discomfort that inhibit a human being's ability to physically, mentally, or emotionally perform in a normal and proper manner.

In most cultures, when people need assistance in maintaining their health, dealing with illness, or coping with problems related to health and illness, they seek assistance from personnel specialized in the fields of healthcare.

Physicians, nurses, and Hospital Corpsmen are frequently referred to as the core team. All health personnel comprise the total healthcare team. Obviously, individual members of the team use their skills differently, depending upon their personal, professional, and technical preparation and experience. Nevertheless—and despite the differences in clinical expertise—they all share one common objective: to respond to the patient's health needs. The overall goal of this response is to assist the patient to maintain, sustain, and restore or rehabilitate a physical or psychological function.

## THE PATIENT

**LEARNING OBJECTIVE:** *Recognize the Patients' Bill of Rights and Responsibilities.*

No discussion about healthcare or the healthcare team would be complete without including the patient, often referred to as the consumer. A patient is a human being under the care of one or more healthcare providers. The patient may or may not be hospitalized. However, regardless of healthcare needs or environmental disposition, the patient is the most important part of the healthcare team. Without a patient, the healthcare team has little, if any, reason for existence.

As a Hospital Corpsman, you are tasked to provide every patient committed to your charge with the best care possible. This care must reflect your belief in the value and dignity of every person as an individual. Additionally, you must understand the patient's rights and responsibilities as they apply to providing and receiving healthcare services.

The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has developed standards that address the rights and responsibilities of patients. Because the goal of JCAHO is to promote excellence in providing healthcare services, this goal is compatible with that of the Navy Medical Department. The next two sections review the rights and responsibilities of patients when they enter a relationship with a healthcare service facility. Students seeking additional detailed information

should refer to the *Patients' Bill of Rights and Responsibilities* (an enclosure to BUMEDINST 6300.10) and the *Accreditation Manual for Hospitals* published by the JCAHO.

## PATIENT'S RIGHTS

The following are the patient's rights:

- **Medical Care and Dental Care**—A patient has the right to quality care and treatment consistent with available resources and generally accepted standards. The patient has the right to refuse treatment to the extent permitted by law and government regulations. However, the patient should be informed of the consequences of refusal.
- **Respectful Treatment**—A patient has the right to considerate and respectful care, with recognition of his personal dignity.
- **Privacy and Confidentiality**—A patient, within law and military regulations, is entitled to privacy and confidentiality concerning medical care.
- **Identity**—A patient has the right to know, at all times, the identity, professional status, and professional credentials of healthcare personnel, as well as the name of the healthcare provider primarily responsible for his care.
- **Explanation of Care**—A patient has the right to an explanation concerning his diagnosis, treatment, procedures, and prognosis of illness in terms the patient can understand.
- **Informed Consent**—A patient has the right to be advised in nonclinical terms of information needed to make knowledgeable decisions on consent or refusal of treatments. Such information should include significant complications, risks, benefits, and alternative treatments available.
- **Research Projects**—A patient has the right to be advised if the facility proposes to engage in or perform research associated with his care or treatment. The patient has the right to refuse to participate in any research projects.
- **Safe Environment**—A patient has the right to care and treatment in a safe environment.
- **Medical Treatment Facility (MTF) or Dental Treatment Facility (DTF) Rules and Regulations**—A patient has the right to be informed of the facility's rules and regulations that relate to patient or visitor conduct. The patient is entitled to information for the initiation, review, and resolution of patient complaints.

## PATIENT'S RESPONSIBILITIES

The following are the patient's responsibilities:

- **Providing Information**—A patient has the responsibility to provide, to the best of his knowledge, accurate and complete information about complaints, past illnesses, hospitalizations, medications, and other matters relating to his personal health.
- **Respect and Consideration**—A patient has the responsibility to be considerate of the rights of other patients and MTF or DTF healthcare personnel, and to assist in the control of noise, smoking, and the number of visitors. The patient is responsible for being respectful of the property of other persons and of the facility.
- **Compliance with Medical Care**—A patient is responsible for complying with the medical and nursing treatment plan, including followup care recommended by healthcare providers.
- **Medical Records**—A patient is responsible for ensuring that medical records are promptly returned to the medical facility for appropriate filing and maintenance when those records are transported by the patient for the purpose of medical appointments or consultation, etc.
- **MTF and DTF Rules and Regulations**—A patient is responsible for following the MTF or DTF rules and regulations affecting patient care.
- **Reporting of Patient Complaints**—A patient is responsible for helping the MTF or DTF commander provide the best possible care to all beneficiaries. The patient's recommendations, questions, or complaints should be reported to the patient contact representative.

## PROFESSIONAL PRACTICE

**LEARNING OBJECTIVE:** *Recognize the key elements of professional practice.*

Each member of the healthcare team has specific responsibilities and limitations that define his area of practice. To fulfill your role as a member of the Hospital Corps within the context of the total mission of the Navy Medical Department, it is imperative that your practice be based on a sound body of knowledge and the development of well-defined technical skills. The rate training manual (TRAMAN) contributes to the development of your body of knowledge. The HM occupational standards (NAVPERS 18068F, chapter 40) define minimal technical skills required of a Hospital Corpsman. As a member of the healthcare team, the mechanism of on-the-job training, in-service classes, and continuing education programs contribute significantly to your continued growth in both healthcare knowledge and skills.

### PROFESSIONAL LIMITATIONS

In conjunction with their professional responsibilities, all healthcare providers should realize that they are subject to certain limitations in providing healthcare services. These standards of practice are based on the amount and kind of education, training, experience, local regulations, and guidelines possessed by the healthcare provider. The mature, responsible individual will recognize, accept, and demand that these limitations be respected. In clinical settings, Hospital Corpsmen are tasked with administering medication, performing treatments, and providing individual patient care in compliance with the orders of the senior healthcare provider. In the hospital and some clinical environments, a Nurse Corps officer divides and delegates portions of the patient's care to other members of the team based on the skills and experiences of each member. In situations where a Nurse Corps officer is not a member of the team, such delegation of duties will generally be made by an experienced chief petty officer or a senior petty officer of the Hospital Corps.

### ACCOUNTABILITY

Regardless of rank, rate, or corps membership, all members of the healthcare team are held accountable for their performance. Being accountable means being held responsible for your actions. As a healthcare provider, you should continue to acquire new knowledge and skills and to strive for clinical competency. Equally important is your ability to apply new knowledge and acquired skills as a competent professional in providing total healthcare.

Accountability becomes a critical issue when determining issues of malpractice. Malpractice occurs when an individual delivers improper care because of negligence or practicing outside of his area of expertise. Because the areas of expertise and responsibility in medicine frequently overlap, legal limits of practice are defined by each state. The assignments and responsibilities of Hospital Corpsmen frequently include areas of practice usually provided by physicians and nurses in the civilian sector. **These responsibilities are only legal when Hospital Corpsmen are performing such duties while under the authority of the United States Government**. Because of this requirement, it is vital that you thoroughly understand your legal rights and limitations when providing patient care services both in government and civilian sectors.

### PATIENT ADVICE

Another area that has potential medical and legal implications regarding your role as a healthcare provider is that of giving advice or opinions. As a result of your frequent and close contact with patients, you will often be asked your opinion of the care or the proposed care a patient is undergoing. Often, these questions are extremely difficult to respond to, regardless of who the healthcare provider is. No one is ever totally prepared or has so much wisdom that he can respond spontaneously in such situations. In such cases, it is best to refer the question to the nurse or physician responsible for the patient's care.

You must always be conscious that you are seen as a representative of Navy medicine by the recipients of your care. As such, you will be accorded the respect that goes with having a specialized body of knowledge and an inventory of unique skills. A caduceus on the sleeve of the Hospital Corpsman marks that person as a member of a prestigious corps worthy of respect.

### PATIENT BEHAVIOR

Remember, you have been charged to provide care to a total, feeling, human person. The person seeking healthcare service has the same needs for security, safety, love, respect, and self-fulfillment as everyone

else. When something threatens the soundness of the body, mind, or spirit, an individual may behave inappropriately. Occasionally, there are temper outbursts, episodes of pouting, sarcastic remarks, unreasonable demands, or other inappropriate responses, often to the point of disruptive behavior. The healthcare provider is challenged to look beyond the behavior being displayed to identify the underlying stress and to attempt to relieve the immediate and obvious source of anxiety. This may be as simple as communicating, through your care and understanding of the patient as an individual, that Navy medicine is pleased to provide a caring service.

## PROFESSIONAL ETHICS

**LEARNING OBJECTIVE:** *Recognize the concept of professional ethics.*

The word **ethics** is derived from the Greek "ethos," meaning custom or practice, a characteristic manner of acting, or a more-or-less constant style of behavior in the deliberate actions of people. When we speak of ethics, we refer to a set of rules or a body of principles. Every social, religious, and professional group has a body of principles or standards of conduct that provides ethical guidance to its members.

During your indoctrination into the military, you were introduced to the Code of the U.S. Fighting Forces. This code of conduct is an ethical guide that charges you with certain high standards of general behavior as a member of the Armed Forces.

All professional interactions must be directly related to codes of behavior that support the principles of justice, equality of human beings as persons, and respect for the dignity of human beings. Upholding medical ethics is the responsibility of all Hospital Corpsmen. Upon completion of basic Hospital Corps School, you took the following pledge:

> I solemnly pledge myself before God and these witnesses to practice faithfully all of my duties as a member of the Hospital Corps. I hold the care of the sick and injured to be a privilege and a sacred trust and will assist the Medical Officer with loyalty and honesty. I will hold all personal matters pertaining to the private lives of patients in strict confidence. I dedicate my heart, mind, and strength to the work before me. I shall do all within my power to show in myself an example of all that is honorable and good throughout my naval career.

This pledge morally binds you to certain responsibilities and rules that are included in the science of medical ethics. Ethics, whether they be classified general or special (e.g., legal or medical), teach us how to judge accurately the moral rightness and wrongness of our actions. The one element that makes healthcare ethics different from general ethics is the inclusion of the moral rule, "Do your duty." This statement is a moral rule because it involves expectations (e.g., of confidentiality). It involves what others have every reason to believe will be forthcoming. Failure to fulfill these expectations is to do harm to your clients (i.e., your patients) and/or your colleagues. Through the Hospital Corpsman Pledge, you committed yourself to fulfilling certain duties, not only to those entrusted to your care, but also to all members of the healthcare team. It is this commitment to service and to mankind that has traditionally distinguished the United States Navy Hospital Corps wherever its members have served.

## PERSONAL TRAITS

**LEARNING OBJECTIVE:** *Recognize important personality traits of a healthcare professional.*

A Hospital Corpsman must develop many personal traits that apply to all petty officers. You can get a general understanding of them by referring to *Military Requirements for Petty Officer Third Class* (NAVEDTRA 12024).

The following traits, however, apply especially to your Hospital Corps duties and are essential for good performance.

### INTEGRITY

Nowhere in the Navy is the need for personal integrity so great as in the Hospital Corps, where we deal continually with people, their illnesses, and their personal problems. The information that we have access to falls into the category of "privileged communication." We, as Hospital Corpsmen, have no right whatsoever to divulge any medical information, however trivial, to any unauthorized individuals.

Medical information is prime gossip material. The prohibition on the release of medical information is sometimes difficult to remember, but it is essential to the maintenance of professional integrity.

One important commitment that all Corps personnel have is the obligation never to abuse the controlled substances that we have access to—or to tolerate abuse by others. These substances are on the ward or in the mount-out block for use, under a medical officer's supervision, for the care of patients. Any other use must not be tolerated.

### PERSONAL APPEARANCE

Excellent personal hygience habits, including cleanliness, neat hair styles, and spotless, correct uniforms are essential for the Hospital Corps. Our appearance can positively or negatively influence the opinion the public has of the medical community. Both a professional appearance and attitude enhance the overall reputation of the Navy Medical Department and reinforce our role as competent healthcare providers.

### LEADERSHIP

Naval leadership is based on personal example, good management, and moral responsibility. All of the personal traits previously discussed are also considered leadership traits. You will learn that many examples of effective leadership are those that are set by officers, chief petty officers, and senior petty officers. The success of the Medical Department rests heavily on the petty officer. Good petty officers are the backbone of the Medical Department, whether they are supervising military personnel or conducting specialist duties.

## INTERPERSONAL RELATIONS

**LEARNING OBJECTIVE:** *Recognize how an understanding of a patient's culture, race, religion, sex, and age can affect interpersonal relations.*

As a healthcare provider, you must be able to identify, understand, and use various kinds of information. In addition, it is important that you develop good "interpersonal relations" skills. In providing total patient care, it is important that you see the individual not only as a biological being, but also as a thinking, feeling person. Your commitment to understanding this concept is the key to your developing good interpersonal relationships.

Simply stated, your interpersonal relationships are the result of how you regard and respond to people. Many elements influence the development of that regard and those responses. In the following discussion, some of these elements will be discussed as they apply to your involvement in the military service and to your relationships with other healthcare providers and the patient.

### CULTURE

Because of the multi- and cross-cultural nature and military mission of the Navy Medical Department, you will frequently encounter members of various cultures. **Culture** is defined as a group of socially learned, shared standards (norms) and behavior patterns. Concepts such as perceptions, values, beliefs, and goals are examples of shared norms. In addition, apparel, eating habits, and personal hygiene reflect common behavior patterns of specific groups of people. An understanding of common norms and behavior patterns enhances the quality—and often the quantity—of service a provider is able to make available. An individual's cultural background has an effect on every area of healthcare service, ranging from a simple technical procedure to the content and effectiveness of health education activities. Becoming familiar with the beliefs and practices of different cultural and subcultural groups (the military community, for example) is not only enriching to the healthcare provider, but also promotes an understanding and acceptance of the various peoples in the world community.

### RACE

The term **race** is a classification assigned to a group of people who share inherited physical characteristics. This term becomes a socially significant reality since people tend to attach great importance to assuming or designating a racial identity. Information identifying racial affiliation can be an asset to the healthcare provider in assessing the patient's needs, carrying out direct-care activities, and planning and implementing patient education programs. Racial identification has the potential to create a negative environment in the healthcare setting when factors such as skin color differences motivate

prejudicial and segregational behaviors. When this is permitted to occur, an environment that feeds a multitude of social illnesses and destructive behaviors develops. In the Navy Medical Department, no expressions or actions based on prejudicial attitudes will be tolerated.

It is both the moral and legal responsibility of the healthcare provider to render services with respect for the life and human dignity of the individual without regard to race, creed, gender, political views, or social status.

**RELIGION**

A large majority of people have some form of belief system that guides many of their life decisions and to which they turn to in times of distress. A person's religious beliefs frequently help give meaning to suffering and illness; those beliefs may also be helpful in the acceptance of future incapacities or death.

As a healthcare professional, you must accept in a nonjudgmental way the religious or nonreligious beliefs of others as valid for them, even if you personally disagree with such beliefs. Although you may offer religious support when asked and should always provide chaplain referrals when requested or indicated, it is not ethical for you to abuse your patients by forcing your beliefs (or nonbeliefs) upon them. You must respect their freedom of choice, offering your support for whatever their needs or desires may be.

**GENDER**

In today's Navy, you will encounter many situations where you are responsible for the care and treatment of service members of the opposite sex. When you treat service members of the opposite sex, you must always conduct yourself in a professional manner.

To ensure the professional conduct of a healthcare provider is not called into question, the Navy Medical Department provides specific guidelines in BUMEDINST 6320.83, *Provisions of Standbys During Medical Examinations*. Some of these guidelines are as follows:

- A standby should be present when you are examining or treating a member of the opposite sex. Whether this standby is a member of the same sex as the patient may be dictated by the availability of personnel.

- Common sense dictates that when you are caring for a patient, sensitivity to both verbal and nonverbal communication is paramount. A grin, a frown, or an expression of surprise may all be misinterpreted by the patient.

- Explanations and reassurances will go far in preventing misunderstandings of actions or intentions.

Knowledge, empathy, and mature judgment should guide the care provided to any patient. This is especially crucial when the care involves touching. As a member of the healthcare team, you are responsible for providing complete, quality care to those who need and seek your service. This care must also be provided in a manner compatible with your technical capabilities.

**AGE**

The age of the patient must be considered in performance of patient care. As a Hospital Corpsman, you will be responsible for the care of infants, children, adults, and the elderly. Communication techniques and patient handling may need to be modified because of the age of the patient.

**Infants and Children**

Infants can communicate their feelings in a variety of positive and negative ways, and they exhibit their needs by crying, kicking, or grabbing at the affected area of pain. An infant, however, usually responds positively to cuddling, rocking, touching, and soothing sounds.

Children need emotional support and display the same feelings an adult would when ill: fear, anger, worry, and so on. When ill, children may display behavior typical for an earlier age. For example, when hospitalized, a child who has been toilet trained may soil himself. This is not unusual, and parents should be informed that this behavior change is temporary. While the child is under your care in the hospital, you are a parent substitute and must gain the child's confidence and trust. Offer explanations of what you are going to do in ways the child will understand.

**Elderly**

In taking care of the elderly patient, a healthcare professional must be alert to the patient's mental and

physical capabilities (i.e., physical coordination, mental orientation, reduced eyesight). Medical management should be modified to accommodate the individual patient. Show genuine respect and warmth with the elderly. Avoid using terms like "gramps" or "granny." You should always show the elderly respect by treating them as the adults they are.

Give older patients the opportunity to control as many aspects of their self-care as possible. Allowing patients to self-pace their own care may take more time, but it will result in reducing their feelings of frustration, anger, and resentment. Listen to patients and allow them to reminisce if they wish to. The conversation can be used as a vehicle to bring today's events into focus for the patient. Remember to involve family members, as needed, into the patient education process. Some of your elderly patients will require assistance from family members for their medical needs once they are back home.

## COMMUNICATION SKILLS

**LEARNING OBJECTIVE:** *Recognize communication techniques used in a healthcare setting.*

Communication is a highly complicated interpersonal process of people relating to each other through conversation, writing, gestures, appearance, behavior, and, at times, even silence. Such communications not only occur among healthcare providers and patients, but also among healthcare providers and support personnel. Support personnel may include housekeeping, maintenance, security, supply, and food service staff. Another critical communication interaction occurs among healthcare providers and visitors. Because of the critical nature of communication in healthcare delivery, it is important that you understand the communication process and the techniques used to promote open, honest, and effective interactions. It is only through effective communication that you are able to identify the goals of the individual and the Navy healthcare system.

### THE COMMUNICATION PROCESS

The human communication process consists of four basic parts: the sender of the message, the message, the receiver of the message, and feedback.

The sender of the message starts the process. The message is the body of information the sender wishes to transmit to the receiver. The receiver is the individual intended to receive the message. Feedback is the response given by the receiver to the message. Feedback, at times, is used to validate whether effective communication has taken place.

#### Verbal and Nonverbal Communication

The two basic modes of communication are verbal and nonverbal. Verbal communication is either spoken or written. Verbal communication involves the use of words. Nonverbal communication, on the other hand, does not involve the use of words. Dress, gestures, touching, body language, face and eye behavior, and even silence are forms of nonverbal communication. Remember that even though there are two forms of communication, both the verbal and the nonverbal are inseparable in the total communication process. Conscious awareness of this fact is extremely important because your professional effectiveness is highly dependent upon successful communication.

#### Barriers to Effective Communication

Ineffective communication occurs when obstacles or barriers are present. These barriers are classified as physiological, physical, or psychosocial. **Physiological barriers** result from some kind of sensory dysfunction on the part of either the sender or the receiver. Such things as hearing impairments, speech defects, and even vision problems influence the effectiveness of communication. **Physical barriers** consist of elements in the environment (such as noise) that contribute to the development of physiological barriers (such as the inability to hear). **Psychosocial barriers** are usually the result of one's inaccurate perception of self or others; the presence of some defense mechanism employed to cope with some form of threatening anxiety; or the existence of factors such as age, education, culture, language, nationality, or a multitude of other socioeconomic factors. Psychological barriers are the most difficult to identify and the most common cause of communication failure or breakdown. A person's true feelings are often communicated more accurately through nonverbal communication than through verbal communication.

#### Listening

Listening, a critical element of the communication process, becomes the primary activity for the healthcare provider, who must use communication as a

tool for collecting or giving information. When one is engaged in listening, it is important to direct attention to both the verbal and nonverbal cues provided by the other person. Like many other skills necessary for providing a healthcare service, listening requires conscious effort and constant practice. Your listening skills can be improved and enhanced by developing the following attitudes and skills:

- Hear the speaker out.
- Focus on ideas.
- Remove or adjust distractions.
- Maintain objectivity.
- Concentrate on the immediate interaction.

As a healthcare provider, you will be using the communication process to service a patient's needs, both short and long-term. To simplify this discussion, short-term needs will be discussed under the heading of "patient contact point." Long-term needs will be discussed under the heading of "therapeutic communications."

**PATIENT CONTACT POINT**

To give you a frame of reference for the following discussion, the following definitions will clarify and standardize some critical terms:

- **Initial contact point**—The physical location where patients experience their first communication encounter with a person representing, in some role, the healthcare facility.
- **Contact point**—The place or event where the contact point person and the patient meet. The contact point meeting can occur anywhere in a facility and also includes telephone events.
- **Contact point person**—The healthcare provider in any healthcare experience who is tasked by role and responsibility to provide a service to the patient.

The contact point person has certain criteria to meet in establishing a good relationship with the patient. Helping the patient through trying experiences is partially the responsibility of all contact point personnel. Such healthcare providers must not only have skills related to their professional assignment, but they must also have the ability to interact in a positive, meaningful way to communicate concern and the desire to provide a service.

Consumers of healthcare services expect to be treated promptly, courteously, and correctly. They expect their care to be personalized and communicated to them in terms they understand. The Navy healthcare system is a service system, and it is the responsibility of every healthcare provider to give professional, quality customer service.

The significance of the contact point and the responsibility of the personnel staffing this area are important to emphasize. The following message from a former Surgeon General of the Navy reflects the philosophy of the Navy Medical Department regarding contact point interactions.

> Some of the most frequent complaints received by the Commander, Bureau of Medicine and Surgery, are those pertaining to the lack of courtesy, tact, and sympathetic regard for patients and their families exhibited by Medical Department personnel and initial points of contact within Navy Medical facilities. These points of initial patient contact, which include central appointment desks, telephones, patient affairs offices, emergency rooms, pharmacies, laboratories, record offices, information desks, walk-in and specialty clinics, and gate guards, are critical in conveying to the entering patient the sense that Navy Medicine is there to help them. The personnel, both military and civilian, who man these critical areas are responsible for ensuring that the assistance that they provide is truly reflective of the spirit of "caring" for which the Navy Medical Department must stand.
>
> No matter how excellent and expert the care in the facility may be, an early impression of nonchalance, disregard, rudeness, or neglect of the needs of patients reflects poorly on its efforts and achievements. Our personnel must be constantly on their guard to refrain from off-hand remarks or jokes in the presence of patients or their families. We must insist that our personnel in all patient areas are professional in their attitudes. What may be commonplace to us may be to a patient frightening or subject to misinterpretation.
>
> By example and precept, we must insist that, in dealing with our beneficiaries, no complaint is ever too trivial not to deserve the best response of which we are capable. . . .

## THERAPEUTIC COMMUNICATION

A distinguishing aspect of therapeutic communication is its application to long-term communication interactions. Therapeutic communication is defined as the face-to-face process of interacting that focuses on advancing the physical and emotional well-being of a patient. This kind of communication has three general purposes: collecting information to determine illness, assessing and modifying behavior, and providing health education. By using therapeutic communication, we attempt to learn as much as we can about the patient in relation to his illness. To accomplish this learning, both the sender and the receiver must be consciously aware of the confidentiality of the information disclosed and received during the communication process. You must always have a therapeutic reason for invading a patient's privacy.

When used to collect information, therapeutic communication requires a great deal of sensitivity as well as expertise in using interviewing skills. To ensure the identification and clarification of the patient's thoughts and feelings, you, as the interviewer, must observe his behavior. Listen to the patient and watch how he listens to you. Observe how he gives and receives both verbal and nonverbal responses. Finally, interpret and record the data you have observed.

As mentioned earlier, listening is one of the most difficult skills to master. It requires you to maintain an open mind, eliminate both internal and external noise and distractions, and channel attention to all verbal and nonverbal messages. Listening involves the ability to recognize pitch and tone of voice, evaluate vocabulary and choice of words, and recognize hesitancy or intensity of speech as part of the total communication attempt. The patient crying aloud for help after a fall is communicating a need for assistance. This cry for help sounds very different from the call for assistance you might make when requesting help in transcribing a physician's order.

The ability to recognize and interpret nonverbal responses depends upon consistent development of observation skills. As you continue to mature in your role and responsibilities as a member of the healthcare team, both your clinical knowledge and understanding of human behavior will also grow. Your growth in both knowledge and understanding will contribute to your ability to recognize and interpret many kinds of nonverbal communication. Your sensitivity in listening with your eyes will become as refined as—if not better than—listening with your ears.

The effectiveness of an interview is influenced by both the amount of information and the degree of motivation possessed by the patient (interviewee). Factors that enhance the quality of an interview consist of the participant's knowledge of the subject under consideration; his patience, temperament, and listening skills; and your attention to both verbal and nonverbal cues. Courtesy, understanding, and nonjudgmental attitudes must be mutual goals of both the interviewee and the interviewer.

Finally, to function effectively in the therapeutic communication process, you must be an informed and skilled practitioner. Your development of the required knowledge and skills is dependent upon your commitment to seeking out and participating in continuing education learning experiences across the entire spectrum of healthcare services.

## PATIENT EDUCATION

**LEARNING OBJECTIVE:** *Recognize the importance of patient education.*

Patient (health) education is an essential part of the healthcare delivery system. In the Navy Medical Department, patient education is defined as "the process that informs, motivates, and helps people adapt and maintain healthful practices and life styles." Specifically, the goals of this process are to

- assist individuals acquire knowledge and skills that will promote their ability to care for themselves more adequately;
- influence individual attitudinal changes from an orientation that emphasizes disease to an orientation that emphasizes health; and
- support behavioral changes to the extent that individuals are willing and able to maintain their health.

All healthcare providers, whether they recognize it or not, are teaching almost constantly. Teaching is a unique skill that is developed through the application of principles of learning. Patient teaching begins with an assessment of the patient's knowledge. Through this assessment, learning needs are identified. For example, a diabetic patient may have a need to learn how to self-administer an injection. After the learner's

needs have been established, goals and objectives are developed. Objectives inform the learner of what kind of (learned) behavior is expected. Objectives also assist the healthcare provider in determining how effective the teaching has been. These basic principles of teaching/learning are applicable to all patient-education activities, from the simple procedure of teaching a patient how to measure and record fluid intake/output to the more complex programs of behavior modification in situations of substance abuse (i.e., drug or alcohol) or weight control.

As a member of the healthcare team, you share a responsibility with all other members of the team to be alert to patient education needs, to undertake patient teaching within the limitation of your own knowledge and skills, and to communicate to other team members the need for patient education in areas you are not personally qualified to undertake.

## REPORTING AND ASSESSMENT PROCEDURES

**LEARNING OBJECTIVE:** *Recall proper patient care reporting and assessment procedures.*

Although physicians determine the overall medical management of a person requiring healthcare services, they depend upon the assistance of other members of the healthcare team when implementing and evaluating that patient's ongoing treatment. Nurses and Hospital Corpsmen spend more time with hospitalized patients than all other providers. This situation places them in a key position as data-collecting and -reporting resource persons.

