FIELD MANUAL
NO. 8-230

*FM 8-230
HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 24 August 1984

MEDICAL SPECIALIST

Preface

This manual is for use in training the Medical Specialist, MOS 91B10, in field medical activities, patient care procedures, and general nursing care duties involved in patient care and treatment. It also serves as a ready reference for use by other Army Medical Department units and activities. The material in this manual is applicable to peacetime, nuclear war, and nonnuclear war.

Use of trade names in this manual is for clarity only and does not constitute endorsement by the Department of Defense.

Users of this manual are encouraged to submit recommendations to improve the publication. Comments should be keyed to the page, paragraph, and line(s) of the text where a change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be submitted on DA Form(s) 2028 (Recommended Changes to Publications and Blank Forms) and forwarded to the **Commandant, Academy of Health Sciences, US Army, ATTN: HSHA-TLD, Fort Sam Houston, Texas 78234.**

When used in this publication, the terms "he," "him," "his," "man," and "men" represent both masculine and feminine genders unless otherwise stated. The terms "patient" and "patients" are considered synonymous with the terms "casualty" and "casualties."

The contents of this manual are subject to and in consonance with the following Standardization Agreements:

TITLE	NATO STANAG
Documentation Relative to Medical Evacuation, Treatment, and Cause of Death of Patients	2132
Basic Military Hospital (Clinical) Records	2348

When amendment, revision, or cancellation of this publication is proposed which will affect or violate the international agreements concerned, the preparing agency will take appropriate reconciliatory action through international standardization channels.

*This manual supersedes TM 8-230, 2 November 1970, and FM 8-36, 15 March 1973.

486-923 O - 85 - 1

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

Section I. THE ARMY MEDICAL DEPARTMENT

1-1. General

As a medical soldier, you are a member of a branch of the Army with a long and proud history of service and achievement. The Army Medical Department (AMEDD) was established by the Continental Congress on 27 July 1775. Since that time the AMEDD has cared for American soldiers and has played a vital role in the growth and advancement of medicine around the world. Breakthroughs in military medicine have had a significant impact on the course of civilian medical practice, just as progress in civilian medicine has affected the military.

1-2. Mission

The AMEDD is responsible for maintaining the health of the Army to conserve its fighting strength. It is responsible for all medical services provided within the Department of the Army (DA) and for other agencies and organizations as prescribed in AR 10-5.

Section II. THE COMBAT MEDIC

1-3. General

a. This section is designed for you, the combat medic—whether you serve in an infantry platoon, an artillery battery, a cavalry troop, an engineer battalion, an isolated detachment, or a temporary task force. Although addressed to you, the section is also designed for your leaders (platoon sergeants, physicians' assistants, and the leaders of medical elements) so they will know your capabilities.

b. Your responsibility is heavy, but you can handle it. You have not been sent out to do an impossible job, just an important one. When it comes to taking care of the men who are seriously wounded in battle, you are the key man. The entire medical treatment system behind you—from the most forward combat zone hospital all the way back to CONUS—depends on you. Consider this: Every patient of yours who is admitted to a medical treatment facility represents a success on your part. If you had not kept the man alive, he would not be admitted to the facility. Medical treatment facilities save about 98 percent of your patients, but they could not do it unless you saved the patients first.

1-4. Your Main Job

In addition to lifesaving and first aid measures, your job includes the disposition of patients. When a soldier is wounded, or when you are faced with a medical problem, ask yourself, "Should I evacuate this man or treat him here?" Often, the tactical situation and the nature of the man's illness or injuries require *you* to treat him. This manual tells you *how* to treat him.

1-5. Your Resources

In the field, you can give emergency medical treatment but you do so with limited resources. Your physical resources are limited by two things: the tactical situation and how much you can carry. You are trained to improvise in many situations, and to request assistance in others.

1-6. What a Good Combat Medic Does

a. Most of your time is spent, not in combat and treating patients, but in waiting. While you are waiting, you care for your equipment and replenish your supplies; equally important you talk with the troops and advise the battalion surgeon, the physicians' assistant, and the platoon sergeant on *minor medical problems.*

b. You must do your share of the hard work. You are expected to defend yourself and your patients when necessary. You are not supposed to carry a radio or parts of crew-served weapons, but do not hesitate to help a fellow soldier carry a heavy load when you are not in contact with the enemy.

c. Besides doing your share of the work, you will always look out for the welfare of your troops. Before the unit goes on a mission, check out each individual. If you find a soldier with a medical problem, advise the platoon sergeant of the man's condition, capabilities, and limitations. During the mission, observe each man. If you get to know the men well, you can quickly tell when one is getting sick and anticipate many medical problems. Make sure you explain the danger of not using proper personal hygiene; take every opportunity to encourage preventive measures.

d. At the end of the mission, check each soldier again to see if anyone is sick or injured. Some will get minor wounds but not complain about them.

e. During rest periods and between missions, you should make sure all minor medical problems are settled. You may want to go with a trooper on sick call and learn from the medical officer the best way to continue treating him. If medication is prescribed, you should be certain it is taken correctly.

1-7. Preoperational Briefings

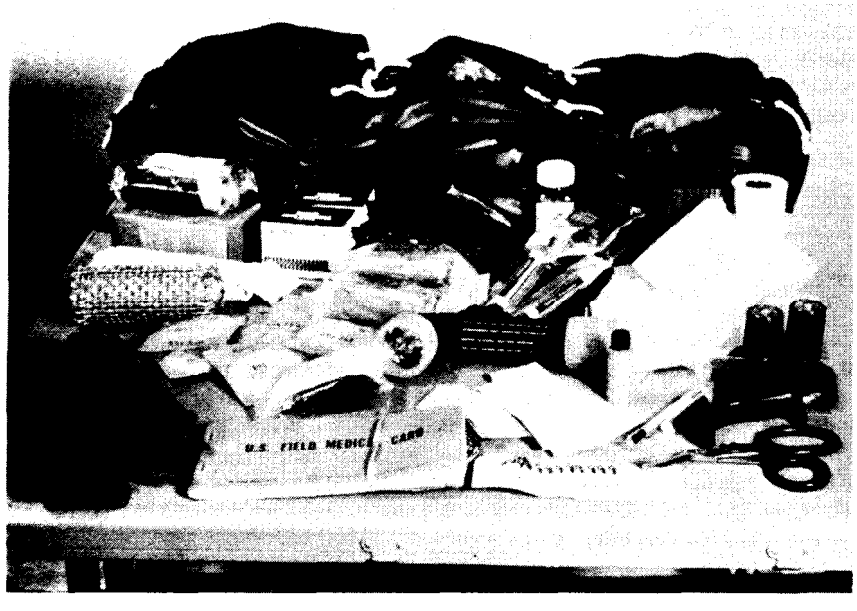
Commanders usually include medical personnel in briefings of tactical situations before a mission. The more you know about the mission and its likely medical hazards, the better you can do your work. When alerted for a mission, go to the platoon sergeant or the platoon leader and ask about it. Find out how far the men are going, how many are going, how long they will be away, and how much enemy action is expected. This information will help you decide what supplies to take.

1-8. Your Aid Bag

The surgical instrument and supply set, individual, is a general use aid bag issued by the medical depot with a standard packing list of supplies. This standard aid bag is a starting point for you. You are responsible for packing and maintaining your aid bag. The aid bag and basic items carried by an aidman are shown in Figure 1-1. What you will need to carry in the aid bag depends upon the nature of the mission. For example, if the mission is to be a walk to and a look around a village, lasting about 2 hours and taking 15 men,

with no enemy action expected, you would take a light bag of supplies. If the mission is to go several miles away, taking 40 men and setting up a night ambush, with enemy action expected, you would take a different bag of supplies. If the company is going on an extended mission, you would take still another aid bag.

CLOSED BAG



OPEN BAG WITH CONTENTS

Figure 1-1. Medical aid bag.