The systematic gathering of information is called **data collection** and is an essential aspect in assessing an individual's health status, identifying existing problems, and developing a combined plan of action to assist the patient in his health needs. The initial assessment is usually accomplished by establishing a health history. Included in this history are elements such as previous and current health problems; patterns of daily living activities, medication, and dietary requirements; and other relevant occupational, social, and psychological data. Additionally, both subjective and objective observations are included in the initial assessment gathering interview and throughout the course of hospitalization.

### REPORTING

Accurate and intelligent assessments are the basis of good patient care and are essential elements for providing a total healthcare service. You must know what to watch for and what to expect. It is important to be able to recognize even the slightest change in a patient's condition, since such changes indicate a definite improvement or deterioration. You must be able to recognize the desired effects of medication and treatments, as well as any undesirable reactions to them. Both of these factors may influence the physician's decision to continue, modify, or discontinue parts or all of the treatment plan.

#### Oral and Written Reporting

Equally as important as assessments is the reporting of data and observations to the appropriate team members. Reporting consists of both oral and written communications and, to be effective, must be done accurately, completely, and in a timely manner. Written reporting, commonly called **recording**, is documented in a patient's clinical record. Maintaining an accurate, descriptive clinical record serves a dual purpose: It provides a written report of the information gathered about the patient, and it serves as a means of communication to everyone involved in the patient's care. The clinical record also serves as a valuable source of information for developing a variety of care-planning activities. Additionally, the clinical record is a legal document and is admissible as evidence in a court of law in claims of negligence and malpractice. Finally, these records serve as an important source of material that can be used for educating and training healthcare personnel and for conducting research and compiling statistical data.

#### Basic Guidelines for Written Entries

It is imperative that you follow some basic guidelines when you make written entries in the clinical record. All entries must be recorded accurately and truthfully. Omitting an entry is as harmful as making an incorrect recording. Each entry should be concise and brief; therefore, avoid extra words and vague notations. Recordings must be legible. If an error is made, it must be deleted following the standard Navy policy for correcting erroneous written notations. Finally, your entries in

the clinical record must include the time and date, your signature, and your rate or rank.

### SOAP Note Format

SOAP stands for SUBJECTIVE, OBJECTIVE, ASSESSMENT, and PLAN. Medical documentation of patient complaint(s) and treatment must be consistent, concise, and comprehensive. The Navy Medical Department uses the SOAP note format to standardize medical evaluation entries made in clinical records. The four parts of a SOAP note are discussed below. For more detailed instructions, refer to chapter 16 of the MANMED.

**SUBJECTIVE**.—The initial portion of the SOAP note format consists of subjective observations. These are symptoms verbally given to you by the patient or by a significant other (family or friend). These subjective observations include the patient's descriptions of pain or discomfort, the presence of nausea or dizziness, and a multitude of other descriptions of dysfunction, discomfort, or illness.

**OBJECTIVE**.—The next part of the format is the objective observation. These objective observations include symptoms that you can actually see, hear, touch, feel, or smell. Included in objective observations are measurements such as temperature, pulse, respiration, skin color, swelling, and the results of tests.

**ASSESSMENT**.—Assessment follows the objective observations. Assessment is the diagnosis of the patient's condition. In some cases the diagnosis may be clear, such as a contusion. However, an assessment may not be clear and could include several diagnosis possibilities.

**PLAN**.—The last part of the SOAP note is the plan. The plan may include laboratory and/or radiologic tests ordered for the patient, medications ordered, treatments performed (e.g., minor surgery procedure), patient referrals (sending patient to a specialist), patient disposition (e.g., binnacle list, Sick-in-Quarters (SIQ), admission to hospital), patient directions, and follow-up directions for the patient.

## SELF-QUESTIONING TECHNIQUES FOR PATIENT ASSESSMENT AND REPORTING

Table 2-1 outlines the self-questioning techniques for patient assessment and reporting is a good guide to assist you in developing proficiency in assessing and reporting patient conditions.

## INPATIENT CARE

A patient will often require inpatient care, whether due to injury or illness. Frequently, the inpatient will need specialized treatments, perhaps even surgery. In this part of the chapter, we will discuss the procedures for assisting both the medical inpatient and the surgical inpatient.

## THE MEDICAL PATIENT

**LEARNING OBJECTIVE:** *Evaluate the needs of a medical patient.*

For purposes of this discussion, the term **medical patient** applies to any person who is receiving diagnostic, therapeutic, and/or supportive care for a condition that is not managed by surgical-, orthopedic-, psychiatric-, or maternity-related therapy. This is not to infer that patients in these other categories are not treated for medical problems. Many surgical, orthopedic, psychiatric, and maternity patients do have secondary medical problems that are treated while they are undergoing management for their primary condition. Although many medical problems can be treated on an outpatient basis, this discussion will address the hospitalized medical patient. It should be noted that the basic principles of management are essentially the same for both the inpatient and outpatient.

The medical management of the patient generally consists of laboratory and diagnostic tests and procedures, medication, food and fluid therapy, and patient teaching. Additionally, for many medical patients, particularly during the initial treatment phase, rest is a part of the prescribed treatment.

### Laboratory Tests And Diagnostic Procedures

A variety of laboratory and diagnostic tests and procedures are commonly ordered for the medical patient. Frequently, the Hospital Corpsman is assigned to prepare the patient for the procedure, collect the specimens, or assist with both the procedure and specimen collection. Whether a specimen is to be collected or a procedure is to be performed, the patient needs a clear and simple explanation about what is to

**Table 2–1.—Self-Questioning Techniques for Patient Assessment and Reporting**

| Area of Concern | Assessment Criteria |
|---|---|
| General Appearance | Is the patient<br>• of average build, short, tall, thin, or obese?<br>• well-groomed?<br>• apparently in pain?<br>• walking with a limp, wearing a cast, walking on crutches, or wearing a prosthetic extremity? |
| Behavior | Does the patient<br>• appear worried, nervous, excited, depressed, angry, disoriented, confused, or unconscious?<br>• refuse to talk?<br>• communicate thoughts in a logical order or erratically?<br>• lisp, stutter, or have slurred speech?<br>• appear sullen, bored, aggressive, friendly, or cooperative?<br>• sleep well or arouse early?<br>• sleep poorly, moan, talk, or cry out when sleeping?<br>• join ward activities?<br>• react well toward other patients, staff, and visitors? |
| Position | Does the patient<br>• remain in one position in bed?<br>• have difficulty breathing while in any position?<br>• use just one pillow or require more pillows to sleep well?<br>• move about in bed without difficulty? |
| Skin | Is the patient's skin<br>• flushed, pale, cyanotic (bluish hue), hot, moist, clammy, cool, or dry?<br>• bruised, scarred, lacerated, scratched, or showing a rash, lumps, or ulcerations?<br>• showing signs of pressure, redness, mottling, edema, or pitting edema?<br>• appearing shiny or stretched?<br>• perspiring profusely?<br>• infested with lice? |
| Eyes | Are the patient's<br>• eyelids swollen, bruised, discolored, or dropping?<br>• sclera (whites of eyes) clear, dull, yellow, or bloodshot?<br>• pupils constricted or dilated, equal in size, react equally to light?<br>• eyes tearing or showing signs of inflammation or discharge?<br>• complaints about pain; burning; itching; sensitivity to light; or blurred, double, or lack of vision? |
| Ears | Does the patient<br>• hear well bilaterally?<br>• hold or pull on his ears?<br>• complain of a buzzing or ringing sound?<br>• have a discharge or wax accumulation?<br>• complain of pain? |
| Nose | Is the patient's<br>• nose bruised, bleeding, or difficult to breathe through?<br>• nose excessively dry or dripping?<br>Are the patient's nares (nasal openings) equal in size?<br>Is the patient sniffling excessively? |
| Mouth | Does the patient's<br>• mouth appear excessively dry?<br>• breath smell sweet, sour, or of alcohol?<br>• tongue appear dry, moist, clean, coated, cracked, red, or swollen?<br>• gums appear inflamed, ulcerated, swollen, or discolored?<br>• teeth appear white, discolored, broken, or absent?<br>Does the patient<br>• wear dentures, braces, or partial plates?<br>• complain of mouth pain or ulcerations?<br>• complain of an unpleasant taste? |

**Table 2–1.—Self-Questioning Techniques for Patient Assessment and Reporting—Continued**

| Area of Concern | Assessment Criteria |
|---|---|
| Chest | Does the patient<br>• have shortness of breath, wheezing, gasping, or noisy respirations? cough?<br>• have a dry, moist, hacking, productive, deep, or persistent cough?<br>• have white, yellow, rusty, or bloody sputum?<br>– Is it thin and watery or thick and purulent (containing pus)?<br>– How much is produced?<br>– Does it have an odor?<br>• complain of chest pain?<br>– Where is the pain?<br>– Is the pain a dull ache, sharp, crushing, or radiating?<br>– Is the pain relieved by resting?<br>– Is the patient using medication to control the pain (i.e., nitroglycerin)? |
| Abdomen | Does the patient<br>• have an abdomen that looks or feels distended, boardlike, or soft?<br>• have a distended abdomen, and, if so, is the abdomen distended above or below the umbilicus or over the entire abdomen?<br>• belch excessively?<br>• feel nauseated, or has he vomited?<br>– If so, how often, and when?<br>– What is the volume, consistency, and odor of the vomitus?<br>– Is it coffee ground, bilious (containing bile), or bloody in appearance?<br>– Is patient vomiting with projectile force? |
| Bladder & Bowel | Does the patient have<br>• bladder and bowel control?<br>• normal urination volume and frequency?<br>– Does the urine have an odor?<br>– Is the urine dark amber or bloody?<br>– Is the urine cloudy; does it have sediment in it?<br>– Is there pain, burning, or difficulty when voiding?<br>• diarrhea, soft stools, or constipation?<br>– What is the color of the stool?<br>– Does the stool contain blood, pus, fat, or worms?<br>– Does the patient have hemorrhoids, fistulas, or rectal pain? |
| Vagina or Penis | Does the patient have<br>• ulcerations or irritations?<br>• a discharge or foul odor?<br>– If there is a discharge present, is it bloody, purulent, mucoid (containing mucous), or watery?<br>– What is the amount?<br>• associated pain?<br>– If pain is present, where is it located?<br>– Is it constant or intermittent?<br>– Is it tingling, dull, aching, burning, gnawing, cramping, or crushing? |
| Food & Fluid Intake | Does the patient<br>• have a good, fair, or poor appetite?<br>• get thirsty often?<br>• have any kind of food intolerance? |
| Medications | Does the patient<br>• take any medications? (If so: what, why, and when last taken?)<br>• have medications with him?<br>• have any history of medication reactions or allergies? |

be done and what the patient can do to assist with the activity. Often the success of the test or procedure is dependent upon the patient's informed cooperation. When collecting specimens, the Hospital Corpsman must complete the following procedures:

- Collect the correct kind and amount of specimen at the right time.
- Place the specimen in the correct container.
- Label the container completely and accurately. This often differs somewhat for each facility, and local policies should be consulted.
- Complete the laboratory request form accurately.
- Record on the patient's record or other forms, as appropriate; the date, time, kind of specimen collected; the disposition of the specimen; and anything unusual about the appearance of the specimen or the patient during the collection.

When assisting with a diagnostic procedure, the Hospital Corpsman must understand the sequence of steps of the procedure and exactly how the assistance can best be provided. Since many procedures terminate in the collection of a specimen, the above principles of specimen collecting must be followed.

Following the completion of a procedure or specimen collection, it is the responsibility of the assisting Hospital Corpsman to ensure that the patient's safety and comfort are attended to, the physician's orders accurately followed, and any supplies or equipment used appropriately discarded.

**Medications**

A major form of therapy for the treatment of illness is the use of drugs. It is not uncommon for the medical patient to be treated with several drugs. As members of the healthcare team, Hospital Corpsmen assigned to preparing and administering medications are given a serious responsibility demanding constant vigilance, integrity, and special knowledge and skills. The preparation and administration of medications were addressed in great detail in the Hospital Corps School curriculum. References and the continued in-service training devoted to medication administration at all medical facilities support the importance of accurate preparation and administration of drugs.

An error—which also includes omissions—can seriously affect a patient, even to the point of causing death. Each Hospital Corpsman is responsible for his own actions, and this responsibility cannot be transferred to another. No one individual is expected to know all there is to know about all patients and medications. However, in every healthcare environment, the Hospital Corpsman can access other healthcare providers who can assist in clarifying orders; explaining the purposes, actions, and effects of drugs; and, in general, answering any questions that may arise concerning a particular patient and that patient's medications. There should be basic drug references available to all personnel handling medications, including the *Physicians' Desk Reference* and a hospital formulary. As a Hospital Corpsman, it is your responsibility to consult these members of the team and these references for assistance in any area in which you are not knowledgeable or whenever you have questions or doubts. You are also responsible for knowing and following local policies and procedures regarding the administration of medications.

**Food and Fluid Therapy**

The following brief discussion covers food and fluid and how it relates specifically to the medical patient. Loss of appetite, food intolerance, digestive disturbances, lack of exercise, and even excessive weight gain influence a medical patient's intake requirements. Regardless of their medical problems, patients have basic nutritional needs that frequently differ from those of the healthy person. As a part of the patient's therapeutic regimen, food is usually prescribed in the form of a special diet. Regardless of the kind of diet prescribed, the patient must understand why certain foods are ordered or eliminated, and how compliance with the regimen will assist in his total care. It is the responsibility of the Corpsman to assist the patient in understanding the importance of the prescribed diet and to ensure that accurate recording of the patient's dietary intake is made on the clinical record.

In many disease conditions, the patient is unable to tolerate food or fluids or may lose these through vomiting, diarrhea, or both. In these cases, replacement fluids as well as nutrients are an important part of the patient's medical management. On the other hand, there are several disease conditions in which fluid restrictions are important aspects of the patient's therapy. In both of these instances, accurate measurement and recording of fluid intake and output must be carefully performed. Very frequently this becomes a major task of the staff Hospital Corpsman.

### Patient Teaching

Earlier in this chapter, under "Patient Education," the goals and principles of patient teaching were addressed. When taken in the context of the medical patient, there are some general areas of patient teaching needs that must be considered, particularly as the patient approaches discharge from an inpatient status. Those areas include the following:

- Follow-up appointments
- Modification in daily living activities and habits
- Modification in diet, including fluid intake
- Medications and treatment to be continued after discharge
- Measures to be taken to promote health and prevent illness

### Rest

The primary reason for prescribing rest as a therapeutic measure for the medical patient is to prevent further damage to the body or a part of the body when the normal demand of use exceeds the ability to respond. However, prolonged or indiscriminate use of rest—particularly bed rest—is potentially hazardous. Some of the common complications occurring as a result of prolonged bed rest are

- circulatory problems (such as development of thrombi and emboli) and subsequent skin problems (such as decubiti);
- respiratory problems (such as atelectasis and pneumonia);
- gastrointestinal problems (such as anorexia, constipation, and fecal impactions);
- urinary tract problems (such as retention, infection, or the formation of calculi);
- musculoskeletal problems (such as weakness, atrophy, and the development of contractures); and
- psychological problems (such as apathy, depression, and temporary personality changes).

The prevention of complications is the key concept in therapeutic management for the patient on prolonged bed rest. Awareness of the potential hazards is the first step in prevention. Alert observations are essential: Skin condition, respirations, food and fluid intake, urinary and bowel habits, evidence of discomfort, range of motion, and mood are all critical elements that provide indications of impending problems. When this data is properly reported, the healthcare team has time to employ measures that will arrest the development of preventable complications.

## THE SURGICAL PATIENT

**LEARNING OBJECTIVE:** *Evaluate the needs of a surgical patient during the preoperative, operative, recovery, and postoperative phases of his treatment.*

Surgical procedures are classified into two major categories: emergency and elective. Emergency surgery is that required immediately to save a life or maintain a necessary function. Elective surgery is that which, in most cases, needs to be done but can be scheduled at a time beneficial to both the patient and the provider. Regardless of the type of surgery, every surgical patient requires specialized care at each of four phases. These phases are classified as **preoperative**, **operative, recovery**, and **postoperative**. The following discussion will address the basic concepts of care in each phase.

### Preoperative Phase

Before undergoing a surgical procedure, the patient must be in the best possible psychological, spiritual, and physical condition. Psychological preparation begins the moment the patient learns of the necessity of the operation. The physician is responsible for explaining the surgical procedure to the patient, including the events that can be expected after the procedure. Since other staff personnel reinforce the physician's explanation, all members of the team must know what the physician has told the patient. In this manner, they are better able to answer the patient's questions. All patients approaching surgery are fearful and anxious. The staff can assist in reducing this fear by instilling confidence in the patient regarding the competence of those providing care. The patient should be given the opportunity and freedom to express any feelings or fears concerning the proposed procedure. Even in an emergency, it is possible to give a patient and the family psychological support. Often this is accomplished simply by the confident and skillful manner in which the administrative and physical preoperative preparation is performed.

The fears of presurgical patients derive from their insecurities in the areas of anesthesia, body disfigurement, pain, and even death. Frequently, religious faith is a source of strength and courage for these patients. If a patient expresses a desire to see a clergyman, every attempt should be made to arrange a visit.

**ADMINISTRATIVE PREPARATION**.—Except in emergencies, the administrative preparation usually begins before surgery. A step-by-step procedure is outlined in *Fundamental Skills and Concepts in Patient Care,* "Caring for the Patient Undergoing Surgery." Only the Request for Administration of Anesthesia and for Performance of Operations and Other Procedures (SF 522) will be addressed here. The SF 522 identifies the operation or procedure to be performed; has a statement written for the patient indicating in lay terms a description of the procedure; and includes the signatures of the physician, patient, and a staff member who serves as a witness. An SF 522 must be completed before any preoperative medications are administered. If the patient is not capable of signing the document, a parent, legal guardian, or spouse may sign it. It is customary to require the signature of a parent or legal guardian if the patient is under 21 years of age, unless the patient is married or a member of the Armed Forces. In these latter two cases, the patient may sign his own permit, regardless of age.

Normally, the physical preparation of the patient begins in the late afternoon or early evening the day before surgery. As with the administrative preparation, each step is clearly outlined in *Fundamental Skills and Concepts in Patient Care,* "Caring for the Patient Undergoing Surgery."

**PREOPERATIVE INSTRUCTIONS.**—Preoperative instructions are an important part of the total preparation. The exact time that preoperative teaching should be initiated greatly depends upon the individual patient and the type of surgical procedure. Most experts recommend that preoperative instructions be given as close as possible to the time of surgery. Appropriate preoperative instructions given in sufficient detail and at the proper time greatly reduce operative and postoperative complications.

### Operative Phase

The operative (or intra-operative) phase begins the moment the patient is taken into the operating room. Two of the major factors to consider at this phase are positioning and anesthesia.

**POSITIONING.**—The specific surgical procedure will dictate the general position of the patient. For example, the **lithotomy** position is used for a vaginal hysterectomy, while the **dorsal recumbent** position is used for a herniorrhaphy. Regardless of the specific position the patient is placed in, there are some general patient safety guidelines that must be observed. When positioning a patient on the operating table, remember the following:

- Whether the patient is awake or asleep, place the patient in as comfortable a position as possible.
- Strap the patient to the table in a manner that allows for adequate exposure of the operative site and is secure enough to prevent the patient from falling, but that does not cut off circulation or contribute to nerve damage.
- Secure all the patient's extremities in a manner that will prevent them from dangling over the side of the table.
- Pad all bony prominences to prevent the development of pressure areas or nerve damage.
- Make sure the patient is adequately grounded to avoid burns or electrical shock to either the patient or the surgical team.

**ANESTHESIA.**—One of the greatest contributions to medical science was the introduction of anesthesia. It relieves unnecessary pain and increases the potential and scope of many kinds of surgical procedures. Therefore, healthcare providers must understand the nature of anesthetic agents and their effect on the human body.

Anesthesia may be defined as a loss of sensation that makes a person insensible to pain, with or without loss of consciousness. Some specific anesthetic agents are discussed in the "Pharmacy" chapter of this manual. Healthcare providers must understand the basics of anesthesiology as well as a specific drug's usage.

The two major classifications of anesthesia are regional and general.

**Regional Anesthesia**.—Regional anesthetics reduce all painful sensations in a particular area of the body without causing unconsciousness. The following is a listing of the various methods and a brief description of each.

- **Topical** anesthesia is administered topically to desensitize a small area of the body for a very short period.
- **Local blocks** consist of the subcutaneous infiltration of a small area of the body with a desensitizing agent. Local anesthesia generally lasts a little longer than topical.
- **Nerve blocks** consist of injecting the agent into the region of a nerve trunk or other large nerve branches. This form of anesthesia blocks all impulses to and from the injected nerves.
- **Spinal** anesthesia consists of injecting the agent into the subarachnoid space of the spinal canal between the third and fourth lumbar space or between the fifth lumbar and first sacral space of the spinal column. This form of anesthesia blocks all impulses to and from the entire area below the point of insertion, provided the patient's position is not changed following injection of the agent. If the patient's position is changed, for example, from dorsal recumbent to Trendelenburg's, the anesthetic agent will move up the spinal column and the level of the anesthesia will also move up. Because of this reaction, care must be exercised in positioning the patient's head and chest above the level of insertion to prevent paralysis (by anesthesia) of the respiratory muscles. In general, spinal anesthesia is considered the safest for most routine major surgery.
- **Epidural blocks** consist of injecting the agent into the epidural space of the spinal canal at any level of the spinal column. The area of anesthesia obtained is similar to that of the subarachnoid spinal method. The epidural method is frequently used when continuous anesthesia is desired for a prolonged period. In these cases, a catheter is inserted into the epidural space through a spinal needle. The needle is removed, but the catheter is left in place. This provides for continuous access to the epidural space.
- **Saddle blocks** consist of injecting the agent into the dural sac at the third and fourth lumbar space. This form of anesthesia blocks all impulses to and from the perineal area of the body.
- **Caudal blocks** consist of injecting the agent into the sacral canal. With this method, anesthesia is obtained from the umbilicus to the toes.

**General Anesthesia**.—General anesthetics cause total loss of sensation and complete loss of consciousness in the patient. They are administered by inhalation of certain gases or vaporized liquids, intravenous infusion, or rectal induction. The induction of inhalation anesthesia is divided into four stages. These stages and the body's main physiological reaction in each phase are explained below and depicted in figure 2–1.

- **Stage 1** is called the stage of analgesia or induction. During this period, the patient experiences dizziness, a sense of unreality, and a lessening sensitivity to touch and pain. At this stage, the patient's sense of hearing is increased, and responses to noises are intensified (fig. 2-1).
- **Stage 2** is the stage of excitement. During this period, there is a variety of reactions involving muscular activity and delirium. At this stage, the vital signs show evidence of physiological stimulation. It is important to remember that during this stage the patient may respond violently to very little stimulation (fig. 2–1).
- **Stage 3** is called the surgical or operative stage. There are four levels of consciousness (also called planes) to this stage. It is the responsibility of the anesthetist or anesthesiologist to determine which plane is optimal for the procedure. The determination is made according to specific tissue sensitivity of

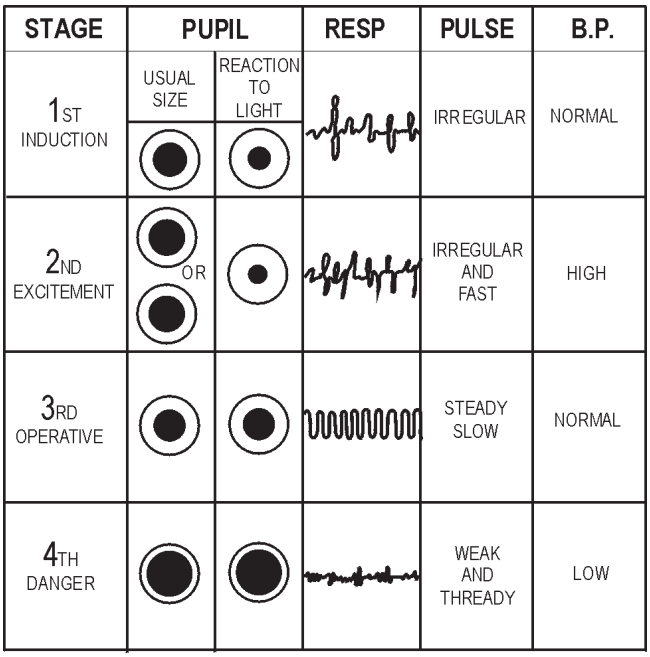


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**Figure 2–1.—Stages of anesthesia.**

the individual and the surgical site. Each successive plane is achieved by increasing the concentration of the anesthetic agent in the tissue (fig. 2–1).

- **Stage 4** is called the toxic or danger stage. Obviously, this is never a desired stage of anesthesia. At this point, cardiopulmonary failure and death can occur. Once surgical anesthesia has been obtained, the healthcare provider must exercise care to control the level of anesthesia. The fourth level of consciousness of stage 3 is demonstrated by cardiovascular impairment that results from diaphragmatic paralysis. If this plane is not corrected immediately, stage 4 quickly ensues (fig. 2–1).

**Recovery Stage**

For purposes of this discussion, the recovery phase consists of the period that begins at the completion of the operation and extends until the patient has recovered from anesthesia. The recovery phase generally takes place in a specialized area called the recovery room. This unit is usually located near the operating room and has access to the following:

- Surgeons and anesthesiologists or anesthetists
- Nurses and Hospital Corps personnel who are specially prepared to care for immediate postoperative patients
- Special equipment, supplies, medication, and replacement fluids

From the time of admission to patient discharge, routine care in the recovery room consists of the following:

- Measuring temperature and vital signs (taken immediately upon admission and as ordered by the physician thereafter)
- Maintaining airway patency

  —Patients having an artificial airway in place will automatically expel it as they regain consciousness.

  —Have a mechanical suction apparatus available to remove excess excretions from the patient's airway.
- Ensuring the integrity of dressings, tubes, catheters and casts

  —Locate the presence of any of the above.

  —Make notations regarding all drainage, including color, type, and amount.

  —Immediately report the presence of copious amounts of drainage to a nurse or physician.
- Monitoring intravenous therapy (including blood and blood components)

  —Make notations including type of infusion, rate of flow, and condition of the infusion site.

  —Observe patients receiving blood or blood components closely for untoward reactions.
- Monitoring skin color changes

  —Check dressings and casts frequently to ensure they are not interfering with normal blood circulation to the area.

  —Notify a physician or nurse of general skin color changes that may indicate airway obstruction, hemorrhage, or shock.
- Assessing level of responsiveness

  —For general anesthetics, check for orientation to the environment each time vital signs are taken.

  —For regular anesthetics, check for return of sensory perception and voluntary movement each time vital signs are taken.
- Observing for side effects of the anesthetic agent

  —Each agent has the potential for causing specific side effects. Some common major side effects that may occur following the administration of both spinal and general anesthesia consist of the following:

  - Hypotension/shock
  - Respiratory paralysis
  - Neurological complications
  - Headache
  - Cardiac arrest
  - Respiratory depression
  - Bronchospasm/laryngospasm
  - Diminished circulation
  - Vomiting/aspiration

### Postoperative Phase

After the patient's condition has been stabilized in the recovery room, a physician will order the patient's transfer to another area of the facility. Generally, this transfer is to the unit that the patient was assigned to preoperatively. Since both surgery and anesthesia have unavoidable temporary ill effects on normal physiological functions, every effort must be made to prevent postoperative complications.

**POSTOPERATIVE GOALS.—**From the time the patient is admitted to the recovery room to the time recovery from the operation is complete, there are definite goals of care that guide the entire postoperative course. These goals are as follows:

- Promoting respiratory function
- Promoting cardiovascular function
- Promoting renal function
- Promoting nutrition and elimination
- Promoting fluid and electrolyte balance
- Promoting wound healing
- Encouraging rest and comfort
- Encouraging movement and ambulation
- Preventing postoperative complications

The physician will write orders for postoperative care that are directed at accomplishing the above goals. Although the orders will be based on each individual patient's needs, there will be some common orders that apply to all patients. These orders will center around the promotion of certain physiological functions and areas addressed in the following paragraphs.

**Respiratory function** is promoted by encouraging frequent coughing and deep breathing. Early movement and ambulation also help improve respiratory function. For some patients, oxygen therapy may also be ordered to assist respiratory function. **Cardiovascular function** is assisted by frequent position changes, early movement and ambulation, and, in some cases, intravenous therapy. **Renal function** is promoted by adequate fluid intake and early movement and ambulation. **Nutritional status** is promoted by ensuring adequate oral and correct intravenous intake and by maintaining accurate intake and output records. **Elimination functions** are promoted by adequate diet and fluid intake. Postoperative patients should be advanced to a normal dietary regimen as soon as possible, since this, too, promotes elimination functions. Early movement and ambulation also help to restore normal elimination activities.

In addition to various medications and dressing change procedures ordered by the physician, **wound healing** is promoted by good nutritional intake and by early movement and ambulation. **Rest and comfort** are supported by properly positioning the patient, providing a restful environment, encouraging good basic hygiene measures, ensuring optimal bladder and bowel output, and promptly administering pain-relieving medications. Early **movement and ambulation** are assisted by ensuring maximum comfort for the patient and providing the encouragement and support for ambulating the patient, particularly in the early postoperative period. As indicated in the above discussion, the value of early movement and ambulation, when permissible, cannot be overemphasized.

**POSTOPERATIVE COMPLICATIONS.—**During the early postoperative phase, the major complications to be guarded against are respiratory obstruction, shock, and hemorrhage. As the patient progresses in the postoperative period, other complications to avoid are the development of pneumonia, phlebitis and subsequent thrombophlebitis, gastrointestinal problems ranging from abdominal distention to intestinal obstruction, and, finally, wound infections. Accurate implementation of the physician's orders and careful observation, reporting, and recording of the patient's condition will contribute markedly to an optimal and timely postoperative recovery course for the patient.

## THE ORTHOPEDIC PATIENT

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**LEARNING OBJECTIVE:** *Evaluate the needs of the orthopedic patient.*

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Patients receiving orthopedic services are those who require treatment for fractures, deformities, and diseases or injuries of some part of the musculoskeletal system. Some patients will require surgery, immobilization, or both to correct their condition.

### General Care

The basic principles and concepts of care for the surgical patient will apply to orthopedic patients. The majority of patients not requiring surgical intervention

will be managed by bed rest, immobilization, and rehabilitation. Many of the basic concepts of care of the medical patient are applicable for orthopedic patient care. In the military, the usual orthopedic patient is fairly young and in good general physical condition. For these patients, bed rest is prescribed only because other kinds of activity are limited by their condition on admission.

**Immobilization**

Rehabilitation is the ultimate goal when planning the orthopedic patient's total management. Whether the patient requires surgical or conservative treatment, immobilization is often a part of the overall therapy. Immobilization may consist of applying casts or traction, or using equipment (such as orthopedic frames). During the immobilization phase, simple basic patient care is extremely important. Such things as skin care, active-passive exercises, position changes in bed (as permitted), good nutrition, adequate fluid intake, regularity in elimination, and basic hygiene contribute to both the patient's physical and psychological well-being.

Lengthy periods of immobilization are emotionally stressful for patients, particularly those who are essentially healthy except for the limitations imposed by their condition. Prolonged inactivity contributes to boredom that is frequently manifested by various kinds of acting-out behavior.

Often, the orthopedic patient experiences exaggerated levels of pain. Orthopedic pain is commonly described as sore and aching. Because this condition requires long periods of treatment and hospitalization, the wise management of pain is an important aspect of care. Constant pain, regardless of severity, is energy consuming. You should make every effort to assist the patient in conserving this energy. There are times when the patient's pain can and should be relieved by medications. There are, however, numerous occasions when effective pain relief can be provided by basic patient-care measures such as proper body alignment, change of position, use of heat or cold (if permitted by a physician's orders), back rubs and massages, and even simple conversation with the patient. Meaningful activity also has been found to help relieve pain. Whenever possible, a well-planned physical/occupational therapy regimen should be an integral part of the total rehabilitation plan.

**CAST FABRICATION**.—As mentioned previously, immobilization is often a part of the overall therapy of the orthopedic patient, and casting is the most common and well-known form of long-term immobilization. In some instances, a Corpsman may be required to assist in applying a cast or be directed to apply or change a cast. In this section, we will discuss the method of applying a short and long arm cast, and a short leg cast.

In applying any cast, the basic materials are the same: webril or cotton bunting, plaster of Paris, a bucket or basin of tepid water, a water source (tap water), protective linen, gloves, a working surface, a cast saw, and seating surfaces for the patient and the Corpsman. Some specific types of casts may require additional material.

**SHORT ARM CAST**.—A short arm cast extends from the metacarpal-phalangeal joints of the hand to just below the elbow joint. Depending on the location and type of fracture, the physician may order a specific position for the arm to be casted. Generally, the wrist is in a neutral (straight) position, with the fingers slightly flexed in the position of function.

Beginning at the wrist, apply three layers of webril (fig. 2–2A). Then apply webril to the forearm and the hand, making sure that each layer overlaps the other by a third (as shown in figure 2–2B). Check for lumps or wrinkles and correct any by tearing the webril and smoothing it.

Dip the plaster of Paris into the water for approximately 5 seconds. Gently squeeze to remove excess water, but do not wring out. Beginning at the wrist (fig. 2–2C) wrap the plaster in a spiral motion, overlapping each layer by one-third to one-half. Smooth out the layers with a gentle palmar motion. When applying the plaster, make tucks by grasping the excess material and folding it under as if making a pleat. Successive layers cover and smooth over this fold. When the plaster is anchored on the wrist, cover the hand and the palmar surface before continuing up the arm (figs. 2–2D and 2–2E). Repeat this procedure until the cast is thick enough to provide adequate support, generally 4 to 5 layers. The final step is to remove any rough edges and smooth the cast surface (fig. 2–2F). Turn the ends of the cast back and cover with the final layer of plaster, and allow the plaster to set for approximately 15 minutes. Trim with a cast saw, as needed.

**LONG ARM CAST**.—The procedure for a long arm cast is basically the same as for a short arm cast, except the elbow is maintained in a 90° position, the

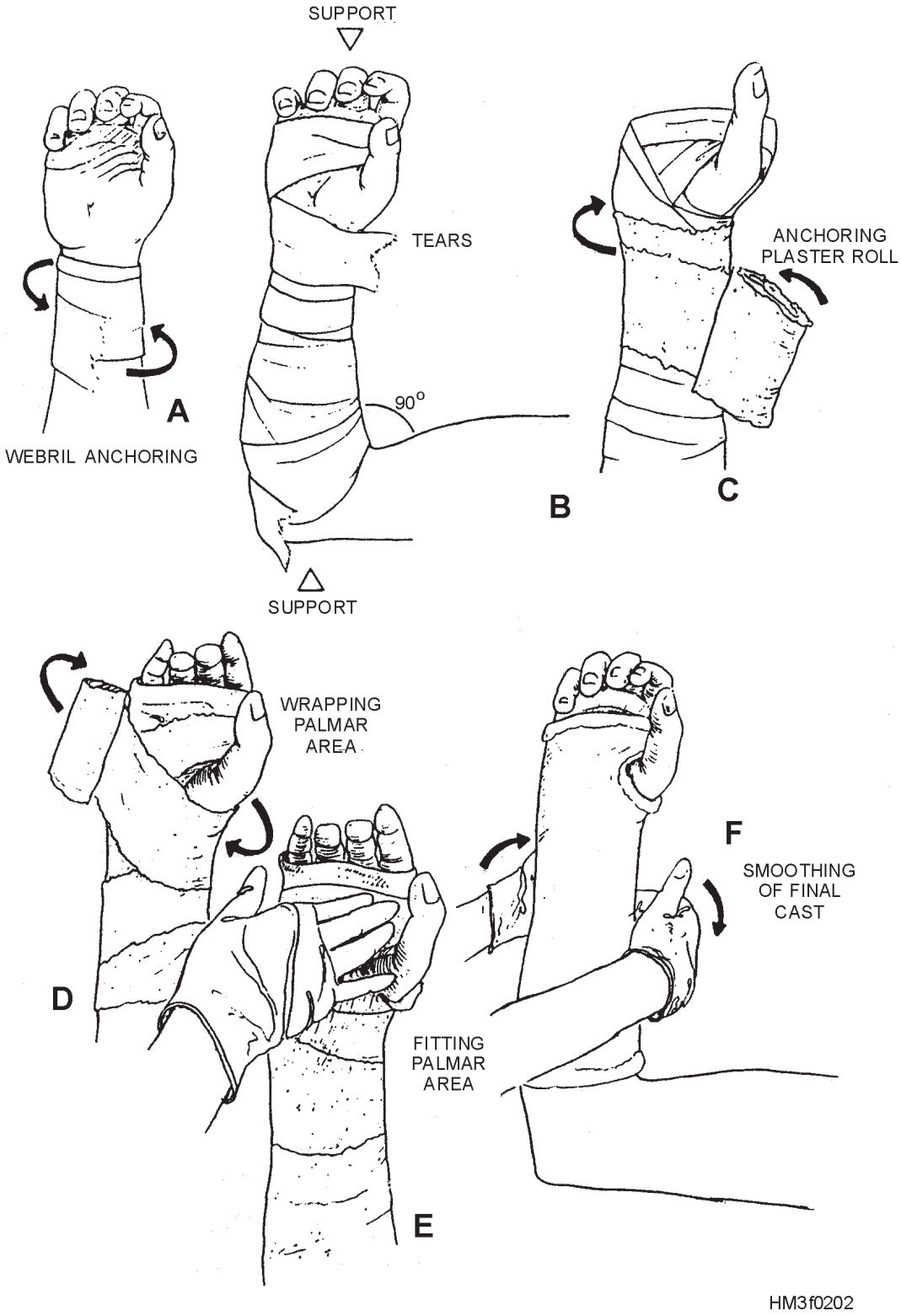


**Figure 2–2.—Applying a short arm cast.**

cast begins at the wrist and ends on the upper arm below the axilla, and the hand is not wrapped.

**SHORT LEG CAST**.—In applying a short leg cast, seat the patient on a table with both legs over the side, flexed at the knee. Instruct the patient to hold the affected leg, with the ankle in a neutral position (90°). Make sure that the foot is not rotated medially or laterally. Beginning at the toes, apply webril (figs. 2–3A, 2–3B, and 2–3C) in the same manner as for the short arm cast, ensuring that there are no lumps or

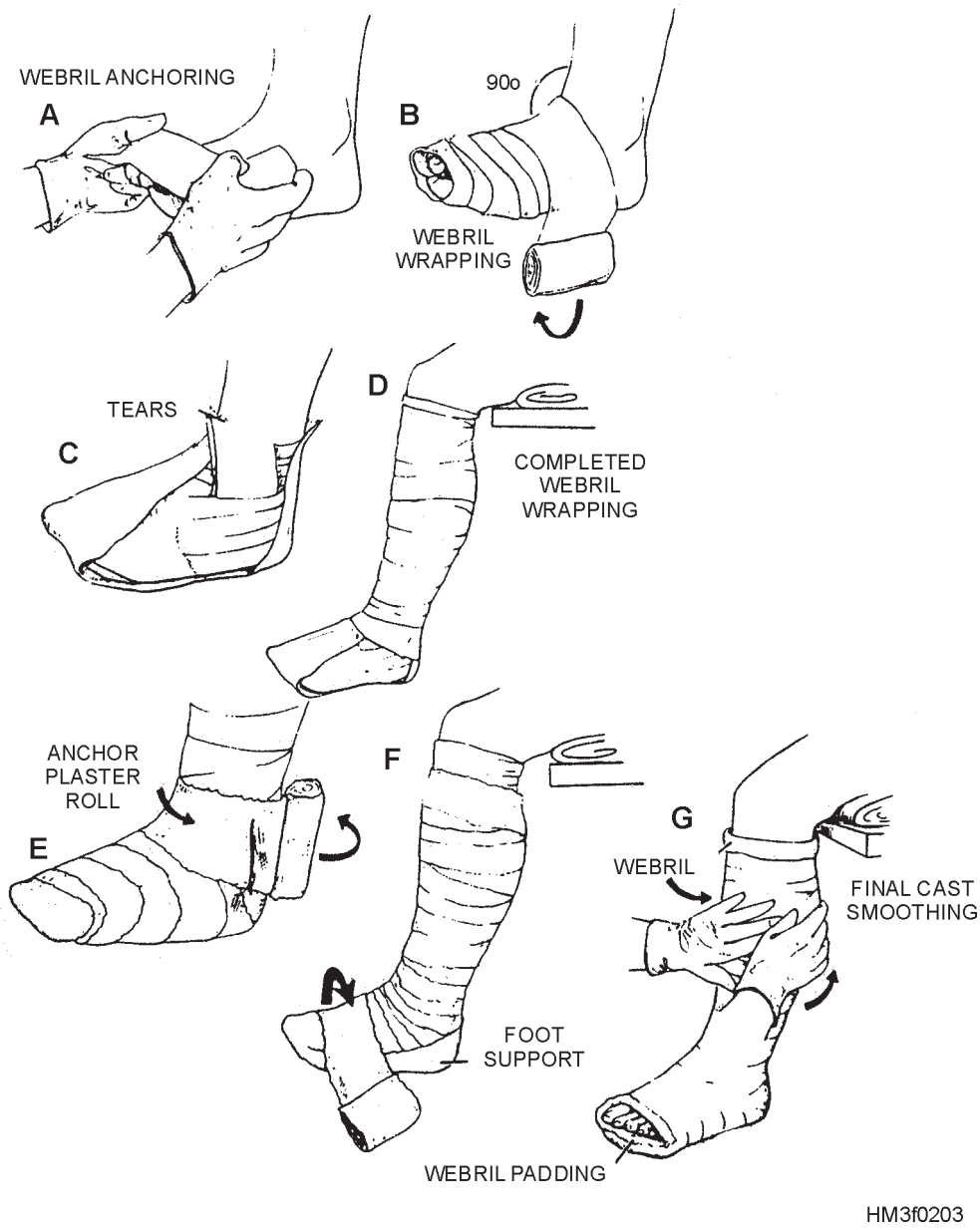


**Figure 2–3.—Applying a short leg cast.**

wrinkles. Apply the plaster beginning at the toes (fig. 2–3E), using the same technique of tucks and folds and smoothing as for the short arm cast. Before applying the last layer, expose the toes and fold back the webril. As the final step, apply a footplate to the plantar surface of the cast, using a generous thickness of plaster splints secured with one or two rolls of plaster (fig. 2–3F). This area provides support to the cast and a weight-bearing surface when used with a walking boot.

Whenever a cast is applied, you must give the patient written and verbal instruction for cast care and circulation checks (i.e., numbness, cyanosis, tingling of extremities). Instruct the patient to return immediately should any of these conditions occur. When a leg cast is applied, the patient must also receive instructions in the proper use of crutches. The cast will take 24 to 48 hours to completely dry, and it must be treated gently during this time. Since plaster is water-soluble, the cast must be protected with a waterproof covering when bathing or during wet weather. Nothing must be inserted down the cast (e.g., coat hangers) since this action can cause bunching of the padding and result in pressure sores. If swelling occurs, the cast may be split and wrapped with an elastic wrap to alleviate pressure.

### Cast Removal

A cast can be removed in two ways: by soaking in warm vinegar-water solution until it dissolves, or by

cutting. To remove by cutting, cast cutters, spreaders, and bandage scissors are necessary. Cuts are made laterally and medially along the long axis of the cast, then widened with the use of spreaders. The padding is then cut with the scissors.

## THE TERMINALLY ILL PATIENT

**LEARNING OBJECTIVE:** *Evaluate the needs of the terminally ill patient.*

The terminally ill patient has many needs that are basically the same as those of other patients: spiritual, psychological, cultural, economic, and physical. What differs in these patients may be best expressed as the urgency to resolve the majority of these needs within a limited time frame. Death comes to everyone in different ways and at different times. For some patients, death is sudden following an acute illness. For others, death follows a lengthy illness. Death not only affects the individual patient; it also affects family and friends, staff, and even other patients. Because of this, it is essential that all healthcare providers understand the process of dying and its possible effects on people.

### Individual's Perspective on Death

People view death from their individual and cultural value perspectives. Many people find the courage and strength to face death through their religious beliefs. These patients and their families often seek support from representatives of their religious faith. In many cases, patients who previously could not identify with a religious belief or the concept of a Supreme Being may indicate (verbally or nonverbally) a desire to speak with a spiritual representative. There will also be patients who, through the whole dying experience, will neither desire nor need spiritual support and assistance. In all these cases, it is the responsibility of the healthcare provider to be attentive and perceptive to the patient's needs and to provide whatever support personnel the patient may require.

### Cultural Influences

An individual's cultural system influences behavior patterns. When we speak of cultural systems, we refer to certain norms, values, and action patterns of specific groups of people to various aspects of life. Dying is an aspect of life, and it is often referred to as the final crisis of living. In all of our actions, culturally approved roles frequently encourage specific behavior responses. For example, in the Caucasian, Anglo-European culture, a dying patient is expected to show peaceful acceptance of the prognosis; the bereaved is expected to communicate grief. When people behave differently, the healthcare provider frequently has difficulty responding appropriately.

### Five Stages of Death

A theory of death and dying has developed that provides highly meaningful knowledge and skills to all persons involved with the experience. In this theory of death and dying (as formulated by Dr. Elizabeth Kubler-Ross in her book *On Death and Dying*), it is suggested that most people (both patients and significant others) go through five stages: **denial**, **anger**, **bargaining**, **depression**, and **acceptance**.

The first stage, **denial**, is one of nonacceptance. "No, it can't be me! There must be a mistake!" It is not only important for the healthcare provider to recognize the denial stage with its behavior responses, but also to realize that some people maintain denial up to the point of impending death. The next stage is **anger**. This is a period of hostility and questioning: "Why me?" The third stage is **bargaining**. At this point, people revert to a culturally reinforced concept that good behavior is rewarded. Patients are often heard stating, "I'd do anything if I could just turn this thing around." Once patients realize that bargaining is futile, they quickly enter into the stage of **depression**. In addition to grieving because of their personal loss, it is at this point that patients become concerned about their family and "putting affairs in order." The final stage comes when the patient finally **accepts** death and is prepared for it. It is usually at this time that the patient's family requires more support than the patient. It is important to remember that one or more stages may be skipped, and that the last stage may never be reached.

### Support for the Dying

Despite the fact that we all realize our mortality, there is no easy way to discuss death. To the strong and healthy, death is a frightening thought. The fact that sooner or later everyone dies does not make death easier. There are no procedure books that tell healthcare providers "how to do" death. The "how to" will only come from the individual healthcare provider who understands that patients are people, and that, more than any other time in life, the dying patient needs to be treated as an individual person.

An element of uncertainty and helplessness is almost always present when death occurs. Assessment and respect for the patient's individual and cultural value system are of key importance in planning the care of the dying. As healthcare personnel, we often approach a dying patient with some feelings of uncertainty, helplessness, and anxiety. We feel helpless in being unable to perform tasks that will keep the patient alive, uncertain that we are doing all that we can do to either make the patient as comfortable as possible or to postpone or prevent death altogether. We feel anxious about how to communicate effectively with patients, their family, or even among ourselves. This is a normal response since any discussion about death carries a high emotional risk for the patient as well as the healthcare provider. Nevertheless, communicating can provide both strength and comfort to all if done with sensitivity and dignity, and it is sensitivity and dignity that is the essence of all healthcare services.

## PATIENT SAFETY

**LEARNING OBJECTIVE:** *Identify patient safety concerns in a medical treatment facility.*

The primary goal of the healthcare provider is maintaining, sustaining, restoring, and rehabilitating a physical or psychological function of the patient. To achieve this goal, healthcare facilities and providers are charged with developing policies and implementing mechanisms that ensure safe, efficient, and therapeutically effective care. The theme of this discussion is safety and will address the major aspects of both environmental and personal safety.

### ENVIRONMENTAL SAFETY

For purposes of this discussion, the environment is defined as the physical surroundings of the patient and includes such things as lighting, equipment, supplies, chemicals, architectural structure, and the activities of both patient and staff personnel. Maintaining safety becomes even more difficult when working with people who are ill or anxious and who cannot exercise their usual control over their environment. Loss of strength, decreased sensory input, and disability often accompany illness. Because of this, you must be constantly alert and responsive to maintaining a safe environment.

Both JCAHO and the National Safety Council of the American Hospital Association (AHA) have identified four major types of accidents that continually occur to patients. These hazards consist of falls, electrical shocks, physical and chemical burns, and fire and explosions.

#### Patient Fall Precautions

The most basic of hospital equipment, the patient's bed, is a common cause of falls. Falls occur among oriented patients getting in and out of bed at night in situations where there is inadequate lighting. Falls occur among disoriented or confused bed patients when bedrails are not used or are used improperly. Slippery or cluttered floors contribute to patient, staff, and even visitor falls. Patients with physical limitations or patients being treated with sensory-altering medications fall when attempting to ambulate without proper assistance. Falls result from running in passageways, carelessness when going around blind corners, and collisions between personnel and equipment. Unattended and improperly secured patients fall from gurneys and wheelchairs.

Healthcare personnel can do much to prevent the incidence of falls by following some simple procedures. These preventive measures include properly using side rails on beds, gurneys, and cribs; locking the wheels of gurneys and wheelchairs when transferring patients; and not leaving patients unattended. Safety straps must also be used to secure patients on gurneys or in wheelchairs. Maintaining dry and uncluttered floors markedly reduces the number of accidental falls. Patients with physical or sensory deficiencies should always be assisted during ambulation. Patients using crutches, canes, or walkers must receive adequate instructions in the proper use of these aids before being permitted to ambulate independently. The total care environment must be equipped with adequate night lights to assist orientation and to prevent falls resulting from an inability to see.

#### Electrical Safety Precautions

The expanded variety, quantity, and complexity of electrical and electronic equipment used for diagnostic and therapeutic care has markedly increased the hazards of burns, shock, explosions, and fire. It is imperative that healthcare providers at all levels be alert to such hazards and maintain an electrically safe environment. Knowledge and adherence to the

following guidelines will contribute significantly to providing an electrically safe environment for all personnel, whether they be patients, staff, or visitors.

- Do not use electrical equipment with damaged plugs or cords.
- Do not attempt to repair defective equipment.
- Do not use electrical equipment unless it is properly grounded with a three-wire cord and three-prong plug.
- Do not use extension cords or plug adapters unless approved by the Medical Repair Department or the safety officer.
- Do not create a trip hazard by passing electrical cords across doorways or walkways.
- Do not remove a plug from the receptacle by gripping the cord.
- Do not allow the use of personal electrical appliances without the approval of the safety officer.
- Do not put water on an electrical fire.
- Do not work with electrical equipment with wet hands or feet.
- Have newly purchased electronic medical equipment tested for electrical safety by Medical Repair before putting it into service.
- Operate all electrical and electronic equipment according to manufacturer's instructions.
- Remove from service electrical equipment that sparks, smokes, or gives a slight shock. Tag defective equipment and expedite repair.
- Be aware that patients with intravenous therapy and electronic monitoring equipment are at high risk from electrical shocks.
- Call Medical Repair when equipment is not functioning properly or Public Works if there is difficulty with the power distribution system.

Since accidents resulting in physical and chemical burns have initiated numerous consumer claims of healthcare provider and facility malpractice, all healthcare personnel must be thoroughly indoctrinated in the proper use of equipment, supplies, and chemicals.

**Physical and Chemical Burn Precautions**

The following discussion will address common causes and precautions to be taken to eliminate the occurrence of burn injuries.

**HOT WATER BOTTLES**.—A common cause of burns—particularly in the elderly, diabetics, and patients with circulatory impairments—is the hot water bottle. When you are filling the bottle, the water temperature must never exceed 125°F (51°C). Test the bottle for leaks and cover it so that there is a protective layer of cloth between the patient and the bottle itself.

**HEATING PADS.**—Heating pads present a dual hazard of potential burns and electrical shock. The precautions that should be taken when using heating pads are the same ones that should be used for hot water bottles: temperature control and protective cloth padding. Precautions you should observe to avoid shock include properly maintaining the equipment; conducting preuse inspections; testing the equipment for wiring and plug defects; and ensuring periodic safety inspections are conducted by Medical Repair personnel.

**ICE BAGS OR COLD PACKS**.—Like hot water bottles, ice bags and cold packs (packaged chemical coolant) can cause skin-contact burns. This kind of burn is commonly referred to as local frostbite. The precautions taken for applying ice bags and cold baths are the same as those for hot water bottles with regard to attention to elderly, diabetic, and patients with circulatory impairments.

**HYPOTHERMIA BLANKETS**.—Like ice bags, hypothermia blankets can also cause contact burns. When using hypothermia blankets, check the patient's skin frequently for signs of marked discoloration (indicating indirect localized tissue damage). Ensure that the bare blanket does not come in direct contact with the patient's unprotected skin. This precaution is easily accomplished by using sheets or cotton blankets between the patient and the hypothermia blanket itself. When using this form of therapy, follow both the physician's orders and the manufacturer's instructions in managing the temperature control of the equipment.

**HEAT (BED) CRADLE**.—When using the heat (bed) cradle, protect the patient from burns resulting from overexposure or placement of the equipment too close to the area of the patient being treated. As with heating pads, heat cradles present the dual hazard of

potential burns and electrical shock. Another hazard to keep in mind is that of fire. Ensure that the bedding and the heat source do not come in direct contact and cause the bedding to ignite. Occasionally, heat lamps are used to accomplish the same results as a heat cradle. Do not use towels, pillow cases, or linen of any kind to drape over heat lamps. In fact, no lamps of any kind should be draped with any kind of material, regardless of the purpose of the draping.

**STEAM VAPORIZERS AND HOT FOODS AND LIQUIDS**.—Steam vaporizers and hot foods and liquids are common causes of patient burns. When using steam vaporizers, ensure that the vapor of steam does not flow directly on the patient as a result of the initial positioning of the equipment or by accidental movement or bumping. Patients sensitive to hot foods and liquids are more likely burned. Also, because of lack of coordination, weakness, or medication, patients may be less able to handle hot foods and liquids safely without spilling them.

In the direct patient care units as well as in diagnostic and treatment areas, there is unlimited potential for inflicting burns on patients. When the modern electrical and electronic equipment and the potent chemicals used for diagnosis and treatment are used properly, they contribute to the patient's recovery and rehabilitation. When they are used carelessly or improperly, these same sources may cause patients additional pain and discomfort, serious illness, and, in some cases, death.