1-9. Steps in Solving Medical Problems

a. Get a history and do a rapid physical examination of the patient. For example, determine whether the wound was caused by a bullet, a mortar round, a booby trap, or a fall from a vehicle. If it is a perforating wound, see if it has both entrance and exit sites. Determine the number of wounds and find out if there is severe hemorrhage, internal bleeding, or a broken bone(s). Quickly assess the vital signs (pulse, blood pressure, respiration) to determine whether the patient's life is in danger.

b. Make a judgment or a tentative diagnosis. For example, if the wound is serious, will the patient die soon without definitive medical treatment? If the wound is not serious, can he continue his mission with some treatment? What is the tactical situation? How much time do you have? How much help can you get?

c. Take positive action.

(1) Get yourself and the patient in the safest position consistent with his injuries and the tactical situation.

(2) Clear the airway and give artificial respiration if necessary. Control hemorrhage as quickly as possible. Treat for shock, if necessary.

(3) Ask for assistance. Move the patient to a safer location and request evacuation if indicated.

(4) Reassure the patient. Positive action will reassure him more than anything you can say to him.

d. For guidance in handling a medical problem beyond your capability, you may be able to use radio communications if the tactical situation permits. The operator can connect you with other medical personnel who can assist you in handling the problem. They can also dispatch personnel and equipment to help you.

Section III. INTERPERSONAL RELATIONSHIPS

1-10. General

There are two kinds of interactions that take place between individuals and individuals and groups: actions and reactions, or cause and effect. When these interactions unite individuals and groups into teams whose members mutually support one another to accomplish their goals, good interpersonal relationships are developed. Since the goal of the AMEDD is to restore a patient to physical and mental health, you must be aware of the importance of good interpersonal relations among the health care team and between the team and the patients/casualties.

1-11. Developing Good Interpersonal Relationships

Development of good interpersonal relationships is not always easy. The number of people involved in providing patient care creates problems of communication and understanding. Good relations are easier to describe than

they are to achieve, and there are few successful formulas that apply in all situations. Some guidance can be given, however, as a means of developing good interpersonal relations.

a. Understanding Oneself. The foundation for good relations with others is a state of good relations with oneself. Self-understanding and self-acceptance (based on a realistic picture of oneself and a genuine feeling of self-worth), justified by performance, are ingredients of effective relationships with others. Just as each individual is a unique person, each must accept the right of another to differ within socially accepted limits. Thus, in any situation where relationships are less than the best, each person must examine himself to see if he has contributed to the faulty relations.

b. Understanding the Patient's Need for Privacy.

(1) You must not divulge information concerning the patient except to those individuals having an official reason to know. Discussions regarding diagnosis, care, and treatment of patients should be held in private to prevent their being overheard by individuals who are not concerned with the medical care being given. Improperly releasing information from a patient's medical records can result in criminal prosecution or disciplinary action for violation of the Privacy Act (see AR 340-21). Release of such information should ordinarily be made only in response to a written request and only after coordination of the request with the Patient Administration Office.

(2) Special attention must be given to the release of information obtained under the provisions of the Army Drug and Alcohol Abuse Program (AR 600-85). Notification of the discovery of potential drug/alcohol abuse is required in certain cases by that program. Notification is also required in certain cases where child or spouse abuse is suspected as the result of providing medical care. These matters must be communicated to medical superiors to determine if reporting is appropriate.

Section IV. LEGAL ASPECTS OF MEDICAL CARE AND TREATMENT

1-12. General

a. Those legal aspects of medical care and treatment of importance to you are covered in this section. This is to alert you to the law as it pertains to your rendering of medical care and treatment.

b. This discussion includes:

(1) Your legal status as a medical service patient care team member.

(2) Some medical-legal problems that could arise when you are assisting with medical care and treatment and when something is done that interferes with the rights and privileges of a patient.

(3) The application of professional practices acts to your duties.

(4) Certain Federal laws, such as the Federal Torts Claims Act (FTCA) and the Gonzalez Act, which apply to your performance of medical duties.

c. The public has special trust in medical and allied professions and in the institutions that provide medical care and treatment. To help insure that this trust is deserved, there are statutes and legal principles which provide patients with legal remedies when they do not receive proper medical care. These remedies are available not only in those rare cases where the patient is harmed intentionally, but also in those cases where the patient is harmed as a result of negligence (carelessness) on the part of medical personnel.

d. Negligent or intentional failure on your part to provide proper medical care to your patients may result in court-martial or administrative actions. Those actions could include MOS reclassification, bar to reenlistment, or administrative discharge from active duty with less than an Honorable Discharge.

e. Negligent actions on your part in the performance of your medical duties may also result in the Army's liability for payment of damages to the patient.

1-13. Law and the Medical Soldier

a. The medical soldier is authorized to perform his assigned military-medical duties within the conditions established for their performance. His legal protection and legal status are established when he works:

(1) Within the scope of his duties (as defined by AR 611-201).

(2) Within the limits of his training.

(3) According to the policies established by his local medical commander. Army regulations that pertain to providing medical services in AMEDD treatment facilities are found in the 40-series.

b. Field Manual (FM) 21-13 contains detailed information regarding the legal status of enlisted personnel as soldiers, subject to and protected by both civil and military law.

1-14. Negligence as a Medical-Legal Problem

a. There is no one uniform code of medical law, but there are laws that have special significance in medical care and treatment areas. A basic rule that applies in providing all medical services is the *rule of negligence.* Everyone—military and civilian, professional and medical specialist—has an absolute duty to conduct himself and operate his property to avoid injury to the person or the property of others. Although the spirit of service to others is a key principle in providing all medical duties, there are responsibilities that extend beyond being kind and thoughtful. When services are rendered, there is *an obligation to use due care* to insure that the patient is not injured because of negligence, which can be defined simply as failure to exercise due care with respect to one to whom care is due. A more complicated legal definition of negligence is doing or failing to do the act (in carrying out a duty) that a

reasonable person in the same or similar circumstances would or would not do where the acting or nonacting in carrying out the duty is the proximate cause of injury to another person or to his property.

b. Although negligence results in an unintentional injury, once injury results, it matters little to the injured patient that it was not intended. Negligence is one of the most common grounds for lawsuits against medical facilities and medical personnel. Examples of negligence include the injuries caused by the use of faulty equipment, burns from applications of hot water bottles and other heating devices, medication errors, falling out of bed, and careless handling of sponges and instruments in operating rooms.

c. In AMEDD treatment facilities, when a patient is the victim of negligent treatment or an accident that may or may not have caused injury, reporting will be accomplished according to the local standing operating procedure (SOP) and the local Risk Management Plan.

1-15. The Federal Torts Claim Act (FTCA)

a. This act permits legal action against the Federal government on damage claims "for injury or loss of property, or personal injury or death caused by the negligent or wrongful act or omission of any employee of the government while acting within the scope of his office or employment, under circumstances where the United States, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred." The phrase "employee of the government" includes members of the military forces, while "scope of his office or employment" for military forces is defined to mean "acting in the line of duty."

b. As the result of a U.S. Supreme Court decision *(Feres v. U.S.),* an Active Duty service member is not permitted to sue the Army if his injury was received incident to his service. This decision prohibits Active Duty personnel from recovering for injuries they incur while receiving medical care as receiving such care is incident to their service. However, dependents of service personnel and retired service members can sue for their own injuries received in such cases.

c. Under terms of the Gonzales Act, 18 USC 1089, the United States is the only defendant that may be required to pay damages in a lawsuit arising out of the provision of military medical care, so long as the health care provider was acting within the scope of his military duties. These lawsuits are defended in Federal courts by the Department of Justice. While this statute protects the health care provider from tort liability (paying money damages), it does not prevent appropriate disciplinary action being taken (para 1-12d). This statute does not protect a military health care provider who is engaged in outside employment or is otherwise acting outside the scope of his military duties.

d. Various states have so-called "Good Samaritan" laws which protect certain individuals who stop at the scene of an accident or other emergency and render medical attention. These laws vary from state to state in terms of who is protected (in some states only physicians are protected) and under what circumstances. In a very few states, you may be required to render such

emergency assistance, but as a rule, there is no such requirement. Your local Staff Judge Advocate Office can provide information concerning such laws in your state.

Section V. MEDICAL TERMINOLOGY

1-16. General

a. Every specialized field has its own vocabulary to communicate special concepts and concerns—medicine is no exception. It is important for you to become familiar with the language of medicine for several reasons. First, an understanding of medical terminology will enable you to think more precisely in terms of medical problems. Also, a knowledge of the terminology will help you communicate effectively with the other health professionals with whom you will be dealing; to communicate, you must speak the same language.

b. Medical terms are often derived from Greek and Latin roots. These root words or key words are the foundation of a word. An example of a root word is "aden," which means pertaining to a gland. A root word, followed by a vowel to facilitate pronunciation (as in "adeno"), is known as a combining form; however, this is not a complete word. Adenocarcinoma (a malignant growth of gland-like cells) or adenoma (a tumor, usually benign, with a gland-like structure) are complete words.

c. When using two or more root words, a root word and a combining form, or a combining form and a whole word put together, the result is called a compound word. Examples of the first two combinations include chicken pox and erythrocyte (red blood cell), respectively. Thermometer, speedometer, and microscope are 2 examples of the latter, whereby "thermo," "speedo," and "micro" are the combining forms and "scope" and "meter" are the words.

1-17. Prefixes

A prefix is a part of a word that precedes the root word and changes its meaning. It is usually a preposition or an adverb. The final vowel of the preposition is dropped when the word to which it is affixed begins with a vowel. "Dys" is a prefix meaning disordered, painful, or difficult. Dysrhythmia implies a disordered heart rhythm. "Neuro" (denoting nerve), another example of a prefix, combines with the term "algia" (pain) to form neuralgia, which refers to an aching along the course of nerve. Tables 1-1 and 1-2 list some of the more common prefix roots with which you should become familiar.

Table 1-1. Common Prefixes Pertaining to the Body

Prefix	Meaning
arthro-	joint
brach-	arm
capit-	head
cardi-	heart
cephalo-	head
cerebro-	brain
cholecyst-	gallbladder
choli-	bile
cyst-	bladder
derma-	skin
entero-	intestines
gastro-	stomach
glosso-	tongue
hemo-	blood
hepato-	liver
hystero-	uterus
laparo-	abdomen
myo-	muscle
nephro-	kidney
neuro-	nerve
ophthalmo-	eye
oral-	mouth
osteo-	bone
oto-	ear
pharyn-	throat
phlebo-	vein
pneumo-	air, lung
procto-	rectum
pyelo-	pelvis
rhino-	nose
thoracic-	chest

Table 1-2. Common Prefixes Pertaining to Conditions

Prefix	Meaning
a-, an-	lacking, absence of
ante-	before
anti-	against
auto-	self
brady-	slow
contra-	against, opposed to
dys-	difficult, painful
endo-	within
hemi-	half
hydro-	water
hyper-	above, increase
hypo-	below, under
mal-	ill, poor, bad, disorder
neo-	new, recent
oligi-	scanty, few
poly-	too many, too much
pyo-	pus
pyro-	heat, temperature
tachy-	fast

1-18. Suffixes

a. A suffix, or word ending, is a part that follows the root word and adds to or changes its meaning. It follows the root word without insertion of a connective "o."

b. The suffix "pnea" means breathing. Dyspnea is interpreted as difficulty in breathing. "Itis" refers to inflammation, as in neuritis, which means inflammation of a nerve. Another common suffix is "ology," or the science of cardiology, which is the science of the heart. Neurology is the science of the nerves and of the nervous system. Tables 1-3 and 1-4 list some of the more common suffix roots with which you should be familiar.

Table 1-3. Common Suffixes Pertaining to Conditions of the Body

Suffix	Meaning
-algia	pain
-cele	tumor, swelling
-clysis	slow injection of a large amount of fluid
-cyte	cell
-emia	blood
-esthesia	sensation
-itis	inflammation
-lith	stone
-mania	insanity
-oma	tumor
-opia	vision
-pathy	disease
-phobia	fear or dread
-plegia	paralysis
-pnea	breathing
-ptosis	falling
-rrhea	flow or discharge
-scopy	looking into
-therapy	treatment
-thermy	heat
-trophic	growth
-uric or uria	urine

Table 1-4. Common Suffixes Pertaining to Surgical Operations

Suffix	Meaning
-ectomy	removal of
-manometer	used to measure pressure
-meter	used to measure
-(o)rrhaphy	repair of
-(o)stomy	creation of an opening
-(o)tomy	cutting into
-pely	to fasten
-plasty	to form or build up
-scope	used to examine by looking into, or by hearing

CHAPTER 2

INTRODUCTION TO THE HUMAN SYSTEM

2-1. General

a. The science of anatomy is the study of the structure of the body. Considering the body as a complex machine, anatomy is the study of how that machine is put together. It deals with the structure of the parts, ranging from the molecular components of the tiniest cell, to the whole individual, and the relationship of these parts to one another.

b. Physiology is concerned with the functions, or mechanics of the body; how it works and what regulates, limits, and protects it. Functions include digestion, respiration, circulation, and reproduction. Structure and function are so closely related that it is impossible to understand one without the other, since the effectiveness with which a function can be carried out depends largely upon the structure of the part.

c. Pathology is the study of changes in the structure or function of the body caused by disease or trauma. In this chapter, we will be concerned with normal structures and functions of the various subsystems of the human body.

2-2. Anatomical Terminology

Terms of position, direction, and location that are used in reference to the body and its parts include the following:

a. Terms of Position. Anatomical position—an artificial posture of the human body. See Figure 2-1. This position is used as a standard reference throughout the medical profession:

(1) The body stands erect with heels together.

(2) Upper extremities are along the sides with the palms of the hand forward.

(3) The head faces forward.

b. Anatomical Postures. The anatomical postures are:

(1) *Erect.* The normal posture of the body in a standing position.

(2) *Supine.* The horizontal position of the body lying flat on the back.

(3) *Prone.* The horizontal position of the body lying face down.

(4) *Lateral recumbent (Sims position).* The horizontal position of the body lying on the left or right side.