### Fire and Explosion Precautions

Often when we speak of safety measures, one of our first thoughts is of a fire or an explosion involving the loss of life or injury to a number of people. Good housekeeping, maintenance, and discipline help prevent such mishaps. Remember that buildings constructed of fire-resistant materials may not be fireproof, and they are certainly not explosion proof. Good maintenance includes checking, reporting, and ensuring correct repair of electrical equipment, and routine checking of fire fighting equipment by qualified personnel. The education and training of personnel are the most effective means of preventing fires. Used in the context of fire safety measures, good discipline means developing a fire plan to use as outlined in a fire bill, having periodic fire drills, and enforcing no-smoking regulations.

**FIRE EVACUATION PROCEDURES**.—Staff members should be familiar with the fire regulations at their duty station and know what to do in case of fire. Staff should know how to report a fire, use a fire extinguisher, and evacuate patients. When a fire occurs, there are certain basic rules to follow: The senior person should take charge and appoint someone to notify the fire department and the officer of the day of the exact location of the fire. Everyone should remain calm. All oxygen equipment and electrical appliances must be turned off unless such equipment is necessary to sustain life. All windows and doors should be closed and all possible exits cleared. When necessary and directed by proper authority, patients should be removed in a calm and orderly fashion and mustered outside.

**SMOKING REGULATIONS**.—By regulation (BUMEDINST 6200.12, *Tobacco Use in Navy Medical Department Activities*), smoking is no longer permitted in Navy hospitals. To ensure general safety and awareness of this prohibition, inform patients, visitors, and staff of the facility's no-smoking status by prominently displaying "No Smoking" signs throughout the hospital—especially in rooms and areas where oxygen and flammable agents are used and stored.

### Safety Precautions in the Operating Room

Since safety practices are important to emphasize, this section will cover some of the situations that are potentially hazardous in the operating room and discuss what might be done to eliminate the hazard.

All personnel should know the location of all emergency medications and equipment in the operating room. This includes drugs, cardiac arrest equipment, and resuscitators. All electrical equipment and plugs must be of the explosion-proof type and bear a label stating such. There should be written schedules of inspections and maintenance of all electrical equipment. Navy regulations prohibit the use of explosive anesthetics in the operating room. These regulations, however, do not mean we can lessen our concern for fire and explosion hazards. The surface of all floors in the operating room must provide a path of electrical conductivity between all persons and equipment making contact with the floor to prevent the accumulation of dangerous electrostatic charges. All furniture and equipment should be constructed of metal or of other electrically conductive material and should be equipped with conductive leg tips, casters, or equivalent devices. Periodic inspections should be made of leg tips, tires, casters, or other conductive

devices of furniture and equipment. These inspections will ensure that they are maintained free of wax, lint, or other foreign material that may insulate them and defeat the purpose for which they are used. Excess lubrication of casters should be avoided to prevent accumulation of oil on conductive wheels. Dry graphite and graphite oil are the preferred lubricants.

Rubber accessories for anesthesia machines should be of the conductive type, plainly labeled as such, and routinely tested to ensure that conductivity is maintained. It is essential that all replacement items be of conductive material.

All personnel entering the operating room should be in electrical contact with the conductive floor by wearing conductive footwear or an alternative method of providing a path of conductivity. Conductive footwear and other personnel-to-floor conductive equipment should be tested on a regularly scheduled basis.

All apparel worn in the operating room should be made of a nonstatic-producing material. Fabrics of 100 percent cotton are the most acceptable. Fabrics made of synthetic blends may be used only if they have been treated by the manufacturer for use in the operating room. Wool blankets and apparel made of untreated synthetic fabrics are not permitted in the operating room.

Operating rooms must have adequate air-conditioning equipment to maintain relative humidity and temperature within a constant range. The relative humidity should be kept at 55 to 60 percent. This level will reduce the possibility of electrostatic discharge and possible explosion of combustible gases. The temperature should be chosen on the basis of the well-being of the patient. The recommended temperature is between 65° and 74°F. The control of bacteria carried on dust particles is facilitated when the recommended humidity and temperature are maintained.

All oxygen cylinders in use or in storage will be tagged with DD Form 1191, Warning Tag for Medical Oxygen Equipment, and measures will be taken to ensure compliance with instructions 1 through 7 printed on the form. An additional tag is required on all cylinders to indicate "EMPTY," "IN USE," or "FULL." Safety precautions should be conspicuously posted in all areas in which oxygen cylinders are stored and in which oxygen therapy is being administered. This posting should be made so it will immediately make all personnel aware of the precautionary measures required in the area.

All electrical service equipment, switchboards, or panelboards should be installed in a nonhazardous location. Devices or apparatus that tend to create an arc, sparks, or high temperatures must not be installed in hazardous locations unless these devices are in compliance with the National Electrical Code. Lamps in a fixed position will be enclosed and will be properly protected by substantial metal guards or other means where exposed to breakage. Cords for portable lamps or portable electrical appliances must be continuous and without switches from the appliance to the attachment plug. Such cords must contain an insulated conductor to form a grounding connection between the electrical outlet and the appliance.

## GENERAL SAFETY

In addition to the specifics presented earlier, some other basic principles are relevant to patient safety. They are:

- Ensure your patients are familiar with their environment, thus making it less hazardous to them. This familiarization can be accomplished in many ways, such as by showing your patients the floor plan of the ward they have been admitted to and by indicating key areas (lounge, bathrooms, nursing station, etc.) that may be of interest to them.

- Be aware of patient sensory impairment and incorporate precautionary procedures into their patient-care plan. For example, this principle can be applied to patients who have been given a pain medication, such as morphine or Demerol®. Medications such as these dull body senses. If a patient in this condition wishes to walk around, precautionary actions dictate that you either be close at hand to prevent the patient from accidental falls or that you do not permit the patient to ambulate until the effects of the medication have stopped.

- Understand that all diagnostic and therapeutic measures have the potential to cause a patient harm.

- Ensure that all accidents and incidents are documented and analyzed to identify and correct high-risk safety hazards.

## ENVIRONMENTAL HYGIENE

**LEARNING OBJECTIVE:** *Identify environmental hygiene concerns in a medical treatment facility.*

Today's public is very much aware of the environment and its effect on the health and comfort of human beings. The healthcare setting is a unique environment and has a distinct character of its own. You need to be aware of that character and ensure that the environment will support the optimum in health maintenance, care, and rehabilitation.

In the context of the environment, hygiene may best be described as practices that provide a healthy environment. Basically, environmental hygiene practices include the following three areas of concern: safety (which has already been addressed); environmental comfort and stimuli; and, finally, infection control (which will be discussed briefly here, but in greater detail later in this chapter under "Medical Asepsis"). You have certain responsibilities for helping to control the facility's general environment as well as the patient's immediate surroundings.

### CONCURRENT AND TERMINAL CLEANING

Maintaining cleanliness is a major responsibility of all members of the healthcare team, regardless of their position on the team. Cleanliness not only provides for patient comfort and a positive stimulus, it also impacts on infection control. The Hospital Corpsman is often directly responsible for the maintenance of patient care areas. The management of cleanliness in patient care areas is conducted concurrently and terminally. **Concurrent cleaning** is the disinfection and sterilization of patient supplies and equipment during hospitalization. **Terminal cleaning** is the disinfection and sterilization of patient supplies and equipment after the patient is discharged from the unit or hospital. Both concurrent and terminal cleaning are extremely important procedures that not only aid the patient's comfort and psychological outlook, but also contribute to both efficient physical care and control of the complications of illness and injury.

### AESTHETICS

Aesthetically, an uncluttered look is far more appealing to the eye than an untidy one. Other environmental factors,such as color and noise, can also enhance or hinder the progress of a person's physical condition. In the past, almost all healthcare facilities used white as a basic color for walls and bedside equipment. However, research has shown that the use of color is calming and restful to the patient, and, as has been previously stated, rest is a very important healing agent in any kind of illness. Noise control is another environmental element that requires your attention. The large number of people and the amount of equipment traffic in a facility serve to create a high noise level that must be monitored. Add to that the noise of multiple radios and televisions, and it is understandable why noise control is necessary if a healing environment is to be created and maintained.

### CLIMATE CONTROL

Another important aspect of environmental hygiene is climate control. Many facilities use air conditioning or similar control systems to maintain proper ventilation, humidity, and temperature control. In facilities without air conditioning, windows should be opened from the top and bottom to provide for cross-ventilation. Ensure that patients are not located in a drafty area. Window sill deflectors or patient screens are often used to redirect drafty airflows. Maintain facility temperatures at recommended energy-conservation levels that are also acceptable as health-promoting temperatures. In addition to maintaining a healthy climate, good ventilation is necessary in controlling and eliminating disagreeable odors. In cases where airflow does not control odors, room fresheners should be discretely used. Offensive, odor-producing articles (such as soiled dressings, used bedpans, and urinals) should be removed to appropriate disposal and disinfecting areas as rapidly as possible. Objectionable odors (such as bad breath or perspiration of patients) are best controlled by proper personal hygiene and clean clothing.

### LIGHTING

Natural light is important in the care of the sick. Sunlight usually brightens the area and helps to improve the mental well-being of the patient. However, light can be a source of irritation if it shines directly in the patient's eyes or produces a glare from the furniture, linen, or walls. Adjust shades or blinds

for the patient's comfort. Artificial light should be strong enough to prevent eyestrain and diffuse enough to prevent glare. Whenever possible, provide a bed lamp for the patient. As discussed earlier under "Safety Aspect," a dim light is valuable as a comfort and safety measure at night. This light should be situated so it will not shine in the patient's eyes and yet provide sufficient light along the floor so that all obstructions can be seen. A night light may help orient elderly patients if they are confused as to their surroundings upon awakening.

In conclusion, it is important that you understand the effects of the environment on patients. People are more sensitive to excessive stimuli in the environment when they are ill, and they often become irritable and unable to cooperate in their care because of these excesses. This is particularly apparent in critical care areas (e.g., in CCUs and ICUs) and isolation, terminal, and geriatric units. You must realize and respond to the vital importance of the environment in the total medical management plan of your patients.

## PATHOGENIC ORGANISM CONTROL

**LEARNING OBJECTIVE:** *Recall medical asepsis principles and recognize medical asepsis practices.*

All health care, regardless of who provides it or where it is provided, must be directed toward maintaining, promoting, and restoring health. Because of this goal, all persons seeking assistance in a healthcare facility must be protected from additional injury, disease, or infection. Adherence to good safety principles and practices protects a patient from personal injury. Additionally, attention to personal and environmental hygiene not only protects against further injury, but also constitutes the first step in controlling the presence, growth, and spread of pathogenic organisms. The discussion that follows addresses infection control, particularly in the context of medical and surgical aseptic practices.

### MEDICAL ASEPSIS

Medical asepsis is the term used to describe those practices used to prevent the transfer of pathogenic organisms from person to person, place to place, or person to place. Medical aseptic practices are routinely used in direct patient care areas, as well as in other service areas in the healthcare environment, to interrupt a chain of events necessary for the continuation of an infectious process. The components of this chain of events consist of the elements defined below.

#### Infectious Agent

An infectious agent is an organism that is capable of producing an infection or infectious disease.

#### Reservoir of Infectious Agents

A reservoir of infectious agents is the carrier on which the infectious agent primarily depends for survival. The agent lives, multiplies, and reproduces so that it can be transferred to a susceptible host. Reservoirs of infectious agents could be man, animal, plants, or soil. Man himself is the most frequent reservoir of infectious agents pathogenic to man.

**PORTAL OF EXIT**.—The portal of exit is the avenue by which the infectious agent leaves its reservoir. When the reservoir is man, these avenues include various body systems (such as respiratory, intestinal, and genitourinary tracts) and open lesions.

**MODE OF TRANSMISSION**.—The mode of transmission is the mechanism by which the infectious agent is transmitted from its reservoir to a susceptible being (host). Air, water, food, dust, dirt, insects, inanimate objects, and other persons are examples of modes of transmission.

**PORTAL OF ENTRY**.—The portal of entry is the avenue by which the infectious agent enters the susceptible host. In man, these portals correspond to the exit route avenues, including the respiratory and gastrointestinal tracts, through a break in the skin, or by direct infection of the mucous membrane.

**SUSCEPTIBLE HOST**.—The susceptible host is man or another living organism that affords an infectious agent nourishment or protection to survive and multiply.

Removal or control of any one component in the above chain of events will control the infectious process.

#### Two Basic Medical Asepsis Practices

The two basic medical asepsis practices that are absolutely essential in preventing and controlling the spread of infection and transmittable diseases are

frequent hand washing and proper linen-handling procedures.

**HAND WASHING**.—The following are some common instances when provider hand washing is imperative:

- Before and after each patient contact
- Before handling food and medications
- After coughing, sneezing, or blowing your nose
- After using the toilet

**LINEN HANDLING**.—Improper handling of linen results in the transfer of pathogenic organisms through direct contact with the healthcare provider's clothing and subsequent contact with the patient, patient-care items, or other materials in the care environment. Proper linen handling is such an elementary procedure that, in theory, it seems almost unnecessary to mention. However, it is a procedure so frequently ignored that emphasis is justified.

All linen, whether clean or used, must never be held against one's clothing or placed on the floor. The floors of a healthcare facility are considered to be grossly contaminated, and, thus, any article coming in contact with the floor will also be contaminated. Place all dirty linen in appropriate laundry bags. Linen from patients having infectious or communicable diseases must be handled in a special manner.

### Isolation Technique

Isolation technique, a medical aseptic practice, inhibits the spread and transfer of pathogenic organisms by limiting the contacts of the patient and creating some kind of physical barrier between the patient and others. Isolation precautions in hospitals must meet the following objectives. They must

- be epidemiologically sound;
- recognize the importance that body fluids, secretions, and excretions may have in the transmission of nosocomial (hospital originating) pathogens;
- contain adequate precautions for infections transmitted by airborne droplets and other routes of transmission; and
- be as simple and as patient friendly as possible.

In isolation techniques, disinfection procedures are employed to control contaminated items and areas. For purposes of this discussion, disinfection is described as the killing of certain infectious (pathogenic) agents outside the body by a physical or chemical means. Isolation techniques employ two kinds of disinfection practices, concurrent and terminal.

**CONCURRENT DISINFECTION**.— Concurrent disinfection consists of the daily measures taken to control the spread of pathogenic organisms while the patient is still considered infectious.

**TERMINAL DISINFECTION**.—Terminal disinfection consists of those measures taken to destroy pathogenic organisms remaining after the patient is discharged from isolation. There are a variety of chemical and physical means used to disinfect supplies, equipment, and environmental areas, and each facility will determine its own protocols based on the recommendation of an Infection Control Committee.

## SURGICAL ASEPTIC TECHNIQUE

**LEARNING OBJECTIVE:** *Recall the principles and guidelines for surgical aseptic technique, and determine the correct sterilization process for different types of materials.*

As used in this discussion, surgical aseptic technique is the term used to describe the sterilization, storage, and handling of articles to keep them free of pathogenic organisms. The following discussion will address the preparation and sterilization of surgical equipment and supplies, and the preparation of the operating room for performing a surgical procedure. It should be noted that specific methods of preparation will vary from place to place, but the basic principles of surgical aseptic technique will remain the same. This discussion will present general guidelines, and individual providers are advised to refer to local instructions regarding the particular routines of a specific facility.

**Before an operation**, it is necessary to sterilize and keep sterile all instruments, materials, and supplies that come in contact with the surgical site. Every item handled by the surgeon and the surgeon's assistants must be sterile. The patient's skin and the hands of the members of the surgical team must be thoroughly scrubbed, prepared, and kept as aseptic as possible.

**During the operation**, the surgeon, surgeon's assistants, and the scrub corpsman must wear sterile gowns and gloves and must not touch anything that is not sterile. Maintaining sterile technique is a cooperative responsibility of the entire surgical team. Each member must develop a surgical conscience, a willingness to supervise and be supervised by others regarding the adherence to standards. Without this cooperative and vigilant effort, a break in sterile technique may go unnoticed or not be corrected, and an otherwise successful surgical procedure may result in complete failure.

**Basic Guidelines**

To assist in maintaining the aseptic technique, all members of the surgical team must adhere to the following principles:

- All personnel assigned to the operating room must practice good personal hygiene. This includes daily bathing and clothing change.
- Those personnel having colds, sore throats, open sores, and/or other infections should not be permitted in the operating room.
- Operating room attire (which includes scrub suits, gowns, head coverings, and face masks) should not be worn outside the operating room suite. If such occurs, change all attire before re-entering the clean area. (The operating room and adjacent supporting areas are classified as "clean areas.")
- All members of the surgical team having direct contact with the surgical site must perform the surgical hand scrub before the operation.
- All materials and instruments used in contact with the site must be sterile.
- The gowns worn by surgeons and scrub corpsmen are considered sterile from shoulder to waist (in the front only), including the gown sleeves.
- If sterile surgical gloves are torn, punctured, or have touched an unsterile surface or item, they are considered contaminated.
- The safest, most practical method of sterilization for most articles is steam under pressure.
- Label all prepared, packaged, and sterilized items with an expiration date.
- Use articles packaged and sterilized in cotton muslin wrappers within 28 calendar days.
- Use articles sterilized in cotton muslin wrappers and sealed in plastic within 180 calendar days.
- Unsterile articles must not come in contact with sterile articles.
- Make sure the patient's skin is as clean as possible before a surgical procedure.
- Take every precaution to prevent contamination of sterile areas or supplies by airborne organisms.

**Methods of Sterilization**

Sterilization refers to the complete destruction of all living organisms, including bacterial spores and viruses. The word "sterile" means free from or the absence of all living organisms. Any item to be sterilized must be thoroughly cleaned mechanically or by hand, using soap or detergent and water. When cleaning by hand, apply friction to the item using a brush. After cleaning, thoroughly rinse the item with clean, running water before sterilization. The appropriate sterilization method is determined according to how the item will be used, the material from which the item is made, and the sterilization methods available. The physical methods of sterilization are moist heat and dry heat. Chemical methods include gas and liquid solutions.

**PHYSICAL METHODS**.—Steam under pressure (autoclave) is the most dependable and economical method of sterilization. It is the method of choice for metalware, glassware, most rubber goods, and dry goods. All articles must be correctly wrapped or packaged so that the steam will come in contact with all surfaces of the article. Similar items should be sterilized together, especially those requiring the same time and temperature exposure. Articles that will collect water must be placed so that the water will drain out of the article during the sterilization cycle. A sterilizer should be loaded in a manner that will allow the free flow of steam in and around all articles. Each item sterilized must be dated with the expiration of sterility. Sterilization indicators must be used in each load that is put through the sterilization process. This verifies proper steam and temperature penetration.

The operating procedures for a steam sterilizer will vary according to the type and manufacturer. There are a number of manufacturers, but there are only two types of steam-under-pressure sterilizers. They are the

**downward displacement** and the **prevacuum, high-temperature** autoclaves.

**Downward Displacement Autoclave**.—In the downward (gravity) displacement autoclave, air in the chamber is forced downward from the top of the chamber. The temperature in the sterilizer gradually increases as the steam heats the chamber and its contents. The actual timing does not begin until the temperature is above 245°F (118°C).

**Prevacuum, High-temperature Autoclave**.—The prevacuum, high-temperature autoclave is the most modern and economical to operate and requires the least time to sterilize a single load. By use of a vacuum pump, air is extracted from the chamber before admitting steam. This prevacuum process permits instant steam penetration to all articles and through all cotton or linen dry goods. The sterilization time is reduced to 4 minutes. The temperature of the chamber is rapidly raised and held at 274°F (134°C). The cycle is timed automatically.

**Sterilizing Times**.—If the temperature is increased, the sterilization time may be decreased. The following are some practical sterilization time periods.

- 3 minutes at 270°F (132°C)
- 8 minutes at 257°F (125°C)
- 18 minutes at 245°F (118°C)

All operating rooms are equipped with high-speed (flash) sterilizers. Wrapped, covered, opened instruments placed in perforated trays are "flash" sterilized for 3 minutes at 270°F (132°C). Sterilization timing begins when the above temperature is reached, not before.

**Dry-Heat Sterilization**.—The use of dry heat as a sterilizing agent has limitations. It should be restricted to items that are unsuitable for exposure to moist heat. High temperatures and extended time periods are required when using dry heat. In most instances, this method often proves impractical. The temperature must be 320°F (160°C), and the time period must be at least 2 hours.

**CHEMICAL STERILIZATION**.—Only one liquid chemical, if properly used, is capable of rendering an item sterile. That chemical is **glutaraldehyde**. The item to be sterilized must be totally submerged in the glutaraldehyde solution for 10 hours. Before immersion, the item must be thoroughly cleansed and rinsed with sterile water or sterile normal saline. It should be noted that this chemical is extremely caustic to skin, mucous membranes, and other tissues.

The most effective method of gas chemical sterilization presently available is the use of **ethylene oxide (ETO) gas**. ETO gas sterilization should be used only for material and supplies that will not withstand sterilization by steam under pressure. Never gas-sterilize any item that can be steam-sterilized. The concentration of the gas and the temperature and humidity inside the sterilizer are vital factors that affect the gas-sterilization process.

ETO gas-sterilization periods range from 3 to 7 hours. All items gas-sterilized must be allowed an aeration (airing out) period. During this period, the ETO gas is expelled from the surface of the item. It is not practical here to present all exposure times, gas concentrations, and aeration times for various items to be gas-sterilized. When using an ETO gas-sterilizer, you must be extremely cautious and follow the manufacturer's instructions carefully.

### Preparation of Supplies for Autoclaving

Comply with the following guidelines in preparing supplies that are to be autoclaved.

- Inspect all articles to be sterilized, making sure they are clean, in good condition, and in working order.
- Wrap instruments and materials in double muslin wrappers or two layers of disposable sterilization wrappers.
- When muslin wrappers are routinely used, launder them after each use, and carefully inspect them for holes and tears before use.
- When articles are placed in glass or metal containers for autoclaving, place the lid of the container so the steam will penetrate the entire inside of the container.
- Arrange the contents of a linen pack in such a way that the articles on top are used first.
- Label every item that is packaged for sterilization to specify the contents and expiration date.
- Do not place surgical knife blades or suture materials inside linen packs or on instrument trays before sterilization.

The following are specific guidelines for sterilizing instruments, glassware, suture materials, and rubber latex materials.

**Instruments:**

- Wash each instrument after use with an antiseptic detergent solution. When washing by hand, pay particular attention to hinged parts and serrated surfaces. Rinse all instruments, and dry them thoroughly.
- Use an instrument washer/sterilizer, if available, to decontaminate instruments and utensils following each surgical procedure.
- Following cleaning and decontamination, leave hinged instruments unclasped and wrapped singly or placed on trays for resterilization.

**Glassware:**

- Inspect all reusable glassware for cracks or chips.
- Wash all reusable glassware with soap or detergent and water after use, and rinse it completely.
- When preparing reusable glass syringes

  —match numbers or syringe parts;

  —wrap each plunger and barrel separately in gauze; and

  —wrap each complete syringe in a double muslin wrapper.

- When glassware, tubes, medicine glasses, and beakers are part of a sterile tray, wrap each glass item in gauze before placing it on the tray.

**Suture Material:** Suture materials are available in two major categories: **absorbable** and **nonabsorbable**. Absorbable suture materials can be digested by the tissues during the healing process. Absorbable sutures are made from collagen (an animal protein derived from healthy animals) or from synthetic polymers. Nonabsorbable suture materials are those that effectively resist the enzymatic digestion process in living tissue. These sutures are made of metal or other inorganic materials. In both types, each strand of specifically sized suture material is uniform in diameter and is predictable in performance.

Modern manufacturing processes make all suture materials available in individual packages, presterilized, with or without a surgical needle attached. Once opened, **do not resterilize** either the individual package or an individual strand of suture material.

> **NOTE:** The only exception to this rule involves the use of surgical stainless steel. This material is often provided in unsterile packages or tubes. Individual strands or entire packages of surgical stainless steel must be sterilized before use.

**Rubber Latex Materials:**

- Wash rubber tubing in an antiseptic detergent solution.

  —Pay attention to the inside of the tubing. Rinse all tubing well and place it flat or loosely coiled in a wrapper or container.

  —When packing latex surgical drains for sterilization, place a piece of gauze in the lumen of the tray. **Never resterilize surgical drains.**

  —**Never resterilize rubber catheters bearing a disposable label.**

  —**Never resterilize surgeon's disposable (rubber) gloves.** These gloves are for one-time use only.

**Handling Sterile Articles**

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**LEARNING OBJECTIVE:** *Recall sterile article handling and surgical hand scrubbing techniques, donning procedure for gowning and gloving, and the steps to clean an operating/treatment room.*

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When you are changing a dressing, removing sutures, or preparing the patient for a surgical procedure, it will be necessary to establish a sterile field from which to work. The field should be established on a stable, clean, flat, dry surface. Wrappers from sterile articles may be used as a sterile field as long as the inside of the wrapper remains sterile. If the size of the wrapper does not provide a sufficient working space for the sterile field, use a sterile towel. Once established, only those persons who have donned sterile gloves should touch the sterile

field. Additionally, the following basic rules must be adhered to:

- An article is either sterile or unsterile; there is no in-between. If there is doubt about the sterility of an item, consider it unsterile.
- Any time the sterility of a field has been compromised, replace the contaminated field and setup.
- Do not open sterile articles until they are ready for use.
- Do not leave sterile articles unattended once they are opened and placed on a sterile field.
- Do not return sterile articles to a container once they have been removed from the container.
- Never reach over a sterile field.
- When pouring sterile solutions into sterile containers or basins, do not touch the sterile container with the solution bottle. Once opened and first poured, use bottles of liquid entirely. If any liquid is left in the bottle, discard it.
- Never use an outdated article. Unwrap it, inspect it, and, if reusable, rewrap it in a **new** wrapper for sterilization.

**Surgical Hand Scrub**

The purpose of the surgical hand scrub is to reduce resident and transient skin flora (bacteria) to a minimum. Resident bacteria are often the result of organisms present in the hospital environment. Because these bacteria are firmly attached to the skin, they are difficult to remove. However, their growth is inhibited by the antiseptic action of the scrub detergent used. Transient bacteria are usually acquired by direct contact and are loosely attached to the skin. These are easily removed by the friction created by the scrubbing procedure.

Proper hand scrubbing and the wearing of sterile gloves and a sterile gown provide the patient with the best possible barrier against pathogenic bacteria in the environment and against bacteria from the surgical team. The following steps comprise the generally accepted method for the surgical hand scrub.