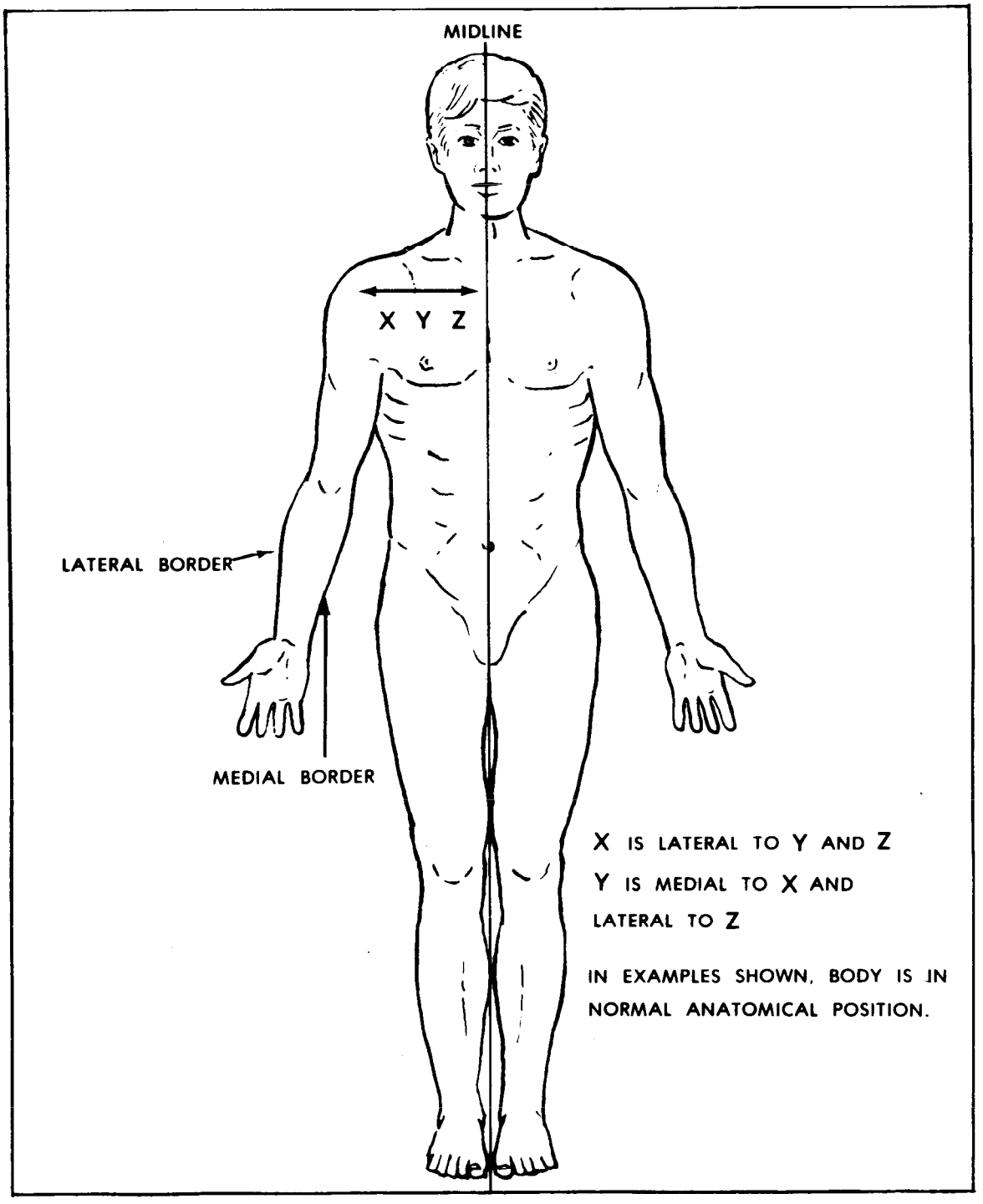


Figure 2-1. The anatomical position.

c. Terms for Anatomical Planes. Imaginary straight line divisions of the body are called planes. Figure 2-2 illustrates the imaginary planes used to describe the body.

(1) *Sagittal planes.* Vertical planes that pass through the body from front to back. The median or midsagittal plane is the vertical plane that divides the body into right and left halves.

(2) *Horizontal (transverse).* Planes that divide the body into two segments. They are perpendicular to both the sagittal and frontal planes.

(3) *Frontal (coronal).* Vertical planes that pass through the body from side to side. They are perpendicular to the sagittal plane.

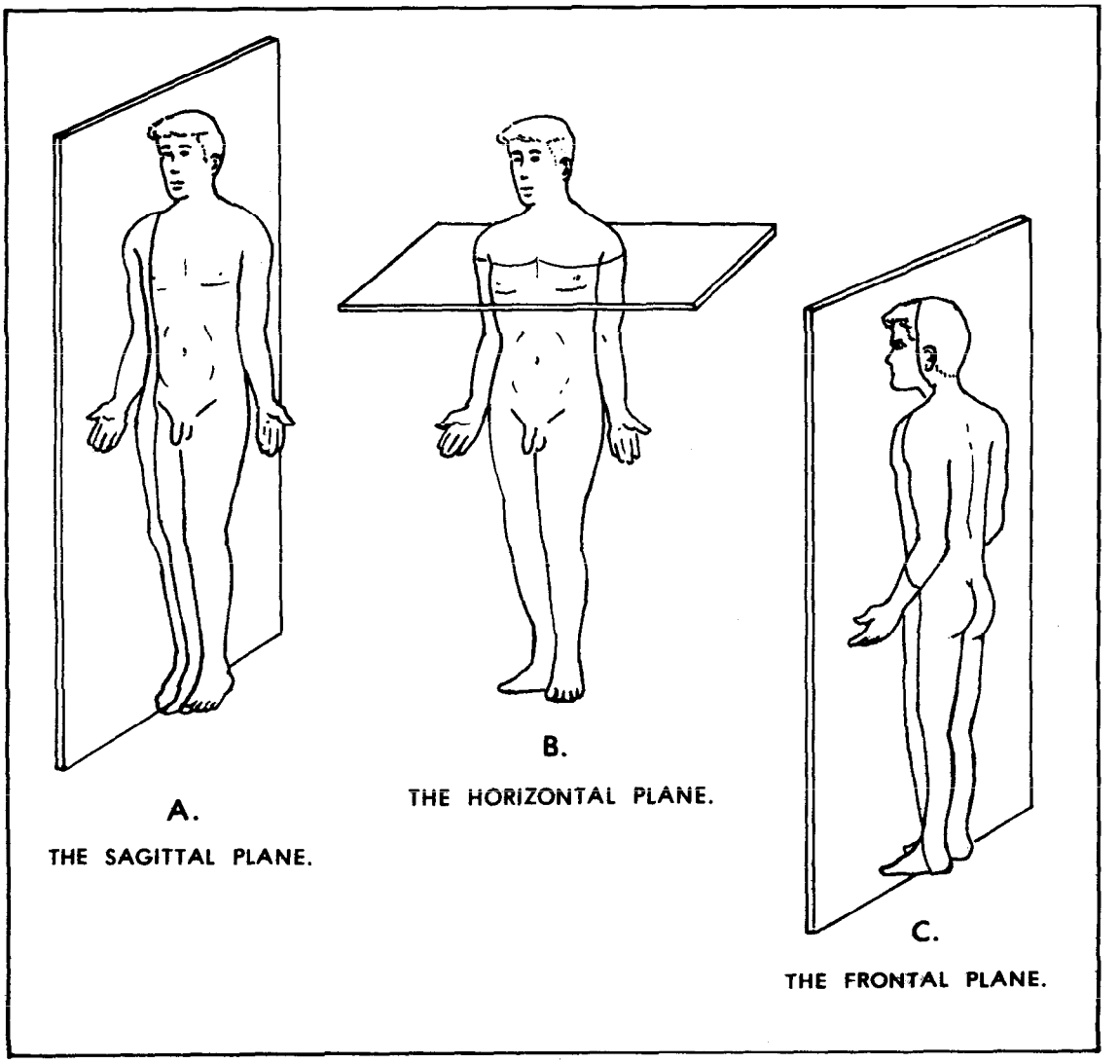


Figure 2-2. Anatomical planes.

d. Terms of Direction and Location.

(1) *Anterior (or ventral)*—at or near the front side of the body.

(2) *Posterior (or dorsal)*—at or near the back side of the body.

(3) *Medial*—toward or near the midline of the body.

(4) *Lateral*—away from the midline or toward the left or right of the midline.

(5) *Proximal*—nearest the point of origin or attachment. Used most in describing the limbs.

(6) *Distal*—away from the point of origin or attachment.

(7) *Superior (cranial)*—above or toward the head.

(8) *Inferior (caudal)*—below or toward the feet.

e. Terms of Body Regions. The body is a single, total composite system. Everything works together. Each part acts in association with all other parts. It is also a series of regions (Figure 2-3). Each region is responsible for certain body activities. These regions are:

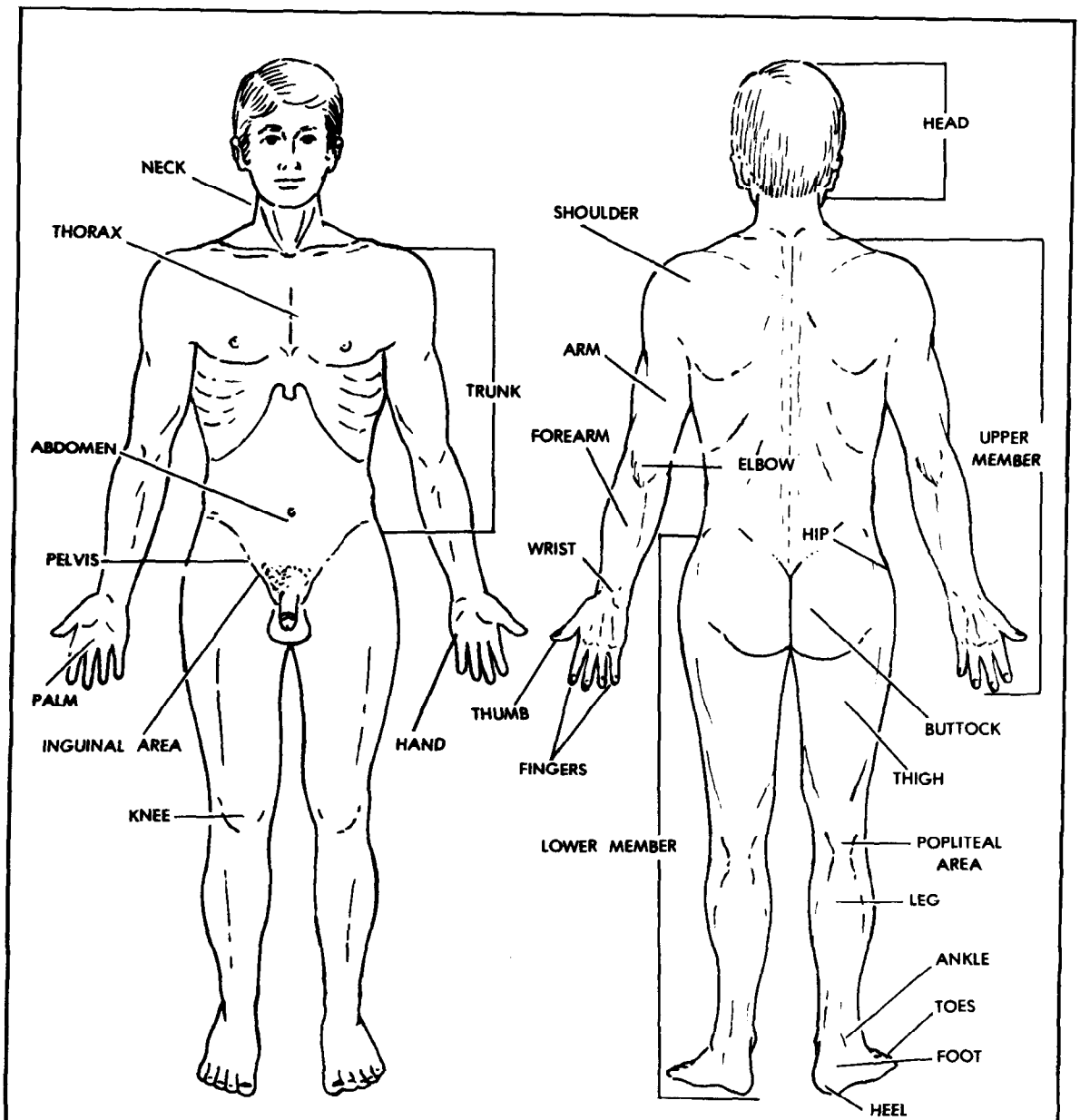
(1) *Back and trunk.* The torso includes the back and the trunk. The trunk includes the thorax (chest) and abdomen. At the lower end of the trunk is the pelvis. The perineum is the portion of the body forming the floor of the pelvis. The lungs, heart, and digestive system are found in the trunk.

(2) *Head and neck.* The brain, eyes, ears, mouth, pharynx, and larynx are found in this region.

(3) *Extremities.*

(a) Each upper extremity includes a shoulder, arm, forearm, wrist, and hand.

(b) Each lower extremity includes a hip, thigh, leg, ankle and foot.



NOTE: The perineal region (perineum) is on the underside of the trunk, between the beginnings of the thighs.

Figure 2-3. Regions of the body.

f. Terms for Directions of Movement.

(1) *Abduction*—movement away from the midline of the body.

(2) *Adduction*—movement toward the midline of the body.

(3) *Lateral rotation*—to rotate outward, or away from the body's midline.

(4) *Medial rotation*—to rotate inward or toward the body's midline.

(5) *Flexion*—is the act of bending.

(6) *Extension*—is the act of straightening.

2-3. Cells

The cell is the basic structural and functional unit of all living things. It may be defined as the minimal structural unit of protoplasm that can carry on all of the vital functions characteristic of living things. The human body is composed of trillions of cells which vary in shape and size. Cells are microscopic in size with the largest being only about 1/1,000 of an inch. Because of this, a special unit of measurement, the micron, is used to determine cell dimensions. (One micron equals 1/1,000 millimeter or about 1/25,000 of an inch.) Each of these cells is a living organism in itself, capable of existing, performing chemical reactions, and contributing its part to the overall function of the body. Although all living matter is composed of cells, animal cells are significantly different from each other. Not only do plant cells contain chlorophyll, a green coloring matter, but also have a cell wall around them which is made up of a very complex carbohydrate known as cellulose. Neither chlorophyll nor cell walls are present in animal cells. A typical animal cell includes a cell membrane, protoplasm, and a nucleus. A typical animal cell is illustrated in Figure 2-4.

a. Cell Membrane. The cell or plasma membrane surrounds and separates the cell from its environment. This membrane allows certain materials to pass through it as they enter or leave the cell. It is through the cell membrane that all materials essential to metabolism are received, and all products of metabolism are disposed of.

b. Protoplasm. The major substance of the cell is known as protoplasm. It is a combination of water and a variety of materials dissolved in water. Outside the cell nucleus, protoplasm is called cytoplasm; inside the cell nucleus, it is called nucleoplasm.