1. Before beginning the hand scrub, don a surgical cap or hood that covers all hair, both head and facial, and a disposable mask covering your nose and mouth.
2. Using approximately 6 ml of antiseptic detergent and running water, lather your hands and arms to 2 inches above the elbow. Leave detergent on your arms and do not rinse.
3. Under running water, clean your fingernails and cuticles, using a nail cleaner.
4. Starting with your fingertips, rinse each hand and arm by passing them through the running water. Always keep your hands above the level of your elbows.
5. From a sterile container, take a sterile brush and dispense approximately 6 ml of antiseptic detergent onto the brush and begin scrubbing your hands and arms.
6. Begin with the fingertips. Bring your thumb and fingertips together and, using the brush, scrub across the fingertips using 30 strokes.
7. Now scrub all four surface planes of the thumb and all surfaces of each finger, including the webbed space between the fingers, using 20 strokes for each surface area.
8. Scrub the palm and back of the hand in a circular motion, using 20 strokes each.
9. Visually divide your forearm into two parts, lower and upper. Scrub all surfaces of each division 20 strokes each, beginning at the wrist and progressing to the elbow.
10. Scrub the elbow in a circular motion using 20 strokes.
11. Scrub in a circular motion all surfaces to approximately 2 inches above the elbow.
12. Do not rinse this arm when you have finished scrubbing. Rinse only the brush.
13. Pass the rinsed brush to the scrubbed hand and begin scrubbing your other hand and arm, using the same procedure outlined above.
14. Drop the brush into the sink when you are finished.
15. Rinse both hands and arms, keeping your hands above the level of your elbows, and allow water to drain off the elbows.
16. When rinsing, do not touch anything with your scrubbed hands and arms.
17. The total scrub procedure must include all anatomical surfaces from the fingertips to approximately 2 inches above the elbow.

18. Dry your hands with a sterile towel. Do not allow the towel to touch anything other than your scrubbed hands and arms.

19. Between operations, follow the same hand-scrub procedure.

**Gowning and Gloving**

If you are the scrub corpsman, you will have opened your sterile gown and glove packages in the operating room before beginning your hand scrub. Having completed the hand scrub, back through the door holding your hands up to avoid touching anything with your hands and arms. Gowning technique is shown in the steps of figure 2–4. Pick up the sterile towel that has been wrapped with your gown (touching only the towel) and proceed as follows:

1. Dry one hand and arm, starting with the hand and ending at the elbow, with one end of the towel. Dry the other hand and arm with the opposite end of the towel. Drop the towel.

2. Pick up the gown in such a manner that hands touch only the inside surface at the neck and shoulder seams.

3. Allow the gown to unfold downward in front of you.


**Figure 2–4.—Gowning.**

4. Locate the arm holes.

5. Place both hands in the sleeves.

6. Hold your arms out and slightly up as you slip your arms into the sleeves.

7. Another person (circulatory) who is not scrubbed will pull your gown onto you as you extend your hands through the gown cuffs.

Continue the process by opening the inner glove packet on the same sterile surface on which you opened the gown. The entire gloving process is shown in the steps of figure 2–5.

1. Pick up one glove by the cuff using your thumb and index finger.

2. Touching only the cuff, pull the glove onto one hand and anchor the cuff over your thumb.

3. Slip your gloved fingers under the cuff of the other glove. Pull the glove over your fingers and hand, using a stretching side-to-side motion.

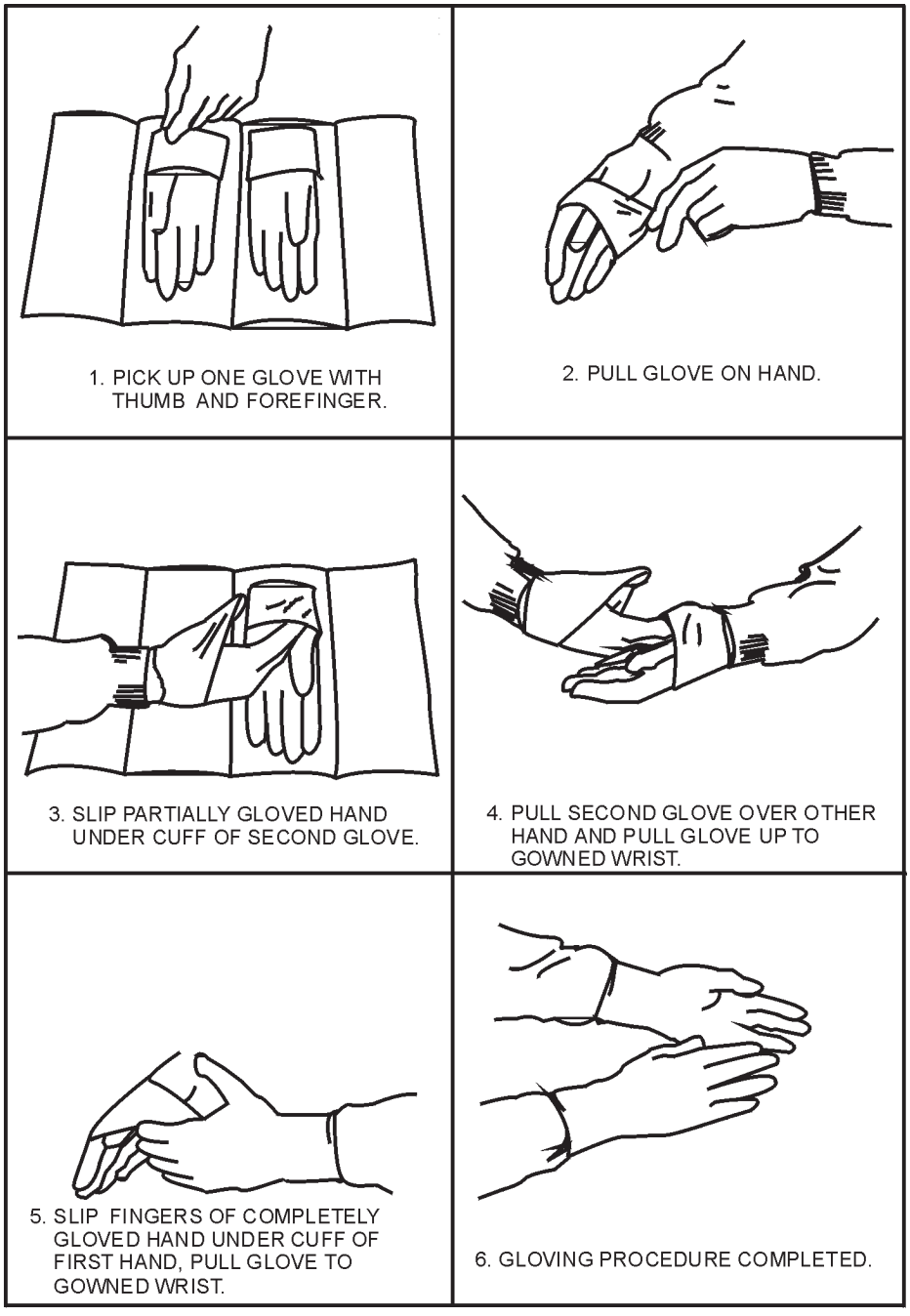


**Figure 2–5.—Gloving.**

4. Anchor the cuff on your thumb. With your fingers still under the cuff, pull the cuff up and away from your hand and over the knitted cuff of the gown.
5. Repeat the preceding step to glove your other hand.
6. The gloving process is complete.

To gown and glove the surgeon, follow these steps:

1. Pick up a gown from the sterile linen pack. Step back from the sterile field and let the gown unfold in front of you. Hold the gown at the shoulder seams with the gown sleeves facing you.
2. Offer the gown to the surgeon. Once the surgeon's arms are in the sleeves, let go of the gown. Be careful not to touch anything but the sterile gown. The circulator will tie the gown.
3. Pick up the right glove. With the thumb of the glove facing the surgeon, place your fingers and thumbs of both hands in the cuff of the glove and stretch it outward, making a circle of the cuff. Offer the glove to the surgeon. Be careful that the surgeon's bare hand does not touch your gloved hands.
4. Repeat the preceding step for the left glove.

**Cleaning the Operating/ Treatment Room**

Cleanliness in the operating room is an absolute must. Cleaning routines must be clearly understood and carefully followed. The cause of postoperative wound infections have, on occasion, been traced to the operating room. Since no two patients are alike and all patients have their own "resident" bacteria, every surgical case must be considered to be contaminated.

At the beginning of each day, all the fixtures, equipment, and furniture in each operating room will be damp-dusted with an antiseptic germicide solution. During the operation, keep the room clean and orderly at all times. Should sponges be dropped on the floor, or if blood or other body fluids spill, clean the area immediately using a disinfectant germicide solution and a clean cloth. Between operations, clean all used items. The area of the floor occupied by the surgical team must be cleaned using the wet vacuum method. If a wet vacuum is not available, mops may be used, but a clean mop head must be used following each operation. Gowns and gloves must be removed before leaving the room. All linens and surgical drapes must be bagged and removed from the room. All trash and disposable items must be bagged and taken from the room. All instruments must be washed by gloved hands or placed in perforated trays and put through a washer/sterilizer.

At the completion of the day's operations, each operating room should be terminally cleaned using an antiseptic germicide solution and the following tasks accomplished.

- Clean all wall- or ceiling-mounted equipment.
- Clean all spotlights and lights on tracks.
- Thoroughly scrub all furniture used in the room, including the wheels.
- Clean metal buckets and other waste receptacles and, if possible, put them through the washer/sterilizer.
- Clean scrub sinks.
- Machine scrub the entire floor in each room. If a machine is not available, use a large floor brush.
- Suction up the disinfectant germicide solution that is used on the floor, using a wet vacuum. If mops are used, make sure a clean mop head is used for each room.

**NOTE:** The use of mops in the operating room is the LEAST DESIRABLE method of cleaning.

## MANAGEMENT OF INFECTIOUS WASTE

**LEARNING OBJECTIVE:** *Identify medical waste sorting, packaging, handling, and disposal procedures.*

Concern about potentially adverse effects of infectious waste on public health and the environment has gained widespread media attention. While scientific evidence shows that infectious waste is no greater threat to the environment or public health than residential solid waste, medical facilities are perceived to be a source of pollution. It is, therefore, imperative that a medical facility establish an effective plan for dealing with infectious waste. This plan should include the segregation, packing and handling, storage, transportation, treatment, and disposal of such

debris. The management plan should establish recordkeeping systems and personnel training programs, and should incorporate the minimally acceptable management standards for Navy MTFs and DTFs (as contained in BUMEDINST 6280.1, *Management of Infectious Waste*).

## INFECTIOUS WASTE

Infectious waste is liquid or solid waste containing pathogens in sufficient numbers and of sufficient virulence to cause infectious disease in susceptible hosts exposed to the waste. Several examples are:

- sharps (needles, scalpel blades),
- microbiology waste (cultures, stocks containing microbes),
- pathological waste (human tissue, body parts),
- liquid waste (blood, cerebrospinal fluid), and
- medical waste from isolation rooms.

## TREATMENT AND DISPOSAL METHODS FOR INFECTIOUS WASTE

Several steps should be used in the treatment and disposal of infectious waste. These steps include the identification of waste; segregation, sorting, packaging,

**Table 2–2.—Treatment and Disposal Methods for Infectious Waste**

| Types of Infectious Waste | Methods of Treatment | Methods of Disposal |
|---|---|---|
| Microbiological | Steam sterilization [1]<br>Chemical disinfection [2]<br>Incineration [3] | Sanitary landfill |
| Pathological [5] | Incineration [3 & 4]<br>Cremation | Sanitary landfill<br>Burial [6] |
| Bulk blood and other potentially infectious liquids | Gelatinization [6] | Sanitary sewer [7]<br>Sanitary landfill [8] |
| Sharps in sharps containers | Steam sterilization<br>Incineration | Sanitary landfill<br>Sanitary landfill |

[1] For effective sterilization, the temperature must be maintained at 121° C (250° F) for at least 90 minutes, at 15 pounds per square inch of gauge pressure. *Bacillus stearothermophilus* spore strips must be used weekly to test the sterilization process.

[2] Chemical disinfection is most appropriate for liquids.

[3] Ash remaining after incineration may go directly to the sanitary landfill, unless state or local regulations require testing the ash for characteristics of hazardous waste.

[4] Disposal of placentas by grinding with subsequent discharge to a sanitary sewer is acceptable unless prohibited by county or local laws/regulations.

[5] Burial or cremation is acceptable.

[6] Must be further treated by steam sterilization or incineration.

[7] Discharge to a sanitary sewer is acceptable unless prohibited by county or local laws/regulations.

[8] Must be treated by steam sterilization or incineration before landfill disposal.

handling, transporting, and treating of waste; and, finally, disposal of the waste. The treatment and disposal methods shown in table 2–2 are the minimally acceptable standards.

## SUMMARY

This chapter has introduced you to many basic patient-care procedures and philosophies, such as patient rights and responsibilities, professional conduct, reporting and assessment procedures, patient education, and patient safety precautions. Additionally, you have learned about inpatient care and the various types of patients you will encounter as a Hospital Corpsman. Finally, you have been introduced to standard rules of hygiene, aseptic techniques, and the management of medical waste. Having a good grasp of these areas of patient care will give you a good base from which you can grow as a Hospital Corpsman.

# CHAPTER 3

# FIRST AID EQUIPMENT, SUPPLIES, RESCUE, AND TRANSPORTATION

This chapter will discuss first aid equipment and supplies, and the rescue and transportation of the injured patient. As a Hospital Corpsman, you will be expected to recognize the uses and application procedures for dressings and bandages, and to be able to identify the protective equipment needed in specific emergencies, along with where and when to use it.

In this chapter, you will learn the phases of a rescue operation and the stages of extrication. You will also learn the precautionary steps that must be taken in special rescue situations. You will learn to recognize the different patient-moving devices and lifting techniques. Additionally, this chapter will familiarize you with the various forms of emergency transportation, and you will learn to identify essential basic life support supplies on Navy ambulances. Finally, this chapter will give you the preparatory, en route, and turnover procedures for patients being transported to medical treatment facilities.

## FIRST AID EQUIPMENT AND SUPPLIES

**LEARNING OBJECTIVE:** *Identify initial equipment and supply needs.*

In a first aid situation, the Corpsman must always be ready to improvise. In many field emergency situations, standard medical supplies and equipment may not be immediately available, or they may run out. When medical supplies and equipment are available, they will probably be found in an ambulance or in the field medical Unit One Bag.

Navy ambulances are stocked in accordance with BUMEDINST 6700.42, *Ambulance Support*. Table 3-1 lists equipment currently required for EMT-Basic level ambulances. Table 3-2 lists the contents of an emergency bag that a Hospital Corpsman might find in an ambulance.

When assigned to Marine Corps Units, Hospital Corpsmen carry their medical equipment and supplies in a special bag. It is referred to as a "Unit One Bag." The Unit One Bag is made of nylon, weighs about 9 pounds, has an adjustable carrying strap, and contains four strong compartments. The contents of the Unit One Bag are listed below in table 3–3.

Unique operational requirements or command decisions may modify the make-up of these lists. As a Corpsman, it is up to you to be familiar with the emergency medical equipment at the command, since a call may come at a moment's notice and you may have to use these items to help save or sustain a life.

## DRESSINGS AND BANDAGES

**LEARNING OBJECTIVE:** *Recognize the uses and application procedures for dressings and bandages.*

There are many different types of dressings and bandages. You should be familiar with the various standard dressings and bandages, their respective functions, and their proper application in first-aid and emergency situations.

### DEFINITION OF A DRESSING

A dressing is a sterile pad or compress (usually made of gauze or cotton wrapped in gauze) used to cover wounds to control bleeding and/or prevent further contamination. Dressings should be large enough to cover the entire area of the wound and to extend at least 1" in every direction beyond the edges. If the dressing is not large enough, the edges of the wound are almost certain to become contaminated. Figure 3–1 shows several commonly used styles of dressings.

Any part of a dressing that is to come in direct contact with a wound should be absolutely sterile (that is, free from microorganisms). The dressings that you will find in first aid kits have been sterilized. However, if you touch them with your fingers, your clothes, or any other unsterile object, they are no longer sterile. If you drag a dressing across the victim's skin or allow it

**Table 3-1.—Essential Equipment for Ambulance ETM-Basic Level**

| ESSENTIAL EQUIPMENT FOR AMBULANCES<br>EMT-BASIC LEVEL | | |
|---|---|---|
| **General Category of Equipment** | **Detailed Breakdown** | **Comments** |
| Patient transfer litter | • Collapsible-wheeled litter | |
| Ventilation and airway equipment | • Portable suction apparatus | • Wide-bore tubing, rigid pharyngeal curved suction cup |
| | • Portable fixed oxygen equipment | • Variable flow regulator, humidifier (on fixed equipment) |
| | • Oxygen administration equipment | • Adequate length tubing, masks (adult, child, and infant sizes; transparent, non-rebreathing, venture and valveless nasal prongs) |
| | • Bag-valve mask | • Hand-operated, self-reexpanding bag (adult and infant sizes, ≥0.85), accumulator (Fi02, 0.9), clear mask (adult, child, and infant sizes), valve (clear, easily cleanable, operable in cold weather) |
| | • Airways | • Nasopharyngeal, oropharyngeal (adult, child, and infant sizes) |
| | • Respirator (optional) | • Volume-cycled valve, on-off operation, 100% oxygen, 40-50 psi pressure |
| Immobilization devices (splints) | • Traction (adult and pediatric sizes) | • Lower extremity, limb-support slings, padded ankle hitch, padded pelvic support, traction strap |
| | • Extremity immobilization devices | • Joint above and joint below fracture, rigid support, appropriate material (cardboard, metal, pneumatic, wood, plastic, etc.) |
| | • | |
| | • Backboards (long, short, and clamshell) | • Joint above and point below fracture site. Chin strap (should not use for head immobilization), hand holds for moving patient, short (extrication: head-to-pelvis length), long (transport: head-to-feet length) |
| Bandages | • Burn sheets | • Two clean (not sterile) |
| | • Triangle bandages | • Eight, three safety pins each |
| | • Dressings | • Sterile, large and small |
| | • Roller bandages | • |
| | — Soft | — Sterile, 4" or larger |
| | — Elastic | — Nonsterile, 4" or larger |
| | • Vaseline gauze | • Sterile, 3" × 8" or larger |
| | • Adhesive tape | • 2" or larger |
| Pneumatic Antishock Garment (MAST) | • Compartmentalized (legs and abdomen separate), control valves (closed/open), inflation pump, lower leg to lower rib cage (does not include chest) | |
| Obstetrical equipment | • Sterile obstetrical kit | • Towels, 4" × 4" dressing, umbilical tape type, bulb syringe, clamps for cords, sterile gloves, blanket |
| | • Aluminum foil roll | • Enough to cover a newborn |
| Miscellaneous | • Sphygmomanometer | |
| | • Stethoscope | |
| | • Heavy bandage scissors for cutting clothing, belts, boots, etc. | |
| | • Mouth gags (commercial or tongue blades covered with gauze) | |
| | • C-collar | |
| | • Flashlight | |
| Radio communication | • Two-way communication (EMT to physician) | • Radio UHF (ultra-high frequency) or VHF (very-high frequency) |
| | • Portable cellular telephone (optional) | |

**Table 3-2.—Ambulance Emergency Bag Contents**

| AMBULANCE EMERGENCY BAG CONTENTS | | |
|---|---|---|
| Regular drip IV tubing | Ambu bag | Syrup of Ipecac |
| Mini drip IV tubing | Trach adaptor | Ace® wrap |
| IV extension tubing | Suction tubing | Klings® |
| 19-gauge butterflies | Straight & Y-connector | Arm slings |
| 18-gauge Medicut® | Toomey syringe | Safety pins |
| 16-gauge Medicut® | 10cc syringe | Tongue blades |
| Tourniquet | 20-gauge needles | Tape |
| Adult oxygen mask | Alcohol swabs | Stethoscope |
| Nasal cannula | Examination gloves | 4 x 4's |
| Oxygen tubing | Sodium Chloride ampules | Lubricant |
| Airways (various sizes) | Ammonia ampules | Grease pencil |

**Table 3–3.—Unit One Bag Contents**

| UNIT ONE BAG CONTENTS | |
|---|---|
| One roll wire fabric, 5" x 36" | One tourniquet |
| Two bottles of aspirin, 324 mg, 100s | One pair scissors, bandage |
| Three packages of morphine inj., 1/4 g, 5s | Six packages of plastic strip bandages, 6s |
| One bottle tetracaine hydrochloride ophthalmic sol. | Three bottles povidone-iodine solution, 1/2 fl oz |
| One airway, plastic, adult/ child | One thermometer, oral |
| Two packages atropine inj., 12s | One card of safety pins, medium, 12s |
| Two muslin triangular bandages | Two books field medical cards |
| Two medium battle dressings, 7 1/4" x 8" | One surgical instrument set, minor surgery |
| Eight small battle dressings 4" x 7" | One pencil, black lead, mechanical |
| One roll adhesive tape, 3 in x 5 yds | Two packages gauze, rolled, 3 in x 5 yds |

to slip after it is in place, the dressing is no longer sterile.

Should an emergency arise when a sterile dressing is not available, the cleanest cloth at hand may be used—a freshly laundered handkerchief, towel, or shirt, for instance. Unfold these materials carefully so that you do not touch the part that goes next to the skin. Always be ready to improvise when necessary, but never put materials directly in contact with wounds if

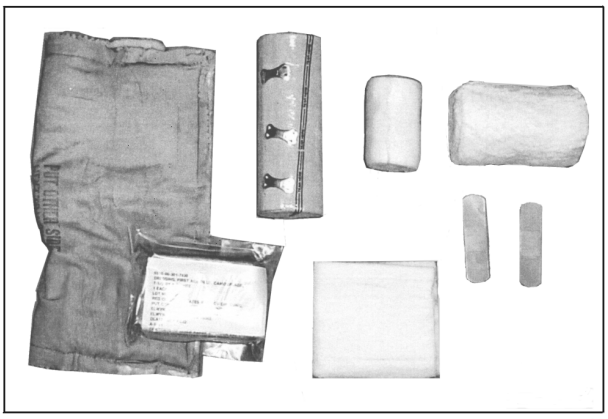

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**Figure 3–1.—Commonly used styles of dressings.**

those materials are likely to stick to the wound, leave lint, or be difficult to remove.

## DEFINITION OF A BANDAGE

Standard bandages are made of gauze or muslin and are used over a sterile dressing to secure the dressing in place, to close off its edge from dirt and germs, and to create pressure on the wound and control bleeding. A bandage can also support an injured part or secure a splint. The most common types of bandages are the roller and triangular bandages.

### Roller Bandage

The roller bandage, shown in figure 3–2, consists of a long strip of material (usually gauze, muslin, or elastic) that is wound into a cylindrical shape. Roller bandages come in various widths and lengths. Most of the roller bandages in the first aid kits have been sterilized, so pieces may be cut off and used as compresses in direct contact with wounds. If you use a piece of roller bandage in this manner, you must be careful not to touch it with your hands or with any other unsterile object.

**GENERAL APPLICATION.—**In applying a roller bandage, hold the roll in the right hand so that the loose end is on the bottom; the outside surface of the loose or initial end is next applied to and held on the body part by the left hand. The roll is then passed around the body part by the right hand, which controls the tension and application of the bandage. Two or three of the initial turns of a roller bandage should overlie each other to properly secure the bandage (see figure 3–3).

In applying the turns of the bandage, it is often necessary to transfer the roll from one hand to the

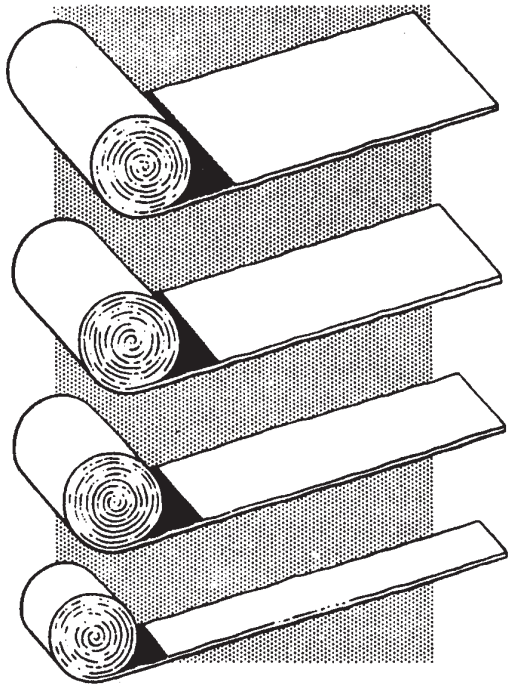


**Figure 3–2.—Roller bandages.**

other. Bandages should be applied evenly, firmly, but not too tightly. Excessive pressure may cause interference with the circulation and may lead to disastrous consequences. In bandaging an extremity, it is advisable to leave the fingers or toes exposed so the circulation of these parts may be readily observed. It is likewise safer to apply a large number of turns of a bandage, rather than to depend upon a few turns applied too firmly to secure a compress.

In applying a wet bandage, or one that may become wet, you must allow for shrinkage. The turns of a bandage should completely cover the skin, as any uncovered areas of skin may become pinched between the turns, with resulting discomfort. In bandaging any extremity, it is advisable to include the whole member (arm or leg, excepting the fingers or toes) so that uniform pressure may be maintained throughout. It is also desirable in bandaging a limb that the part is placed in the position it will occupy when the dressing is finally completed, as variations in the flexion and extension of the part will cause changes in the pressure of certain parts of the bandage.

The initial turns of a bandage on an extremity (including spica bandages of the hip and shoulder) should be applied securely, and, when possible, around the part of the limb that has the smallest circumference. Thus, in bandaging the arm or hand, the initial turns are usually applied around the wrist, and in bandaging the leg or foot, the initial turns are applied immediately above the ankle.

The final turns of a completed bandage are usually secured in the same manner as the initial turns, by employing two or more overlying circular turns. As both edges of the final circular turns are exposed, they should be folded under to present a neat, cufflike appearance. The terminal end of the completed bandage is turned under and secured to the final turns by either a safety pin or adhesive tape. When these are not available, the end of the bandage may be split lengthwise for several inches, and the two resulting tails may be secured around the part by tying.

**ROLLER BANDAGE FOR ELBOW.—**A spica or figure-eight type of bandage is used around the elbow joint to retain a compress in the elbow region and to allow a certain amount of movement. Flex the elbow slightly (if you can do so without causing further pain or injury), or anchor a 2- or 3-inch bandage above the elbow and encircle the forearm below the elbow with a circular turn. Continue the bandage upward across the hollow of the elbow to the starting point. Make another circular turn around the upper arm, carry it downward, repeating the figure-eight procedure, and gradually ascend the arm. Overlap each previous turn about two-thirds of the width of the bandage. Secure the bandage with two circular turns above the elbow, and tie. To secure a dressing on the tip of the elbow, reverse the procedure and cross the bandage in the back (fig. 3–4).

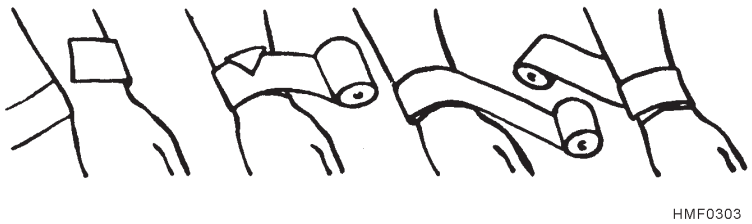


**Figure 3–3.—Applying a roller bandage.**

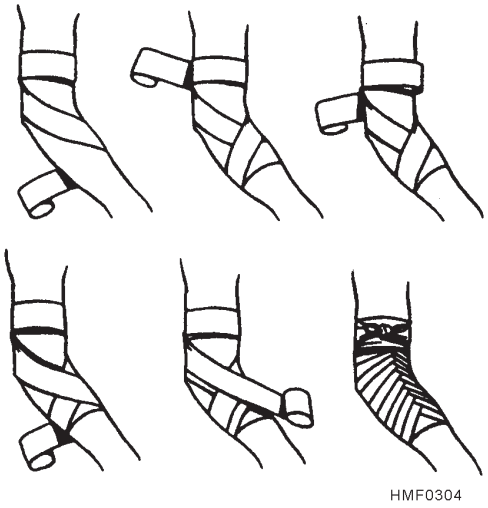


**Figure 3–4.—Roller bandage for the elbow.**

**ROLLER BANDAGE FOR HAND AND WRIST.—**For the hand and wrist, a figure-eight bandage is ideal. Anchor the dressing, whether it is on the hand or wrist, with several turns of a 2- or 3-inch bandage. If on the hand, anchor the dressing with several turns and continue the bandage diagonally upward and around the wrist and back over the palm. Make as many turns as necessary to secure the compress properly (fig. 3–5).