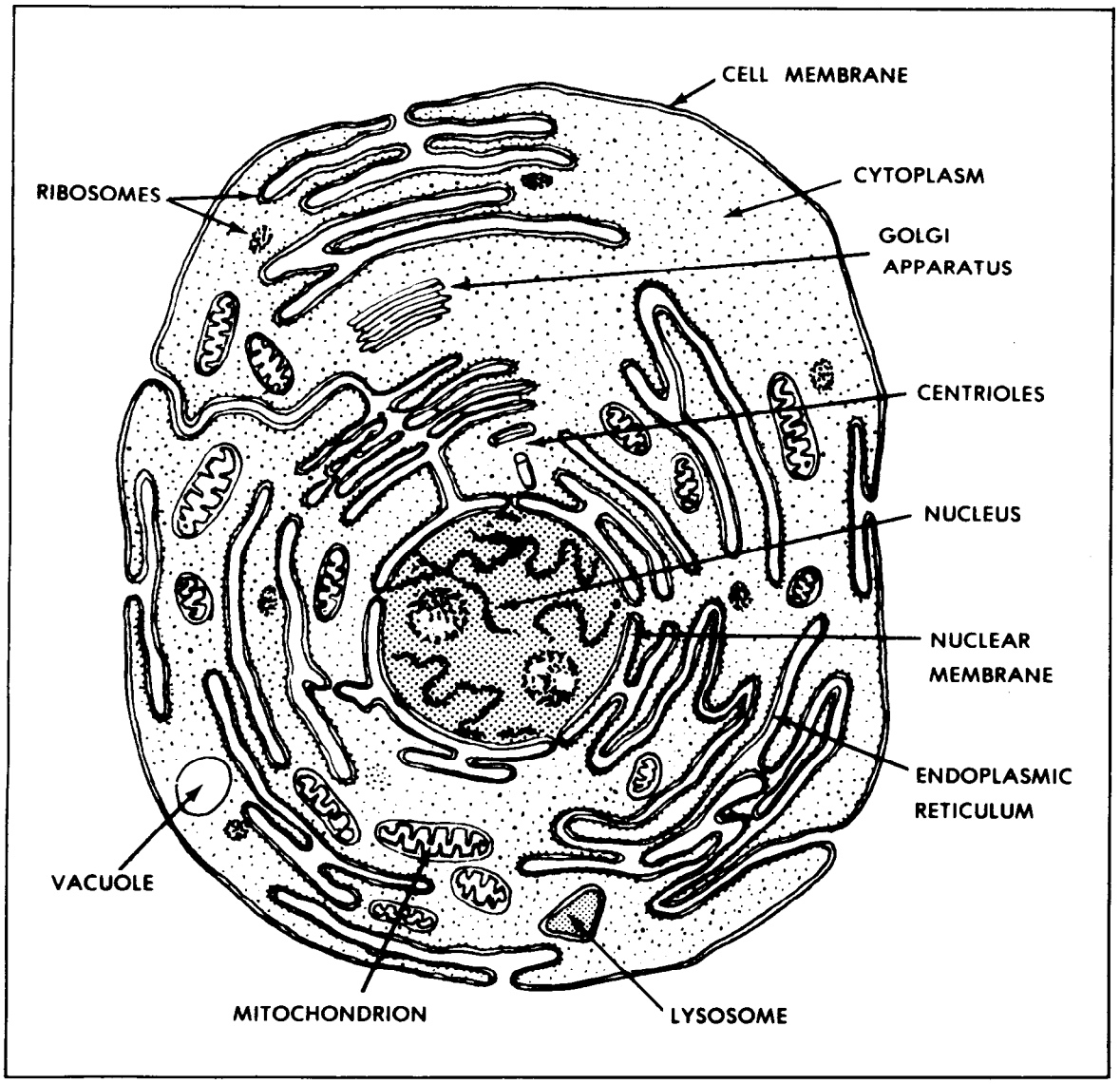


Figure 2-4. Simple animal cell.

c. *Nucleus.* The nucleus plays a central role in the cell. It controls all activities of the cell including growth and reproduction. Information is stored in the nucleus and distributed to guide the life process of the cell. This information is in a chemical form called nucleic acids. Two types of structures found in the nucleus are chromosomes and nucleoli. Chromosomes can be seen clearly only during cell division. Chromosomes are composed of both nucleic acids and proteins, and contain genes. Genes are the basic units of heredity which are passed from parents to their children. Genes guide the activities of each individual cell.

d. Vital Functions. Reduced to the simplest terms, the so-called vital functions may be identified by four properties: metabolism, growth, irritability and adaptability, and reproduction.

(1) Metabolism is the ability to carry on all the chemical activities required for cell function. The processes are involved in energy exchange. It includes using food and oxygen, producing and eliminating waste, and manufacturing new materials for growth, repair, and use by other cells. Growth and metabolism involve many of the same functions, but they are two different things.

(2) Growth occurs when the metabolic balance is tipped slightly in favor of building processes over breakdown processes. It is because of the metabolic processes that cells grow larger and more numerous. The metabolism of special cells allows them to form structures such as bones and fibrous tissues, enlarging the entire body. Thus metabolism is the basic function not only for energy needed by the body, but also for growth itself.

(3) Irritability and adaptability denote the ability to respond to a change in the environment, that is, to a stimulus. Adaptation is a long-range response to environmental change, as observed in evolutionary changes over many generations. The nature of the responses varies with the structure or cell stimulated, as well as the nature of the stimulus.

(4) Reproduction is the ability to perpetuate an individual's own kind. Reproduction also insures the continuity of the species. Cell growth and reproduction usually go together, with both occurring simultaneously. We know that certain cells, such as blood cells, bone marrow, and layers of the skin, grow and reproduce all the time. However, many other cells, such as muscle cells do not reproduce for many years. A few cells, such as neurons, do not reproduce during the entire life cycle of the human body. Most cells of the body reproduce continually, though that rate of reproduction usually remains greatly surpressed. Yet, if there is an insufficiency of a given type of cell in the body, this type of cell will usually grow and reproduce very rapidly until appropriate numbers are again available.

2-4. Tissue

Tissue is a cohesive group of similar cells. For example, liver cells are bound together to form liver tissue, and bone cells are bound together with lime salts to form bony tissue. The tissues of the body have different characteristics because the cells which compose them are different both in structure and function. There are four primary types of body tissue:

a. Epithelial tissue which makes up all covering and lining membranes of the body and all glands.

b. Connective tissue which supports and connects other tissues.

c. Nervous tissue which is specialized to receive stimuli and conduct messages over long distances.

d. Muscle tissue which is specialized to contract (shorten) in response to stimuli from nerves.

2-5. Connective Tissues

Connective tissues are the tissues that support or hold other tissues together, or fill spaces. Among and outside the cells of the connective tissue is a material called matrix. The matrix is manufactured by the connective tissue cells. Each type of connective tissue has its own particular type of matrix. Several major types of connective tissue (CT) include fibrous CT (FCT), cartilage CT, bone CT, and fat CT.

2-6. Muscle Tissue

There are muscle tissues and there are organs called muscle tissues. Muscle tissue and the muscles they make up are specialized to contract. Because of their ability to shorten (contract), muscles are able to produce motion. Figure 2-5 illustrates the three types of muscle tissue: smooth, striated, and cardiac.

a. Smooth Muscle Tissue. Cells of smooth muscle are long, but remain as individual cells. Smooth muscle tissue is found generally in the walls of hollow organs, such as the digestive system, the respiratory system, the blood vessels, and the urinary bladder.

b. Striated Muscle Tissue. The cells of striated muscle tissue have united to form fibers. Striated muscle tissues are found making up the skeletal muscles that assist in activities such as pushing, pulling, running, walking, or swimming.

c. Cardiac Muscle Tissue. In the myocardium (the muscle layer of the heart), the cells have also united to form cardiac fibers. These fibers are cross-striated, but branched. The heart and its component parts will be discussed in a later chapter.

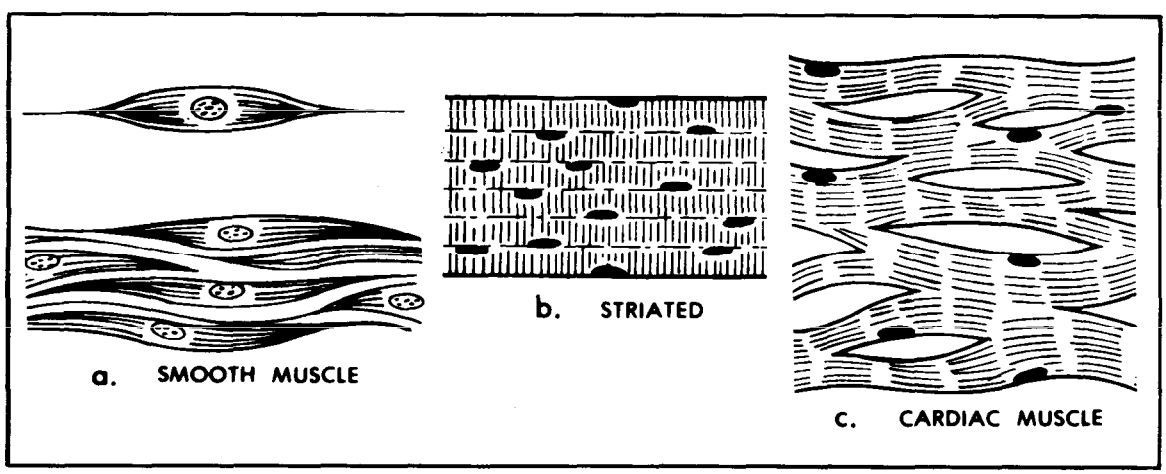


Figure 2-5. Types of muscle tissue.

2-7. Nervous Tissue

Nervous tissue is a collection of cells that respond to stimuli and transmit information.

a. A neuron (Figure 2-6), or nerve cell, is the cell of the nervous tissue that actually picks up and transmits a signal from one part of the body to another. A synapse (Figure 2-7) is the point at which a signal passes from one neuron to the next.

b. The neuroglia (also known as glia) is made up of the supporting cells of the nervous system. The nervous tissues will be discussed in a later chapter.

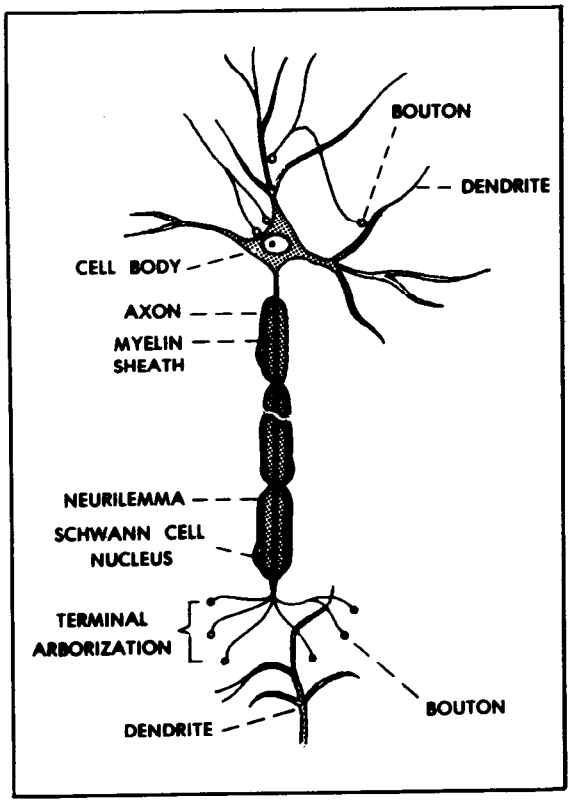


Figure 2-6. A neuron.

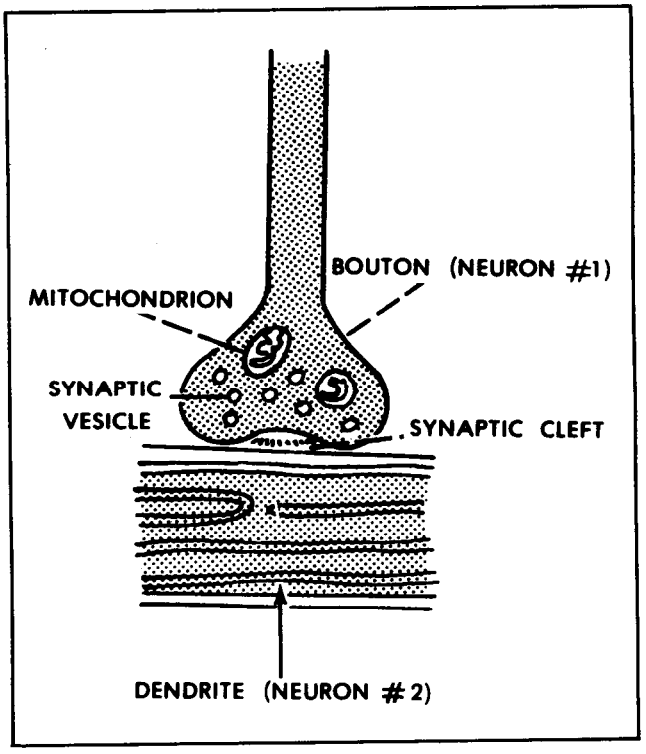


Figure 2-7. A synapse.

CHAPTER 3

THE INTEGUMENTARY SYSTEM

3-1. General

The integumentary system includes the integument proper and the integumentary derivatives. The integument proper is commonly known as the skin and is the outermost covering of the entire body. The integumentary derivatives include the hairs, nails, and various glands of the skin. The skin, as the largest organ of the body, serves the body in many important ways:

a. Protection as a mechanical barrier to the entrance of bacteria and foreign objects and against minor injury.

b. Regulation of body temperature through control of heat and loss or retention of water.

c. Sensory perception through neuron endings that transmit sensations of heat, cold, touch, pain, and pressure.

d. Limited excretion of body wastes through sweat. The skin also protects inner tissues from drying. Although this is not one of its normal functions, the skin can absorb water and other substances. This function is used to advantage in the local application of certain drugs. It can also be harmful when toxins and chemical agents are absorbed through the skin.

3-2. The Integument Proper

The integument proper (skin) is the outermost layer of the body. The skin consists of two layers: the outer layer and the inner layer. The outer layer is called the epidermis and the inner layer is called the dermis.

a. The Epidermis. The epidermis is a stratified squamous epithelium. This means that it is made up of several layers of cells. There are no blood vessels or neuron endings in the epidermis. The outermost cells are flat and resemble scales. These dead cells are constantly flaking off the surface. As this happens, growing inner epidermal cells are pushing up toward the surface to replace the outer cells. Skin pigment called melanin is produced in cells located below the epidermis and injected into the epidermal cells. It determines the darkness or lightness of skin color. However, the skin color is also due to the quantity and state of the blood circulating in the dermis. Pinkness, blueness (cyanosis), or paleness (pallor) of the skin surface is due to the amount of blood circulation.

b. The Dermis (Dermal Layer). The dermis is the layer of the skin lying just beneath the epidermis. It is dense fibrous connective tissue consisting of white and yellow fibers. The dermis has fingerlike projections called papillae. These papillae extend into the epidermis and keep the dermis and epidermis from sliding on each other. The dermal layer includes blood vessels, lymph vessels, nerve endings, hair follicles, and glands.

3-3. Integumentary Derivatives (Skin Accessory Organs)

The integumentary derivatives include the glands, hairs, and nails associated with the skin. All integumentary derivatives are formed from the tissues of the integument proper (dermis and epidermis). They are appended (attached) to the integument proper and are often known as the appendages of the skin. (See Figure 3-1.)