**ROLLER BANDAGE FOR ANKLE AND FOOT.—**The figure-eight bandage is also used for dressings of the ankle, as well as for supporting a sprain. While keeping the foot at a right angle, start a 3-inch bandage around the instep for several turns to anchor it. Carry the bandage upward over the instep and around behind the ankle, forward, and again across the instep and down under the arch, thus completing one figure-eight. Continue the figure-eight turns, overlapping one-third to one-half the width of the bandage and with an occasional turn around the ankle, until the compress is secured or until adequate support is obtained (fig. 3–6).

**ROLLER BANDAGE FOR HEEL.—**The heel is one of the most difficult parts of the body to bandage. Place the free end of the bandage on the outer part of the ankle and bring the bandage under the foot and up. Then carry the bandage over the instep, around the heel, and back over the instep to the starting point. Overlap the lower border of the first loop around the heel and repeat the turn, overlapping the upper border of the loop around the heel. Continue this procedure until the desired number of turns is obtained, and secure with several turns around the lower leg (fig. 3–7).

**ROLLER BANDAGE FOR ARM AND LEG.—**The spiral reverse bandage must be used to cover wounds of the forearms and lower extremities;


**Figure 3–6.—Roller bandage for the ankle and foot.**

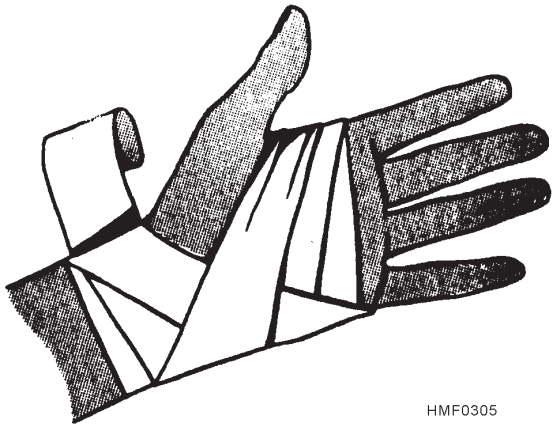


**Figure 3–5.—Roller bandage for the hand and wrist.**

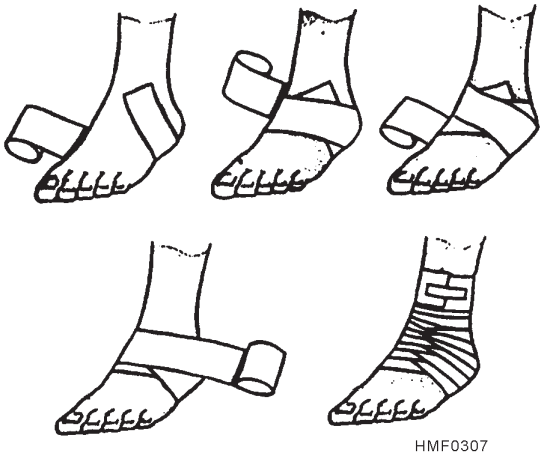


**Figure 3–7.—Roller bandage for the heel.**

only such bandages can keep the dressing flat and even. Make two or three circular turns around the lower and smaller part of the limb to anchor the bandage and start upward, going around making the reverse laps on each turning, overlapping about one-third to one-half the width of the previous turn. Continue as long as each turn lies flat. Continue the spiral and secure the end when completed (fig. 3–8).

**FOUR-TAILED BANDAGE.—**A piece of roller bandage may be used to make a four-tailed bandage. The four-tailed bandage is good for bandaging any protruding part of the body because the center portion of the bandage forms a smoothly fitting pocket when the tails are crossed over. This type of bandage is created by splitting the cloth from each end, leaving as large a center area as necessary. Figure 3–9A shows a bandage of this kind. The four-tailed bandage is often used to hold a compress on the chin, as shown in figure 3–9B, or on the nose, as shown in figure 3–9C.

**BARTON BANDAGE.—**The Barton bandage is frequently used for fractures of the lower jaw and to retain compresses to the chin. As in the progressive steps illustrated in figure 3–10, the initial end of the roller bandage is applied to the head, just behind the right mastoid process. The bandage is then carried under the bony prominence at the back of the head, upward and forward back of the left ear, obliquely across the top of the head. Next bring the bandage downward in front of the right ear. Pass the bandage obliquely across the top of the head, crossing the first turn in the midline of the head, and then backward and downward to the point of origin behind the right mastoid. Now carry the bandage around the back of the head under the left ear, around the front of the chin, and under the right ear to the point of origin. This procedure is repeated several times, each turn exactly overlaying the preceding turn. Secure the bandage with a pin or strip of adhesive tape at the crossing on top of the head.

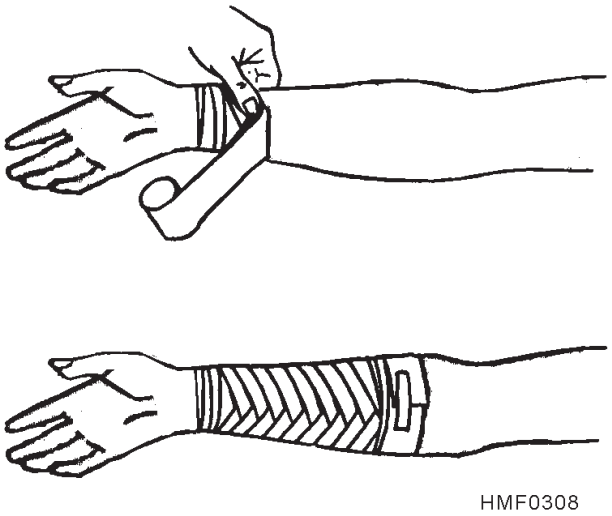


**Figure 3–8.—Roller bandage for the arm or leg.**

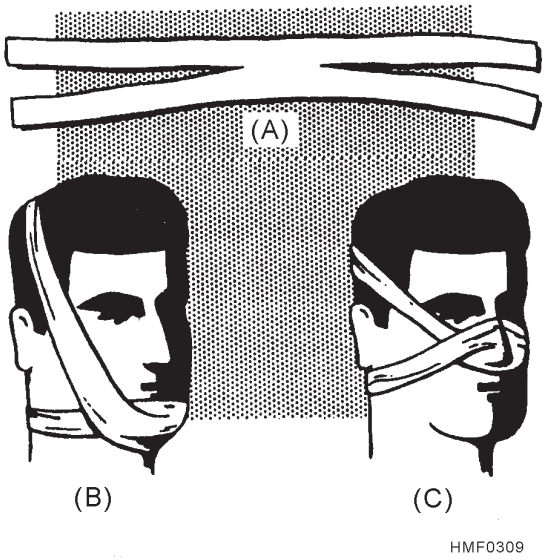


**Figure 3–9.—Four-tailed bandages: A. Four-tailed bandage; B. Four-tailed bandage applied to chin; C. Four-tailed bandage applied to nose.**

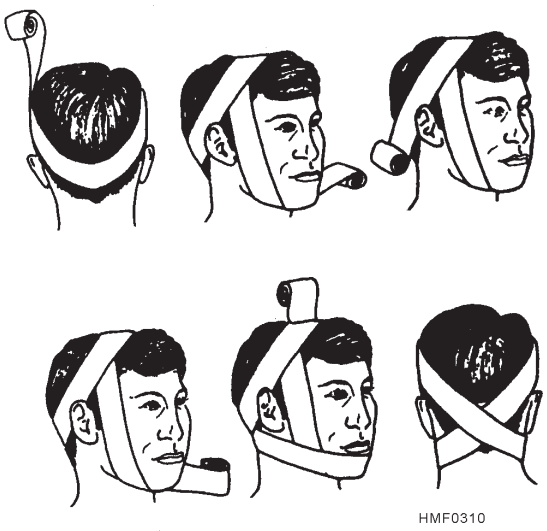


**Figure 3–10.—Barton bandage.**

## Triangular Bandage

Triangular bandages are usually made of muslin. They are made by cutting a 36- to 40-inch square of a piece of cloth and then cutting the square diagonally, thus making two triangular bandages (in sterile packs on the Navy's medical stock list). A smaller bandage

may be made by folding a large handkerchief diagonally. The longest side of the triangular bandage is called the base; the corner directly opposite the middle of the base is called the point; and the other two corners are called ends (fig. 3–11).

The triangular bandage is useful because it can be folded in a variety of ways to fit almost any part of the body. Padding may be added to areas that may become uncomfortable.

**TRIANGULAR BANDAGE FOR HEAD.—** This bandage is used to retain compresses on the forehead or scalp. Fold back the base about 2 inches to make a hem. Place the middle of the base on the forehead, just above the eyebrows, with the hem on the outside. Let the point fall over the head and down over the back of the head. Bring the ends of the triangle around the back of the head above the ears, cross them over the point, carry them around the forehead, and tie

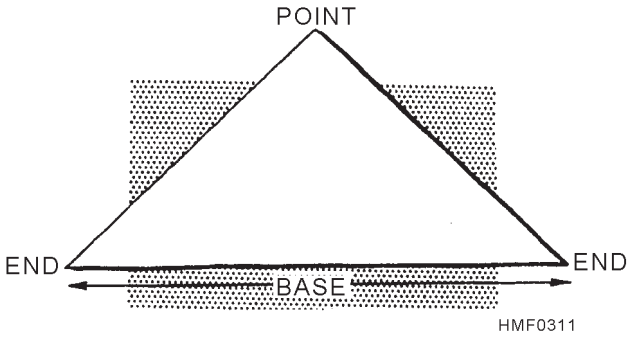


**Figure 3–11.—Triangular bandage.**

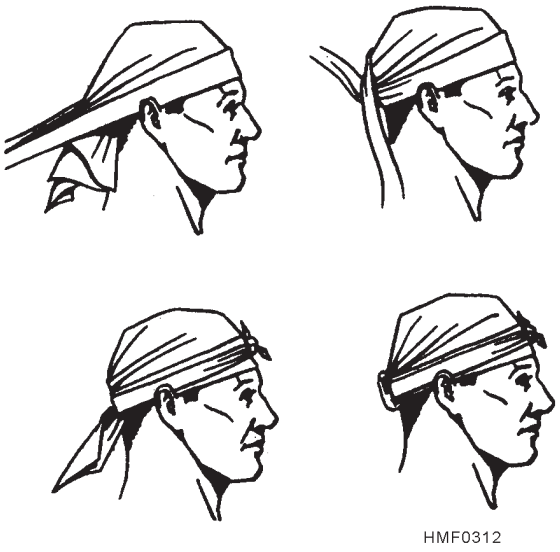


**Figure 3–12.—Triangular bandage for the head.**

in a SQUARE KNOT. Hold the compress firmly with one hand, and, with the other, gently pull down the point until the compress is snug; then bring the point up and tuck it over and in the bandage where it crosses the back part of the head. Figure 3–12 shows the proper application of a triangular bandage for the head.

**TRIANGULAR BANDAGE FOR SHOULDER.—** Cut or tear the point, perpendicular to the base, about 10 inches. Tie the two points loosely around the patient's neck, allowing the base to drape down over the compress on the injured side. Fold the base to the desired width, grasp the end, and fold or roll the sides toward the shoulder to store the excess bandage. Wrap the ends snugly around the upper arm, and tie on the outside surface of the arm. Figure 3–13 shows the proper application of a triangular bandage for the shoulder.

**TRIANGULAR BANDAGE FOR CHEST.—** Cut or tear the point, perpendicular to the base, about 10 inches. Tie the two points loosely around the patient's neck, allowing the bandage to drape down over the chest. Fold the bandage to the desired width, carry the ends around to the back, and secure by tying. Figure 3–14 shows the proper application of a triangular bandage for the chest.

**TRIANGULAR BANDAGE FOR HIP OR BUTTOCK.—**Cut or tear the point, perpendicular to the base, about 10 inches. Tie the two points around the thigh on the injured side. Lift the base up to the waistline, fold to the desired width, grasp the ends, fold or roll the sides to store the excess bandage, carry the ends around the waist, and tie on the opposite side of the body. Figure 3–15 shows the proper application of a triangular bandage for the hip or buttock.

**TRIANGULAR BANDAGE FOR SIDE OF CHEST.—**Cut or tear the point, perpendicular to the base, about 10 inches. Place the bandage, points up, under the arm on the injured side. Tie the two points on top of the shoulder. Fold the base to the desired width, carry the ends around the chest, and tie on the opposite side. Figure 3–16 shows the proper application of a triangular bandage for the side of the chest.

**TRIANGULAR BANDAGE FOR FOOT OR HAND.—**This bandage is used to retain large compresses and dressings on the foot or the hand. **For the foot:** After the compresses are applied, place the foot in the center of a triangular bandage and carry the point over the ends of the toes and over the upper side of the foot to the ankle. Fold in excess bandage at the side of the foot, cross the ends, and tie in a square knot

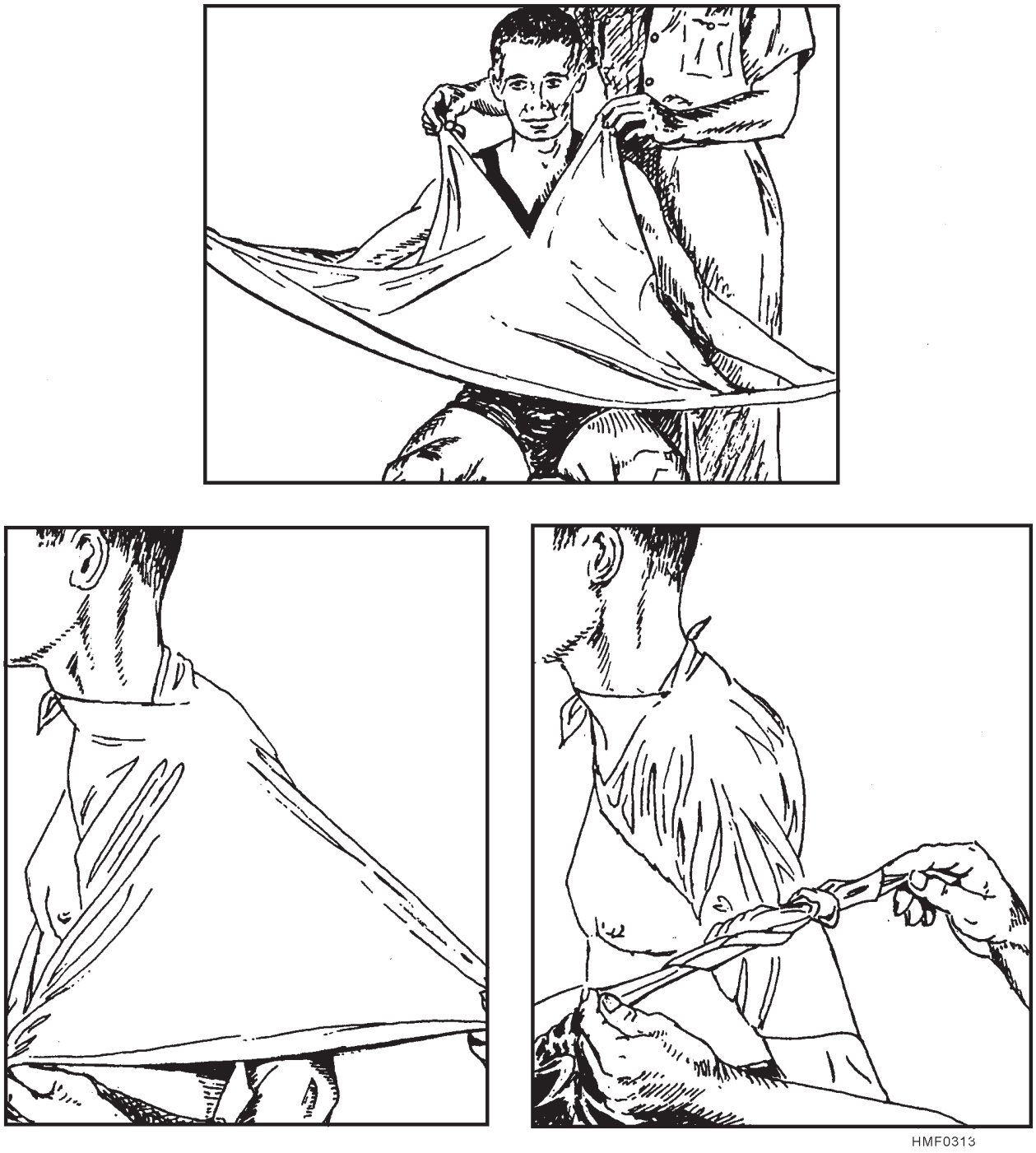


**Figure 3–13.—Triangular bandage for the shoulder.**

in front. **For the hand:** After the dressings are applied, place the base of the triangle well up in the palmar surface of the wrist. Carry the point over the ends of the fingers and back of the hand well up on the wrist. Fold the excess bandage at the side of the hand, cross the ends around the wrist, and tie a square knot in front. Figure 3–17 shows the proper application of a triangular bandage for either the foot or the hand.

**CRAVAT BANDAGE.—**A triangular bandage can be folded into a strip for easy application during an emergency. When folded as shown in figure 3–18, the bandage is called a cravat. To make a cravat bandage, bring the point of the triangular bandage to the middle of the base and continue to fold until a 2-inch width is obtained. The cravat may be tied, or it may be secured with safety pins (if the pins are available).

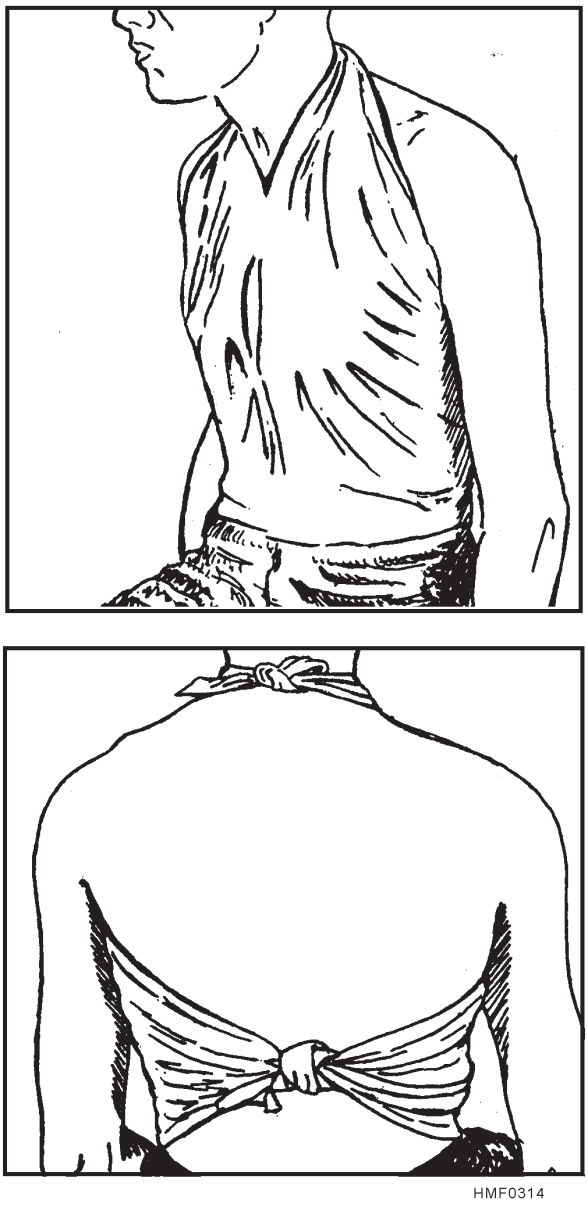


**Figure 3–14.—Triangular bandage for the chest.**

When necessary, a cravat can be improvised from common items such as T-shirts, bed linens, trouser legs, scarves, or any other item of pliable and durable material that can be folded, torn, or cut to the desired size.

**Cravat Bandage for Head.—**This bandage is useful to control bleeding from wounds of the scalp or forehead. After placing a compress over the wound, place the center of the cravat over the compress and carry the ends around to the opposite side; cross them, continue to carry them around to the starting point, and tie in a square knot.

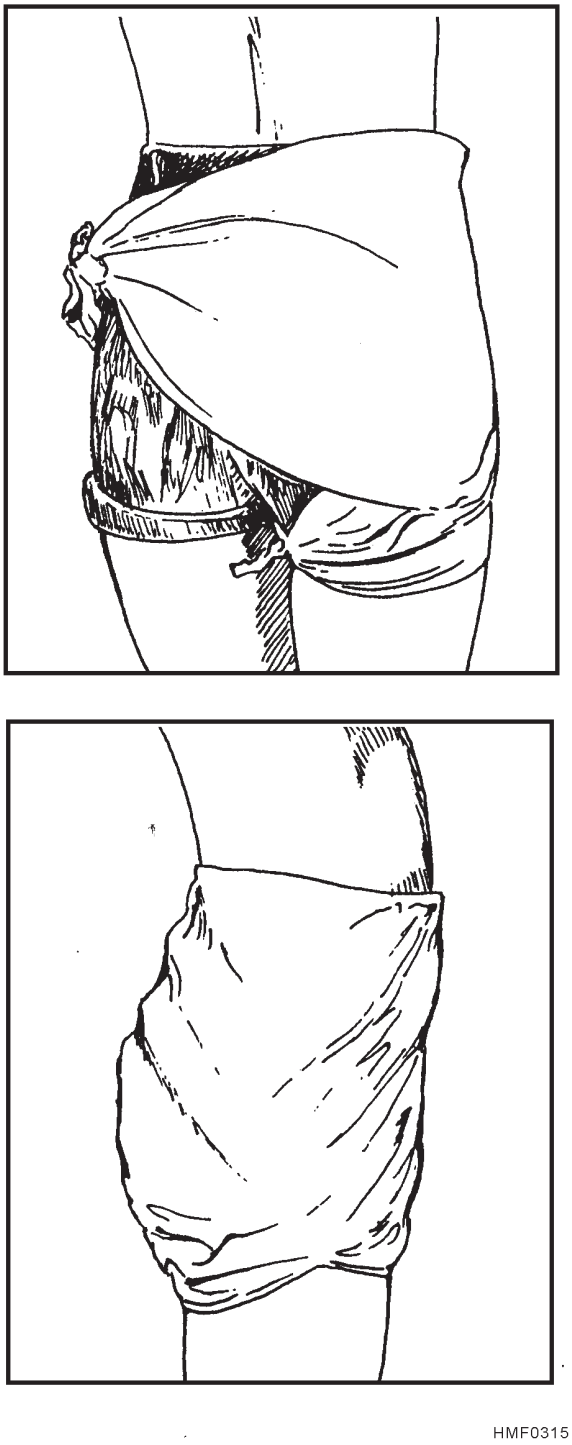


**Figure 3–15.—Triangular bandage for the hip or buttock.**

**Cravat Bandage for Eye.—**After applying a compress to the affected eye, place the center of the cravat over the compress and on a slant so that the lower end is inclined downward. Bring the lower end around under the ear on the opposite side. Cross the ends in back of the head, bring them forward, and tie them over the compress. Figure 3–19 shows the proper application of a cravat bandage for the eye.

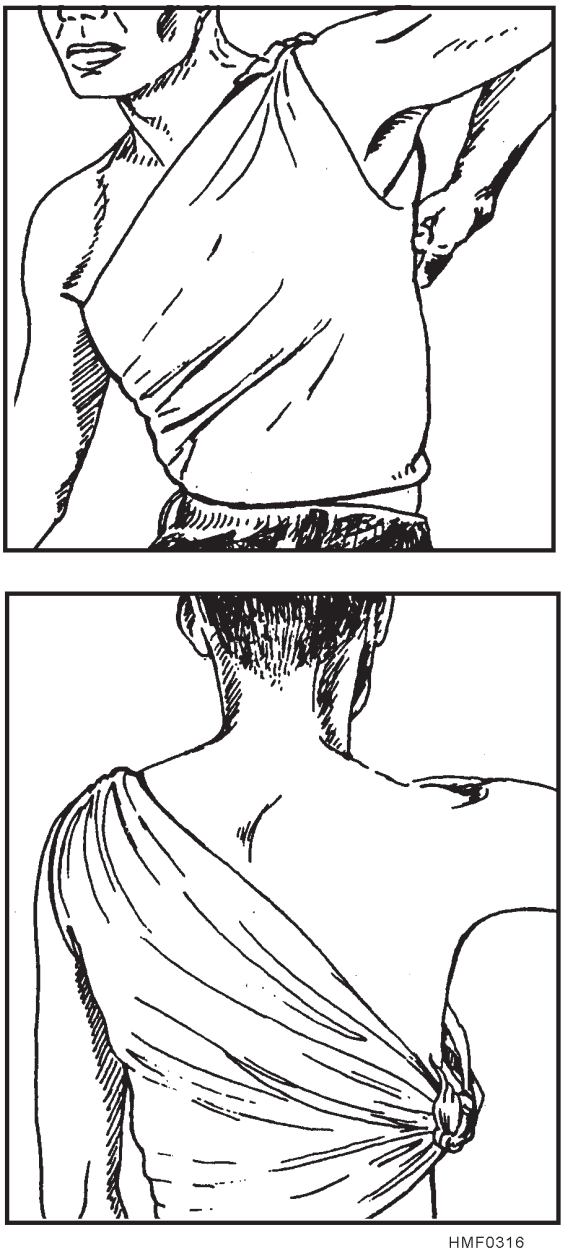


**Figure 3–16.—Triangular bandage for the side of the chest.**

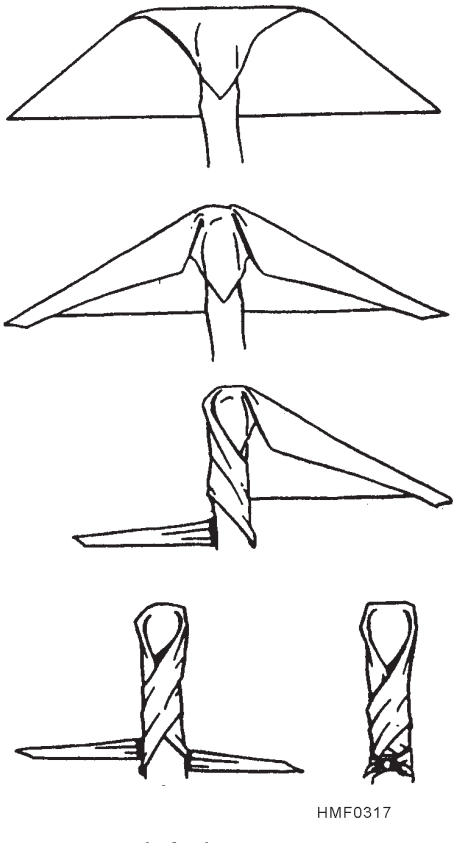


**Figure 3–17.—Triangular bandage for the foot or hand.**

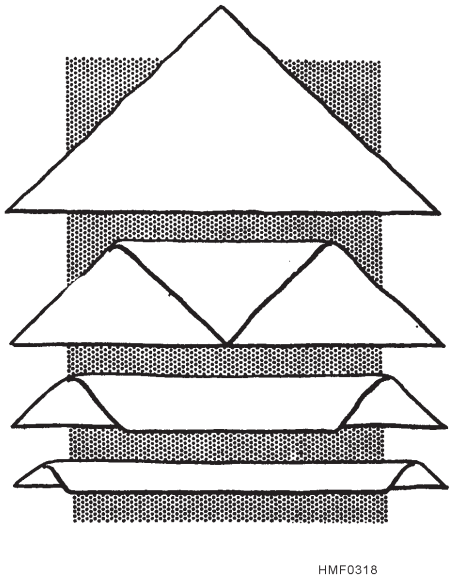


**Figure 3–18.—Cravat bandage.**

**Cravat Bandage for Temple, Cheek, or Ear.—**After a compress is applied to the wound, place the center of the cravat over it and hold one end over the top of the head. Carry the other end under the jaw and up the opposite side, over the top of the head, and cross the two ends at right angles over the temple on the injured side. Continue one end around over the forehead and the other around the back of the head to meet over the temple on the uninjured side. Tie the ends in a square knot. (This bandage is also called a Modified Barton.) Figure 3–20 shows the proper application of a cravat bandage for the temple, cheek, or ear.

**Cravat Bandage for Elbow or Knee.—**After applying the compress, and if the injury or pain is not too severe, bend the elbow or knee to a right-angle position before applying the bandage. Place the

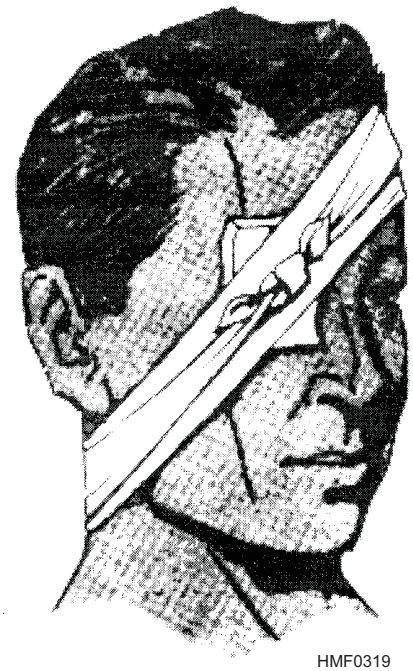


**Figure 3–19.—Cravat bandage for the eye.**

middle of a rather wide cravat over the point of the elbow or knee, and carry the upper end around the upper part of the elbow or knee, bringing it back to the hollow, and the lower end entirely around the lower part, bringing it back to the hollow. See that the bandage is smooth and fits snugly; then tie in a square knot outside of the hollow. Figure 3–21 shows the proper application of a cravat bandage for the elbow or knee.

**Cravat Bandage for Arm or Leg.—**The width of the cravat you use will depend upon the extent and area of the injury. For a small area, place a compress over the wound, and center the cravat bandage over the compress. Bring the ends around in back, cross them, and tie over the compress. For a small extremity, it may be necessary to make several turns around to use all the bandage for tying. If the wound covers a larger area, hold one end of the bandage above the compress and wind the other end spirally downward across the compress until it is secure, then upward and around again, and tie a knot where both ends meet. Figure 3–22 shows the proper application of a cravat bandage for the arm, forearm, leg, or thigh.

**Cravat Bandage for Axilla (Armpit).—**This cravat is used to hold a compress in the axilla. It is similar to the bandage used to control bleeding from the axilla. Place the center of the bandage in the axilla over the compress and carry the ends up over the top of the shoulder and cross them. Continue across the back and chest to the opposite axilla, and tie them. Do not tie

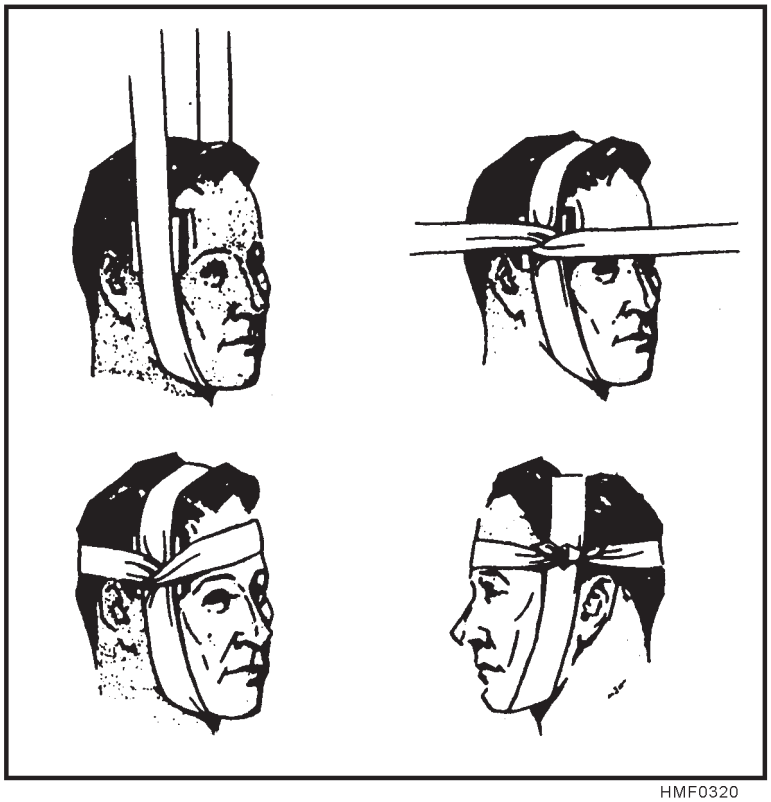


**Figure 3–20.—Cravat (Modified Barton) bandage for the temple, cheek, or ear.**


**Figure 3–21.—Cravat bandage for the elbow or knee.**

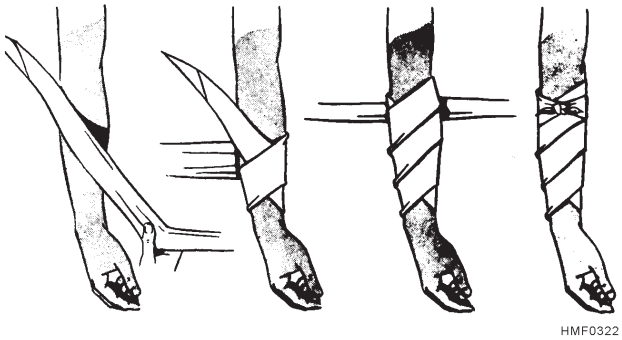


**Figure 3–22.—Cravat bandage for the arm, forearm, leg, or thigh.**

too tightly or the axillary artery will be compressed, adversely affecting the circulation of the arm. Figure 3–23 shows the proper application of a cravat bandage for the axilla.

## BATTLE DRESSING

A battle dressing is a combination compress and bandage in which a sterile gauze pad is fastened to a gauze, muslin, or adhesive bandage (fig. 3–24). Most Navy first aid kits contain both large and small battle dressings of this kind.

## RESCUE AND TRANSPORTATION

**LEARNING OBJECTIVE:** *Identify protective equipment items that are used during patient rescues, and recall how and when each protective equipment item should be used.*

It is a basic principle of first aid that an injured person must be given essential treatment **before** being moved. However, it is impossible to treat an injured person who is in a position of immediate danger. If the victim is drowning, or if his life is endangered by fire, steam, electricity, poisonous or explosive gases, or other hazards, rescue must take place before first aid treatment can be given.

The life of an injured person may well depend upon the manner in which rescue and transportation to a medical treatment facility are accomplished. Rescue operations must be accomplished quickly, but unnecessary haste is both futile and dangerous. After rescue and essential first aid treatment have been given, further transportation must be accomplished in a manner that will not aggravate the injuries. As a Corpsman, it may be your responsibility to direct—and be the primary rescuer in—these operations. The life and safety of the victim and the members of the rescue team may rest on your decisions.

In this section, we will consider the use of common types of protective equipment; rescue procedures; special rescue situations; ways of moving

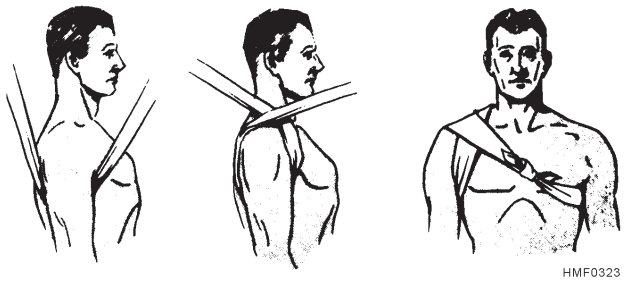


**Figure 3–23.—Cravat bandage for the axilla.**

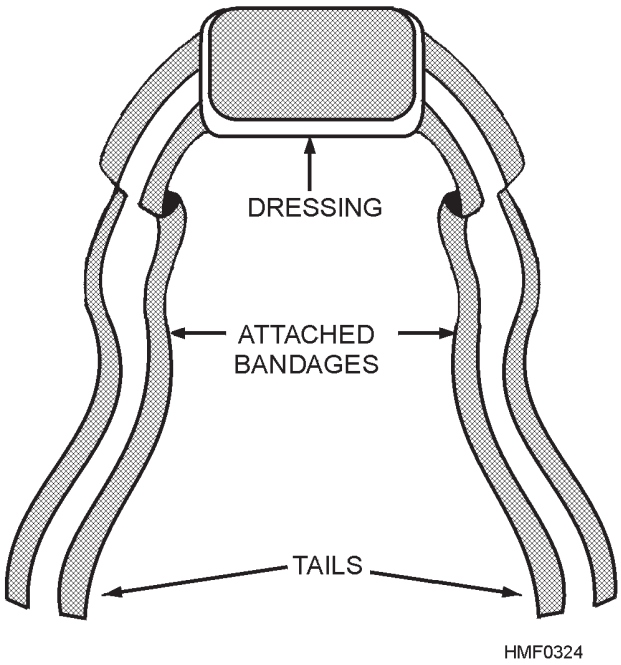


**Figure 3-24.—Battle dressing.**

the patient to safety; and procedures for transporting the injured after first aid has been given.

## PROTECTIVE EQUIPMENT

The use of appropriate items of protective equipment will increase your ability to effect rescue from life-threatening situations. Protective equipment that is generally available on naval vessels and some shore activities include the oxygen breathing apparatus (OBA); hose (air line) masks; protective (gas) masks; steel-wire lifelines; and devices for detecting oxygen insufficiency, explosive vapors, and some poisonous gases.

### Oxygen Breathing Apparatus

An oxygen breathing apparatus (OBA) is provided for emergency use in compartments containing toxic gases. The apparatus is particularly valuable for rescue purposes because it is a self-contained unit. The wearer is not dependent upon outside air or any type of air line within the effective life of the canister.

There are several types of OBAs, but they are all similar in operation. Independence of the outside atmosphere is achieved by having air within the apparatus circulated through a canister. Within the canister, oxygen is continuously generated. The effective life of the canister varies from 20 to 45 minutes, depending on the particular apparatus and the type of work being done. One of the newer types of OBA is designed so that you can change canisters without leaving the toxic atmosphere.

If you are to enter an extremely hazardous area, you should also wear a lifeline. The lifeline should be tended by two persons, one of whom is also wearing a breathing apparatus.

Never allow oil or grease to come in contact with any part of an OBA. Oxygen is violently explosive in the presence of oil or grease. If any part of the apparatus becomes contaminated with oil or grease smudges, clean it before it is stowed. Care should be taken to prevent oil or oily water from entering the canister between the time it is opened and the time of disposal.

### Hose (Air Line) Masks

Hose masks are part of the allowance of all ships having repair party lockers. They are smaller than the oxygen breathing outfits and can, therefore, be used by persons who must enter voids or other spaces that have very small access hatches. The hose or air line mask consists essentially of a gas mask facepiece with an adjustable head harness and a length of airhose. Note that the air line mask uses **air** rather than pure oxygen. It must **NEVER** be connected to an oxygen bottle, oxygen cylinder, or other source of oxygen. Even a small amount of oil or grease in the air line could combine rapidly with the oxygen and cause an explosion.

Safety belts are furnished with each air line mask and **MUST BE WORN**. A lifeline must be fastened to the safety belt; and the lifeline should be loosely lashed to the airhose to reduce the possibility of fouling. The airhose and lifeline must be carefully tended at all times so that they do not become fouled or cut. The person wearing the air line mask and the person tending the lines should maintain communication by means of standard divers' signals.

### Protective (Gas) Masks

Protective masks provide respiratory protection against chemical, biological, and radiological warfare agents. They do not provide protection from the effects of carbon monoxide, carbon dioxide, and a number of industrial gases. Protection from these gases is discussed in the section, "Rescue from Unventilated Compartments," later in this chapter.

In emergencies, protective masks may be used for passage through a smoke-filled compartment or for

entry into such a compartment to perform a job that can be done quickly (such as to close a valve, secure a fan, or de-energize a circuit). However, they provide only limited protection against smoke. The length of time you can remain in a smoke-filled compartment depends on the type of smoke and its concentration.

The most important thing to remember about protective masks is that they do not manufacture or supply oxygen. They merely filter the air as it passes through the canister.

**Lifelines**

The lifeline is a steel-wire cable, 50 feet long. Each end is equipped with a strong hook that closes with a snap catch. The line is very pliable and will slide freely around obstructions. See figure 3–25.

Lifelines are used as a precautionary measure to aid in the rescue of persons wearing rescue breathing apparatus, hose masks, or similar equipment. Rescue, if necessary should be accomplished by having another person equipped with a breathing apparatus follow the lifeline to the person being rescued, rather than by attempting to drag the person out. Attempts to drag a person from a space may result in fouling the lifeline on some obstruction or in parting the harness, in which case it would still be necessary to send a rescue person into the space.

An important point to remember is that a stricken person must never be hauled by a lifeline attached to the waist. The victim may be dragged along the deck a short distance, but his weight must never be suspended on a line attached to the waist. If not wearing a harness of some kind, pass the line around the chest under the armpits and fasten it in front or in back.

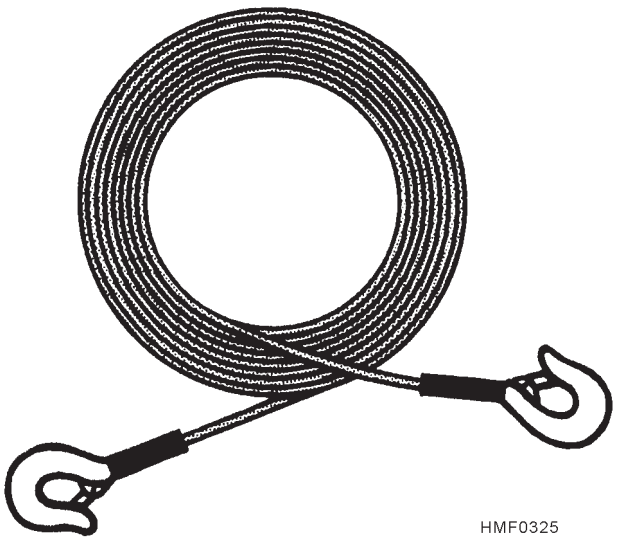


**Figure 3–25.—Steel wire lifeline.**

When tending a lifeline, you must wear gloves to be able to handle the line properly. Play out the line carefully to keep it from fouling. Try to keep the lifeline in contact with grounded metal; do not allow it to come in contact with any energized electrical equipment.

**Detection Devices**

The detection devices used to test the atmosphere in closed or poorly ventilated spaces include the **oxygen indicator**, for detecting oxygen deficiency; **combustible-gas indicators**, for determining the concentration of explosive vapors; and **toxic-gas indicators**, such as the **carbon monoxide indicator**, for finding the concentration of certain poisonous gases. The devices are extremely valuable and should be used whenever necessary. However, they **MUST BE USED ONLY AS DIRECTED**. Improper operation of these devices may lead to false assurances of safety or, worse yet, to an increase in the actual danger of the situation. For example, the use of a flame safety lamp in a compartment filled with acetylene or hydrogen could cause a violent explosion.

## RESCUE PROCEDURES

**LEARNING OBJECTIVE:** *Recognize the phases of rescue operations and the stages of extrication.*

If you are faced with the problem of rescuing a person threatened by fire, explosive or poisonous gases, or some other emergency, do not take any action until you have had time to determine the extent of the danger and your ability to cope with it. In a large number of accidents, the rescuer rushes in and becomes the second victim. Do not take unnecessary chances! Do not attempt any rescue that needlessly endangers your own life!

**Phases of Rescue Operations**

In disasters where there are multiple patients (as in explosions or ship collisions), rescue operations should be performed in phases. These rescue phases apply only to extrication operations.

The first phase is to remove lightly pinned casualties, such as those who can be freed by lifting boxes or removing a small amount of debris.

In the second phase, remove those casualties who are trapped in more difficult circumstances but who can be rescued by use of the equipment at hand and in a minimum amount of time.

In the third phase, remove casualties where extrication is extremely difficult and time consuming. This type of rescue may involve cutting through decks, breaching bulkheads, removing large amounts of debris, or cutting through an expanse of metal. An example would be rescuing a worker from beneath a large, heavy piece of machinery.

The last phase is the removal of dead bodies.

**Stages of Extrication**

The first stage of extrication within each of the rescue phases outlined above is gaining access to the victim. Much will depend on the location of the accident, damage within the accident site, and the position of the victim. The means of gaining access must also take into account the possibility of causing further injury to the victim since force may be needed. Further injury must be minimized.

The second stage involves giving lifesaving emergency care. If necessary, establish and maintain an open airway, start artificial respiration, and control hemorrhage.

The third stage is disentanglement. The careful removal of debris and other impediments from the victim will prevent further injury to both the victim and the rescuer.

The fourth stage is preparing the victim for removal, with special emphasis on the protection of possible fractures.

The final stage, removing the victim from the trapped area and transporting to an ambulance or sickbay, may be as simple as helping the victim walk out of the area or as difficult as a blanket dragged out of a burning space.

**Special Rescue Situations**

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**LEARNING OBJECTIVE:** *Recognize the procedural and precautionary steps that must be taken in various rescue situations.*

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The procedures you follow in an emergency situation will be determined by the nature of the disaster or emergency you encounter. Some of the more common rescue situations and the appropriate procedures for each are outlined below.

**RESCUE FROM FIRE**.—If you must go to the aid of a person whose clothing is on fire, try to smother the flames by wrapping the victim in a coat, blanket, or rug. Leave the head **UNCOVERED**. If you have no material with which to smother the fire, roll the victim over—**SLOWLY**—and beat out the flames with your hands. Beat out the flames around the head and shoulders, then work downward toward the feet. If the victim tries to run, throw him down. Remember that the victim **MUST** lie down while you are trying to extinguish the fire. Running will cause the clothing to burn rapidly. Sitting or standing may cause the victim to be killed instantly by inhaling flames or hot air.

**CAUTION:** Inhaling flames or hot air can kill YOU, too. **Do not get your face directly over the flames. Turn your face away from the flame when you inhale.**

If your own clothing catches fire, roll yourself up in a blanket, coat, or rug. **KEEP YOUR HEAD UNCOVERED**. If material to smother the fire is not available, lie down, roll over slowly, and beat at the flames with your hands.

If you are trying to escape from an upper floor of a burning building, be very cautious about opening doors into hallways or stairways. Always feel a door before you open it. If the door feels hot, do not open it if there is any other possible way out. Remember, also, that opening doors or windows will create a draft and make the fire worse. So do not open any door or window until you are actually ready to get out.

If you are faced with the problem of removing an injured person from an upper story of a burning building, you may be able to improvise a lifeline by tying sheets, blankets, curtains, or other materials together. Use square knots to connect the materials to each other. Secure one end of the line around some heavy object inside the building, and fasten the other end around the casualty under the arms. You can lower the victim to safety and then let yourself down the line. Do not jump from an upper floor of a burning building except as a last resort.

It is often said that the “best” air in a burning room or compartment is near the floor, but this is true only to a limited extent. There is less smoke and flame down low, near the floor, and the air may be cooler. But it is also true that carbon monoxide and other deadly gases are just as likely to be present near the floor as near the

ceiling. Therefore, if possible, use an oxygen breathing apparatus or other protective breathing equipment when you go into a burning compartment. If protective equipment is not available, cover your mouth and nose with a wet cloth to reduce the danger of inhaling smoke, flame, or hot air.

**CAUTION: A WET CLOTH GIVES YOU NO PROTECTION AGAINST POISONOUS GASES OR LACK OF OXYGEN!**

**RESCUE FROM STEAM-FILLED SPACES**.—It is sometimes possible to rescue a person from a space in which there is a steam leak. Since steam rises, escape upward may not be possible. If the normal exit is blocked by escaping steam, move the casualty to the escape trunk or, if there is none, to the lowest level in the compartment.

**RESCUE FROM ELECTRICAL CONTACT.—** Rescuing a person who has received an electrical shock is likely to be difficult and dangerous. Extreme caution must be used, or you may be electrocuted yourself.

**CAUTION: YOU MUST NOT TOUCH THE VICTIM'S BODY, THE WIRE, OR ANY OTHER OBJECT THAT MAY BE CONDUCTING ELECTRICITY.**

First of all, look for the switch. If you find the switch, turn off the current immediately. Do not waste too much time hunting for the switch: Every second is important.

If you cannot find the switch, try to remove the wire from the victim with a **DRY** broom handle, branch, pole, oar, board, or similar **NONCONDUCTING** object. It may be possible to use a **DRY** rope or **DRY** clothing to pull the wire away from the victim. You can also break the contact by cutting the wire with a **WOODEN-HANDLED** axe, but this is extremely dangerous because the cut ends of the wire are likely to curl and lash back at you before you have time to get out of the way. When you are trying to break an electrical contact, always stand on some nonconducting material such as a **DRY** board, **DRY** newspapers, or **DRY** clothing. See figure 3–26.

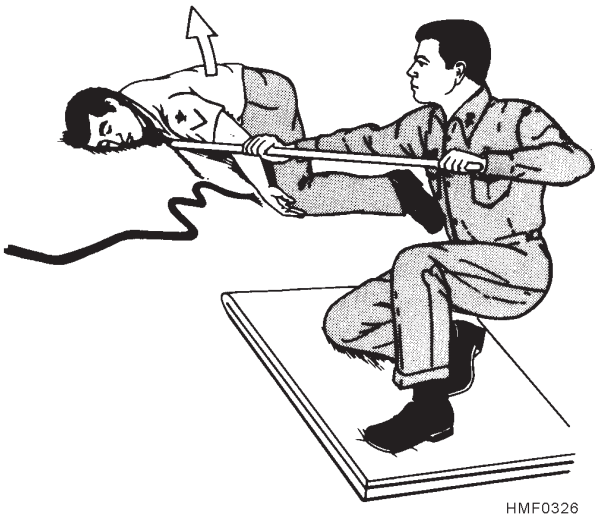


**Figure 3–26.—Moving a victim away from an electrical line.**

**RESCUE FROM UNVENTILATED COMPARTMENTS.—**Rescuing a person from a void, double bottom, gasoline or oil tank, or any closed compartment or unventilated space is generally a very hazardous operation. Aboard naval vessels and at naval shore stations, no person is permitted to enter any such space or compartment until a damage control officer (DCO), or some person designated by the DCO, has indicated that the likelihood of suffocation, poisoning, and fire or explosion has been eliminated as far as possible. The rescue of a person from any closed space should therefore be performed under the supervision of the DCO or in accordance with the DCO's instructions. In general, it is necessary to observe the following precautions when attempting to rescue a person from any closed or poorly ventilated space:

- If possible, test the air for oxygen deficiency, poisonous gases, and explosive vapors.
- Wear a hose (air line) mask or oxygen breathing apparatus. The air line mask is preferred for use in spaces that may contain high concentrations of oil or gasoline vapors. Do not depend upon a protective mask or a wet cloth held over your face to protect you from oxygen deficiency or poisonous gases.
- Before going into a compartment that may contain explosive vapors, be sure that people are stationed nearby with fire-extinguishing equipment.

- When going into any space that may be deficient in oxygen or contain poisonous or explosive vapors, be sure to maintain communication with someone outside. Wear a lifeline, and be sure that it is tended by a competent person.

- Do not use, wear, or carry any object or material that might cause a spark. Matches, cigarette lighters, flashlights, candles or other open flames, and ordinary electrical lights must **NEVER** be taken into a compartment that may contain explosive vapors. The kind of portable light used by cleaning parties in boilers, fuel tanks, and similar places may be taken into a suspect compartment. This is a steam-tight, glove-type light whose exposed metal parts are either made of nonsparking alloy or protected in some way so they will not strike a spark.

An electrical apparatus or tool that might spark must never be taken into a compartment until a DCO has indicated that it is safe to do so. When electrical equipment is used (e.g., an electric blower might be used to vent a compartment of explosive vapors), it must be explosion proof and properly grounded.

If you go into a space that may contain explosive vapors, do not wear clothing that has any exposed spark-producing metal. For example, do not wear boots or shoes that have exposed nailheads or rivets, and do not wear coveralls or other garments that might scrape against metal and cause a spark.

A particular caution must be made concerning the use of the steel-wire lifeline in compartments that may contain explosive vapors. If you use the line, be sure that it is carefully tended and properly grounded at all times. When other considerations permit, you should use a rope line instead of the steel-wire lifeline when entering compartments that may contain explosive vapors.

**RESCUE FROM THE WATER.—**You should never attempt to swim to the rescue of a drowning person unless you have been trained in lifesaving methods—and then only if there is no better way of reaching the victim. A drowning person may panic and fight against you so violently that you will be unable either to carry out the rescue or to save yourself. Even if you are not a trained lifesaver, however, you can help a drowning person by holding out a pole, oar, branch, or stick for the victim to catch hold of, or by throwing a lifeline or some buoyant object that will support the victim in the water.

Various methods are used aboard ship to pick up survivors from the water. The methods used in any particular instance will depend upon weather conditions, the type of equipment available aboard the rescue vessel, the number of people available for rescue operations, the physical condition of the people requiring rescue, and other factors. In many cases it has been found that the best way to rescue a person from the water is to send out a properly trained and properly equipped swimmer with a lifeline.

It is frequently difficult to get survivors up to the deck of the rescuing vessel, even after they have been brought alongside the vessel. Cargo nets are often used, but many survivors are unable to climb them without assistance. Persons equipped with lifelines (and, if necessary, dressed in anti-exposure suits) can be sent over the side to help survivors up the nets. If survivors are covered with oil, it may take the combined efforts of four or five people to get one survivor up the net.

A seriously injured person should never, except in an extreme emergency, be hauled out of the water by means of a rope or lifeline. Special methods must be devised to provide proper support, both to keep the victim in a horizontal position and to provide protection from any kind of jerking, bending, or twisting motion. The Stokes stretcher (described later in this chapter) can often be used to rescue an injured survivor. People on the deck of the ship can then bring the stretcher up by means of handlines. Life preservers, balsa wood, unicellular material, or other flotation gear can be used, if necessary, to keep the stretcher afloat.

## MOVING THE VICTIM TO SAFETY

**LEARNING OBJECTIVE:** *Recognize the different patient-moving devices and lifting techniques that can be used in patient rescues.*

In an emergency, there are many ways to move a victim to safety, ranging from one-person carries to stretchers and spineboards. The victim's condition and the immediacy of danger will dictate the appropriate method. Remember, however, to give all necessary first aid **BEFORE** moving the victim.

**Stretchers**

The military uses a number of standard stretchers. The following discussion will familiarize you with the most common types. When using a stretcher, you should consider a few general rules:

- Use standard stretchers when available, but be ready to improvise safe alternatives.
- When possible, bring the stretcher to the casualty.
- Always fasten the victim securely to the stretcher.
- Always move the victim **FEET FIRST** so the rear bearer can watch for signs of breathing difficulty.

**STOKES STRETCHER.—**The Navy service litter most commonly used for transporting sick or injured persons is called the Stokes stretcher. As shown in figure 3–27, the Stokes stretcher is essentially a wire basket supported by iron rods. Even if the stretcher is tipped or turned, the casualty can be held securely in place, making the Stokes adaptable to a variety of uses. This stretcher is particularly valuable for transferring injured persons to and from boats. As mentioned before, it can also be used with flotation devices to rescue injured survivors from the water. It is also used for direct ship-to-ship transfer of injured persons. Fifteen-foot handling lines are attached to each end for shipboard use in moving the victim.

The Stokes stretcher should be padded with three blankets: two of them should be placed lengthwise (so that one will be under each of the casualty's legs), and the third should be folded in half and placed in the upper part of the stretcher to protect the head and shoulders. The casualty should be lowered gently into the stretcher and made as comfortable as possible. The feet must be fastened to the end of the stretcher so that the casualty will not slide down. Another blanket (or more, if necessary) should be used to cover the casualty. The casualty must be fastened to the stretcher by means of straps that go over the chest, hips, and knees. Note that the straps go **OVER** the blanket or other covering, thus holding it in place.

**ARMY LITTER.—**The Army litter, shown in figure 3–28, is a collapsible stretcher made of canvas and supported by wooden or aluminum poles. It is very useful for transporting battle casualties in the field. However, it is sometimes difficult to fasten the casualty onto the Army litter, and for this reason its use is somewhat limited aboard ship. The litter legs keep the patient off the ground. The legs fit into the restraining tracks of a jeep or field ambulance to hold the litter in place during transport.

**MILLER (FULL BODY) BOARD.—**The Miller Board (fig 3-29) is constructed of an outer plastic shell with an injected foam core of polyurethane foam. It is impervious to chemicals and the elements and can be used in virtually every confined-space rescue and vertical extrication. The Miller Board provides for full body immobilization through a harness system, including a hood and two-point contact for the head (forehead and chin) to stabilize the head and cervical spine. The board's narrow design allows passage through hatches and crowded passageways. It fits

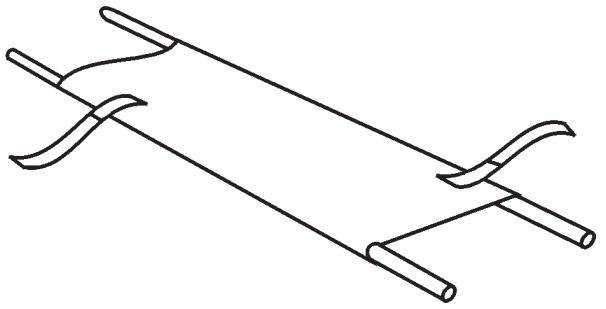


**Figure 3–28.—Opening an Army litter.**

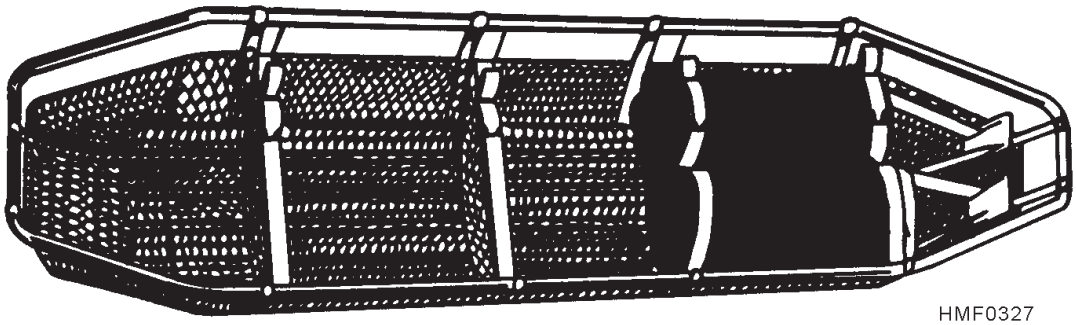


**Figure 3–27.—Stokes stretcher.**

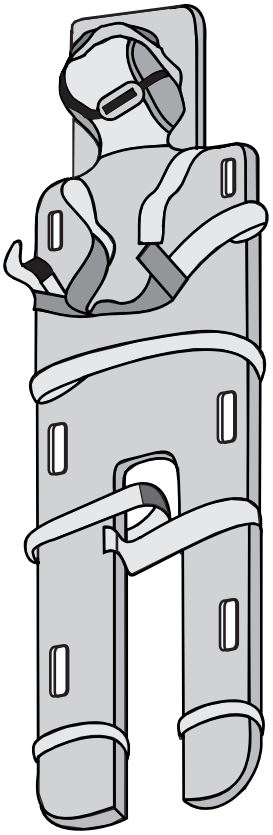

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**Figure 3–29.—Miller (full body) Board.**

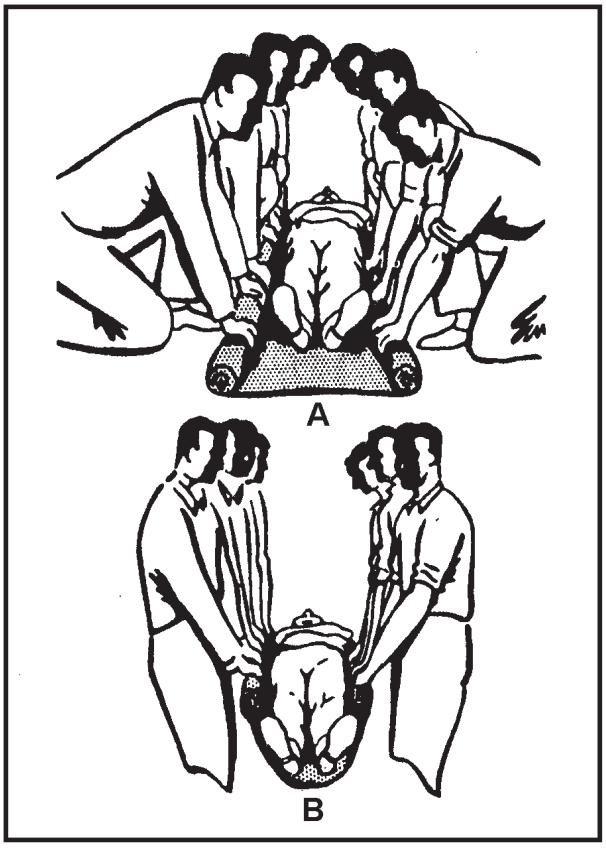


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**Figure 3–30.—Blanket used as an improvised stretcher.**

within a Stokes (basket) stretcher and will float a 250-pound person.

**IMPROVISED STRETCHERS.—**Standard stretchers should be used whenever possible to transport a seriously injured person. If none are available, it may be necessary for you to improvise. Shutters, doors, boards, and even ladders may be used as stretchers. All stretchers of this kind must be very well padded and great care must be taken to see that the casualty is fastened securely in place.

Sometimes a blanket may be used as a stretcher, as shown in figure 3–30. The casualty is placed in the middle of the blanket in the supine position. Three or four people kneel on each side and roll the edges of the blanket toward the casualty, as shown in figure 3–30A. When the rolled edges are tight and large enough to grasp securely, the casualty should be lifted and carried as shown in figure 3–30B.

Stretchers may also be improvised by using two long poles (about 7 feet long) and strong cloth (such as a rug, a blanket, a sheet, a mattress cover, two or three gunny sacks, or two coats). Figure 3–31 shows an improvised stretcher made from two poles and a blanket.

**CAUTION:** Many improvised stretchers do not give sufficient support in cases where there are fractures or extensive wounds of the body. They should be used only when the casualty is able to stand some sagging, bending, or twisting without serious consequences. An example of this type of improvised stretcher would be one made of 40 to 50 feet of rope or 1-1/2-inch firehose (fig. 3–32).

### Spineboards

Spineboards are essential equipment in the immobilization of suspected or real fractures of the spinal column. Made of fiberglass or exterior plywood, they come in two sizes, short (18" × 32") and long (18" × 72"), and are provided with handholds and straps. Spineboards also have a runner on the bottom to allow clearance to lift (fig. 3–33).

A short spineboard is primarily used in extrication of sitting victims, especially in automobile wrecks (where it would be difficult to maneuver the victim out of position without doing additional damage to the spine). The long board makes a firm litter, protecting the back and neck, and providing a good surface for

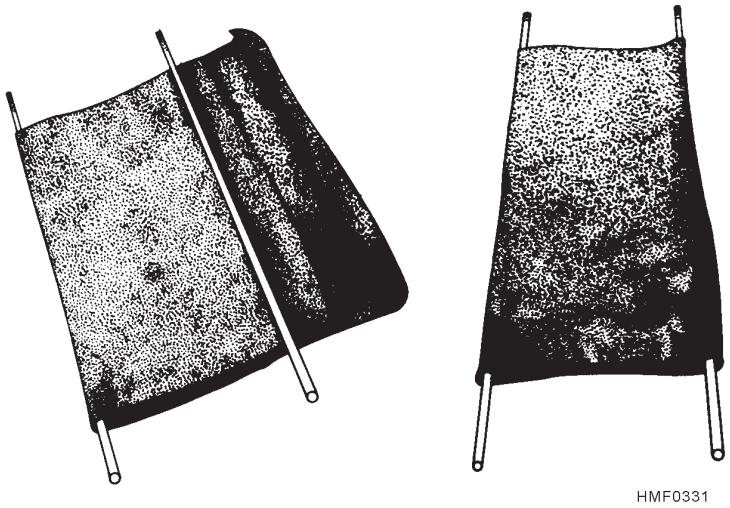


**Figure 3–31.—Improvised stretcher using blankets and poles.**

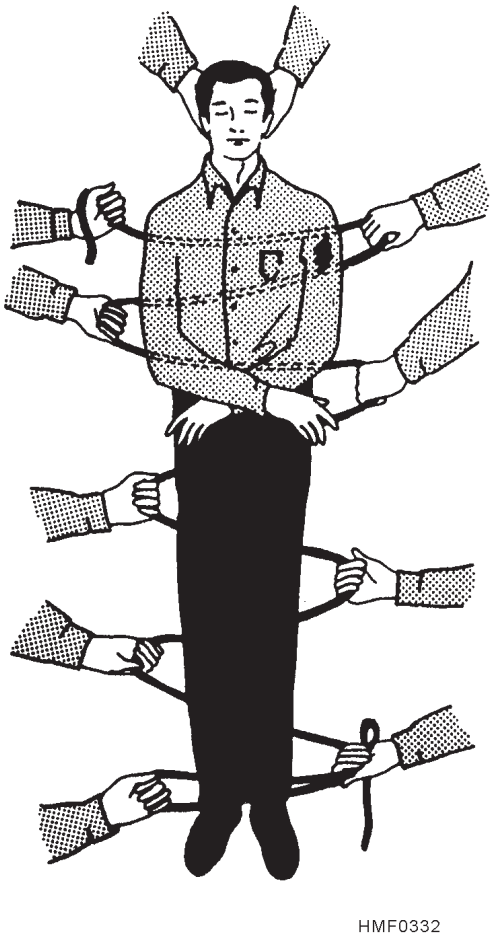


**Figure 3–32.—Improvised stretcher using rope or firehose.**

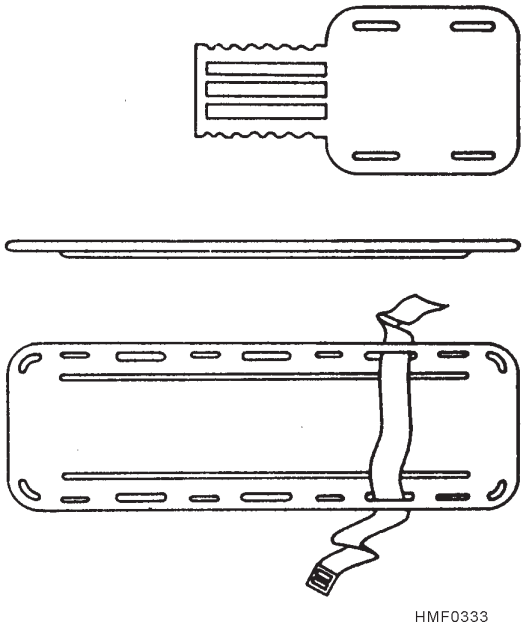


**Figure 3–33.—Spineboards.**

CPR and a good sliding surface for difficult extractions.

The short and long boards are often used together. For example, at an automobile accident site, the Corpsman's first task is to assess the whole situation and to plan the rescue. If bystanders must be used, it is essential that they be briefed in thorough detail on what you want them to do. After all accessible bleeding has been controlled and the fractures splinted, the short spineboard should be moved into position behind the victim. A neck collar should be applied in all cases and will aid in the immobilization of the head and neck. The head should then be secured to the board with a headband or a 6-inch self-adhering roller bandage. The victim's body should then be secured to the board by use of the supplied straps around the chest and thighs. The victim may then be lifted out. If, however,

the victim is too large, or further immobilization of the lower extremities is necessary, the long spineboard may be slid at a right angle behind the short spineboard, and the victim maneuvered onto his side and secured to the longboard.

The possible uses of the spineboard in an emergency situation are limited only by the imagination of the rescuers.

**Emergency Rescue Lines**

As previously mentioned, the steel-wire lifeline can often be used to haul a person to safety. An emergency rescue line can also be made from any strong fiber line. Both should be used only in extreme emergencies, when an injured person must be moved and no other means is available. Figure 3–34 shows an emergency rescue line that could be used to hoist a person from a void or small compartment. Notice that a running bowline is passed around the body, just below the hips, and a half hitch is placed just under the arms. Notice also that a guideline is tied to the casualty's ankles to prevent banging against bulkheads and hatchways.

**Rescue Drag and Carry Techniques**

There will be times when you, as a Corpsman, will be required to evacuate a sick or injured person from an emergency scene to a location of safety. Casualties carried by manual means must be carefully and correctly handled, otherwise their injuries may become more serious or possibly fatal. Situation permitting, evacuation or transport of a casualty should be organized and unhurried. Each movement should be performed as deliberately and gently as possible.

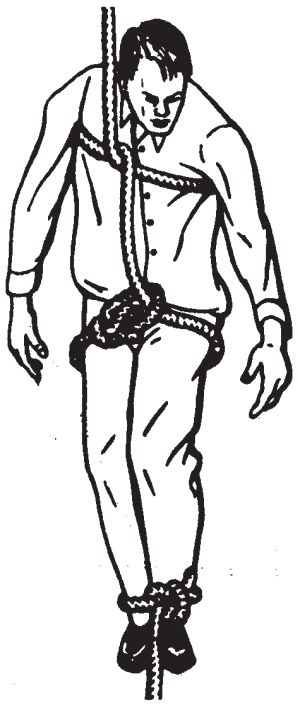


**Figure 3–34.—Hoisting a person.**

Manual carries are tiring for the bearer(s) and involve the risk of increasing the severity of the casualty's injury. In some instances, however, they are essential to save the casualty's life. Although manual carries are accomplished by one or two bearers, the two-man carries are used whenever possible. They provide more comfort to the casualty, are less likely to aggravate his injuries, and are also less tiring for the bearers, thus enabling them to carry him farther. The distance a casualty can be carried depends on many factors, such as

- strength and endurance of the bearer(s),
- weight of the casualty,
- nature of the casualty's injury, and
- obstacles encountered during transport.

You should choose the evacuation technique that will be the least harmful, both to you and the victim. When necessary and appropriate, use a one-rescuer technique (several of which are described in the following section). Two-rescuer techniques and the circumstances under which those techniques are appropriate are also listed below.

**ONE-RESCUER TECHNIQUES.—**If a victim can stand or walk, assist him to a safe place. If there are no indications of injury to the spine or an extremity but the casualty is not ambulatory, he can be carried by means of any of the following:

- **Fireman's Carry**: One of the easiest ways to carry an unconscious person is by means of the fireman's carry. Figure 3–35 shows the steps of this procedure.

- **Pack-strap Carry**: With the pack-strap carry, shown in figure 3–36, it is possible to carry a heavy person for some distance. Use the following procedure:

1. Place the casualty in a supine position.
2. Lie down on your side along the casualty's uninjured or less injured side. Your shoulder should be next to the casualty's armpit.
3. Pull the casualty's far leg over your own, holding it there if necessary.

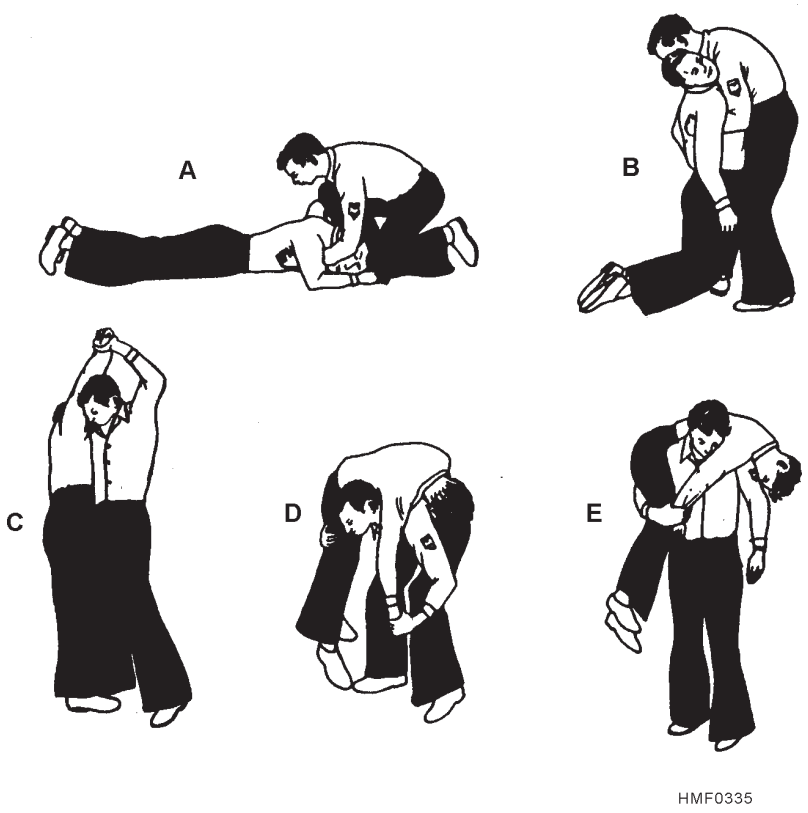


**Figure 3–35.—Fireman's carry.**


**Figure 3–36.—Pack-strap carry.**

4. Grasp the casualty's far arm at the wrist and bring it over your upper shoulder as you roll and pull the casualty onto your back.
5. Raise up your knees, holding your free arm for balance and support. Hold both the casualty's wrists close against your chest with your other hand.
6. Lean forward as you rise to your feet, and keep both of your shoulders under the casualty's armpits.

Do not attempt to carry a seriously injured person by means of the pack-strap carry, especially if the arms, spine, neck, or ribs are fractured.

- **Arm Carry**: The technique for a one-person arm carry is shown in figure 3–37. However, you should never try to carry a person who is seriously injured with this method. Unless considerably smaller than you are, you will not be able to carry the casualty very far using this technique.

- **Blanket Drag**: The blanket drag, shown in figure 3–38, can be used to move a person who, due to the severity of the injury, should not be lifted or carried by one person alone. Place the casualty in the supine position on a blanket and pull the blanket along the floor or deck. Always pull the casualty head first, with the head and shoulders slightly raised so that the head will not bump against the deck.


**Figure 3–37.—One-person arm carry.**

A variant of the blanket drag is the **clothes drag**, where the rescuer drags the victim by the clothing on the victim's upper body.

- **Tied-hands Crawl**: The tied-hands crawl, shown in figure 3–39, may be used to drag an unconscious person for a short distance. It is particularly useful when you must crawl underneath a low structure, but it is the least desirable because the victim's head is not supported.

To be carried by this method, the casualty must be in the supine position. Cross the wrists and tie them together. Kneel astride the casualty and lift the arms over your head so that the wrists are at the back of your neck. When you crawl forward, raise your shoulders high enough so that the casualty's head will not bump against the deck.

**TWO-RESCUER TECHNIQUES.—**If the casualty is ambulatory, you and your partner should assist him to safety. However, if the victim has either a spinal injury or a fractured extremity, there are a number of two-rescuer techniques that can be used to move him to safety.

- Chair Carry: The chair carry can often be used to move a sick or injured person away from a position of danger. The casualty is seated on a chair, as shown in figure 3–40, and the chair is carried by two rescuers. This is a particularly good method to use when you must carry a person up or down stairs or through narrow, winding passageways. **This carry must NEVER be used to move a person who has an injured neck, back, or pelvis.**

- **Arm Carry**: The two-person arm carry, shown in figures 3–41 and 3–42, can be used in some cases to move an injured person. However, **this carry should not be used to carry a person who has serious wounds or broken bones.**

Another two-person carry that can be used in emergencies is shown in figure 3–43. Two rescuers position themselves beside the casualty, on the same side, one at the level of the chest and the other at the thighs. The rescuers interlock adjacent arms as shown, while they support the victim at the shoulders and knees. In unison, they lift the victim and roll his front toward theirs. **This carry must not be used to move seriously injured persons.**

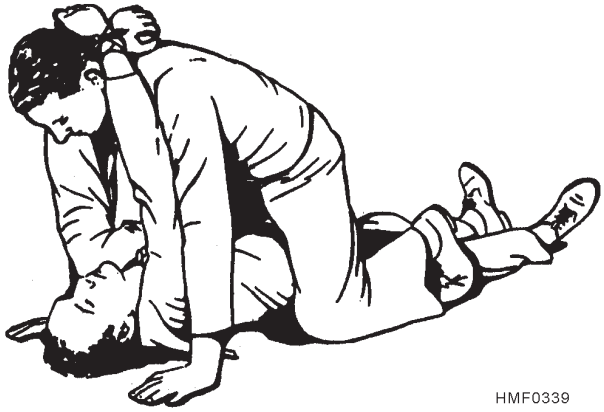


**Figure 3–39.—Tied-hands crawl.**


**Figure 3–38.—Blanket drag.**


**Figure 3–40.—Chair carry.**


**Figure 3–41.—Two-person arm carry.**

## TRANSPORTATION OF THE INJURED

**LEARNING OBJECTIVE:** *Recognize the different forms of emergency transportation, and identify essential BLS equipment and supplies on Navy ambulances.*


**Figure 3–42.—Two-person arm carry (alternate).**

Thus far we have dealt with emergency methods used to move an injured person out of danger and into a position where first aid can be administered. As we have seen, these emergency rescue procedures often involve substantial risk to the casualty and should be used only when clearly necessary.

Once you have rescued the casualty from the immediate danger, **SLOW DOWN**! Casualties should not be moved before the type and extent of injuries are evaluated and the required emergency medical treatment is given. (The exception to this occurs, of course, when the situation dictates immediate movement for safety purposes. For example, it may be necessary to remove a casualty from a burning vehicle. The situation dictates that the urgency of casualty movement outweighs the need to administer emergency medical treatment.)

From this point on, handle and transport the casualty with every regard for the injuries that have been sustained. In the excitement and confusion that almost always accompany an accident, you are likely to feel rushed, wanting to do everything rapidly. To a certain extent, this is a reasonable feeling. Speed is essential in treating many injuries and in getting the casualty to a medical treatment facility. However, it is not reasonable to let yourself feel so hurried that you


**Figure 3–43.—Two-person arm carry (alternate).**

become careless and transport the victim in a way that will aggravate the injuries.

**Emergency Vehicles**

In most peacetime emergency situations, some form of ambulance will be available to transport the victim to a medical treatment facility. Navy ambulances vary in size and shape from the old "gray ghost" to modern van and modular units. Although there are many differences in design and storage capacity, most Navy ambulances are equipped to meet the same basic emergency requirements. They contain equipment and supplies for emergency airway care, artificial ventilation, suction, oxygenation, hemorrhage control, fracture immobilization, shock control, blood pressure monitoring, and poisoning. They will also contain litters, spineboards, and other supplies and equipment as mandated in BUMEDINST 6700.42. (Table 3–1, at the beginning of this chapter, lists the currently required equipment for EMT-Basic level ambulances, and table 3–2 lists the contents of an emergency bag that a Hospital Corpsman might find in that ambulance.)

Deployed units at sea and in the field and certain commands near air stations will also have access to helicopter MEDEVAC support. Helicopters are ideal for use in isolated areas but are of limited practical use at night, in adverse weather, under certain tactical conditions, or in developed areas where building and power lines interfere. In addition to taking these factors into consideration, the Corpsman must decide if the victim's condition is serious enough to justify a call for a helicopter.

Some injuries require very smooth transportation or are affected by pressure changes that occur in flight. The final decision will be made by the unit commander, who is responsible for requesting the helicopter support.

**Preparing the Patient for Transport**

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**LEARNING OBJECTIVE:** *Recall preparatory, en route, and turnover procedures for patients being transported to medical treatment facilities.*

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Once emergency medical care has been completed on-scene, the patient must be transferred to the medical treatment facility. A process known as **packaging** provides the means of properly positioning, covering, and securing the patient to avoid any unnecessary aggravation to the patient's condition. (Covering helps maintain the patient's body temperature, prevents exposure to the elements, and provides privacy.) Do not "package" a badly traumatized patient; it is more important to transport the critical or unstable patient to the medical treatment facility quickly. The most important aspect of each rescue or transfer is to complete it as safely and efficiently as possible.

**Care of Patient en Route**

The emergency care a Corpsman can offer patients en route is limited only by the availability of supplies, the level of external noise and vibrations, and the degree and ingenuity the Corpsman possesses.

### Care at the Medical Treatment Facility

Do not turn the victim over to anyone without giving a complete account of the situation, especially if a tourniquet was used or medications administered. If possible, while en route, write down the circumstances of the accident, the treatment given, and keep a log of vital signs. After turning the patient over to the medical treatment facility, ensure that depleted ambulance supplies are replaced so that the vehicle is in every way ready to handle another emergency.

## SUMMARY

This chapter covered first aid equipment and supplies, and rescue and transportation of the injured patient. You should now be able to recognize the various types of dressings and bandages, as well as how and when to apply them. You should be familiar with protective equipment, rescue operations, the stages of extrication, and the precautionary steps that must be taken in special rescue situations. Additionally, you should be acquainted with the different patient-moving devices and lifting techniques. Further, you should be able to identify essential basic life support equipment and supplies on Navy ambulances, and you should be able to recognize different forms of emergency transportation. Finally, you should now be able to recall preparatory, en route, and turnover procedures for patients being transported to medical treatment facilities.