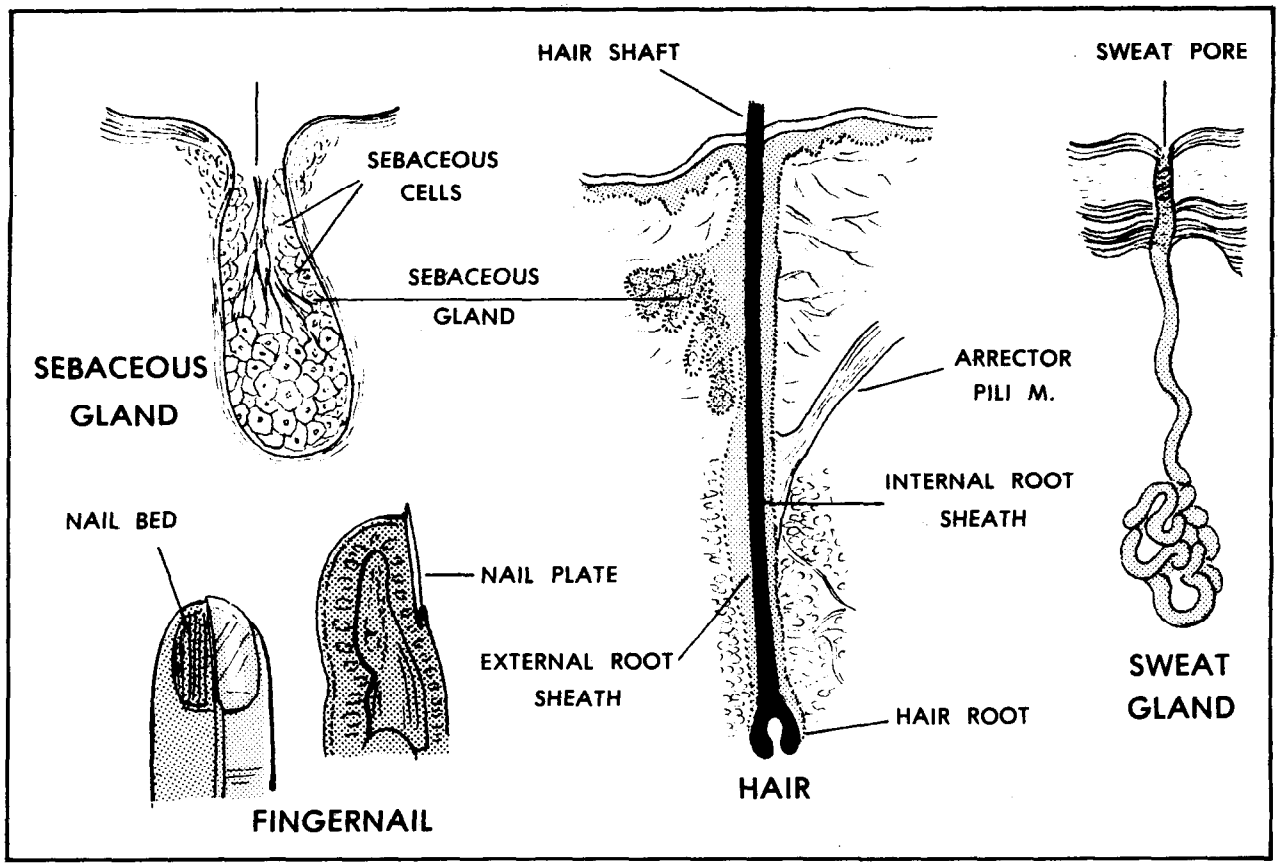


Figure 3-1. The integumentary derivatives.

a. Hairs.

(1) A hair follicle is formed by the extension of the skin (dermis and epidermis) deeper into the surface of the body. Follicles may extend into the subcutaneous layer. At the base of the hair follicle is the hair root. The hair shaft grows out from the root and is made up of cells from the outermost layers of the epidermis.

(2) Scalp and facial hairs grow continuously. Other hairs of the body grow to fixed lengths. The types and patterns of hairs are determined for each individual by genetics.

(3) Friction against the integument is reduced by hairs and outer dead cells.

b. Glands. The types of glands include the sweat glands, the sebaceous (fat/oil) glands, and the mammary glands (breasts). The ducts and secretory parts of these glands are made of epithelial tissues. Backup or supporting tissue is of fibrous connective tissue.

(1) *Sweat glands.* Sweat glands consist of a coiled secretory portion and a duct leading to the surface of the skin. The coiled secretory portion is located in the dermis or deeper. Sweat glands are found everywhere on the body in association with the skin. Sweat glands manufacture sweat, or perspiration, from fluid drawn from blood. Sweat contains salts and organic wastes and is about 99 percent water. It is discharged through skin openings called pores. As sweat evaporates, the body is cooled. Sweat formation and excretion are important mechanisms for reducing body heat.

(2) *Sebaceous glands.* Sebaceous glands produce an oily substance called sebum, which lubricates the skin and hairs. The oil keeps the skin and hairs pliable and helps keep the skin waterproof. The sebaceous glands are usually found as a part of the walls of hair follicles and their oil flows into the follicle. In a few places without hairs, they open directly to the skin surface. When the openings of the sebaceous glands become plugged with dirt, they form blackheads.

(3) *Mammary glands.* In the adult human female, the mammary glands lie in the subcutaneous layer anterior to the chest muscle (pectoralis major). Their function is to nourish the newborn. A nipple is located near the center of each breast. Around each nipple is a darkened area known as the areola. The tip of the nipple has many small openings to allow the passage of the milk from the milk ducts. These ducts are connected to lobes of glandular tissue located throughout the breast. Fat and fibrous connective tissue fill in the spaces among the lobes.

c. Nails. Nails are located in the ends of the digits (thumbs, fingers, and toes). Nails help to protect the ends of these digits and aid in picking up objects. Each nail bed is attached to the top of the terminal phalanx (bone of each digit). The nail itself is made up of cornified (hardened) outer cell layers of the epidermis. The nails grow continuously from their roots.

3-4. Fascial Tissue

A fascia is a sheet or collection of fibrous connective tissue. The superficial fascia is the connective tissue which lies immediately beneath the skin and is often known as the subcutaneous layer. Deep fasciae (plural) form envelopes for muscles and other organs. Portions of the integumentary system and fascial tissue are shown in Figure 3-2.

a. Superficial Fascia.

(1) The superficial fascia is the second envelope of the body. It is the connective tissue that lies immediately between the skin (integument proper) and the deep fascial envelope. It is often called the subcutaneous layer, but it is technically not a part of the integumentary system. Fat deposits located here store reserve energy for the body and form an insulating layer. Fat and other fibrous connective tissues in the subcutaneous layer round out body surfaces and cushion bony parts.

(2) The superficial fascia is made up primarily of loose areolar fibrous connective tissue with the spaces filled by fatty tissue and tissue fluid. It contains the superficial or cutaneous branches of nerves, arteries, veins, and lymphatics (NAVL) of the skin.

b. Deep Fasciae.

(1) The deep fasciae include various membranes made of consolidated or dense fibrous connective tissue. A deep fascia envelops the entire body as the third envelope. This third envelope is known as the investing deep fascia. It is beneath the skin and subcutaneous layers.

(2) Deep fasciae also include the envelopes of the muscles and other organs. Around individual organs (for example, the kidney) it is called a capsule.

(3) Another form of deep fascia is found in the collections of loose areolar fibrous connective tissue and fat that are found as filling among the organs. Similar deep fasciae attach organs to the body wall.

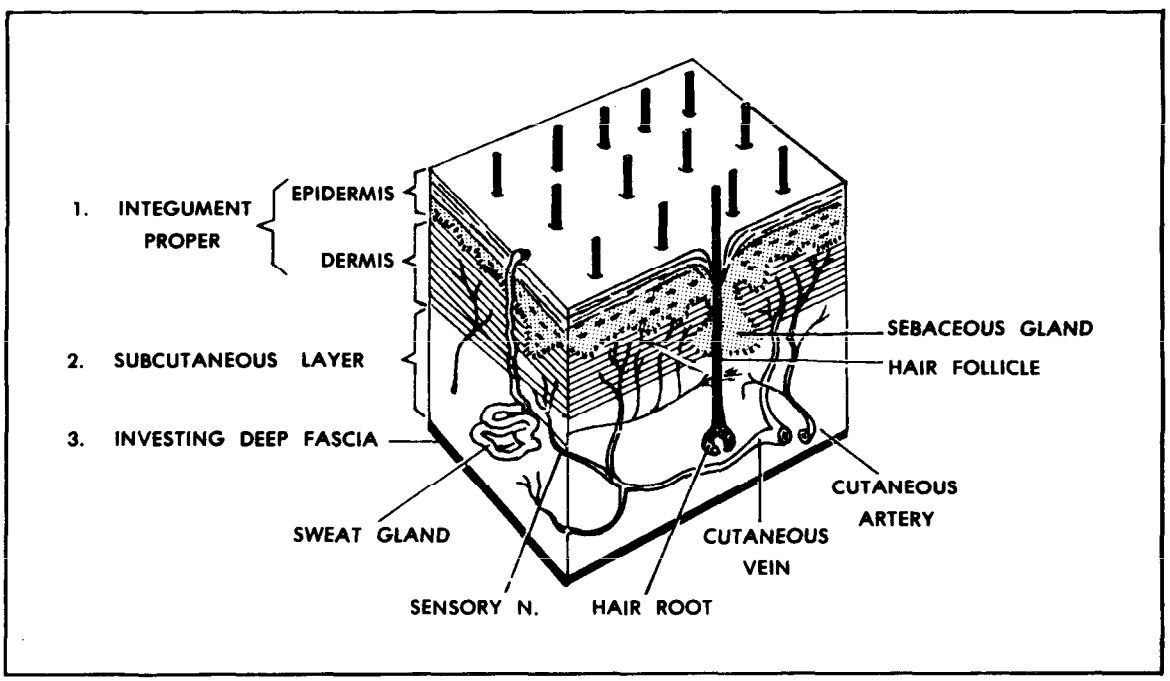


Figure 3-2. The integument and related structures.

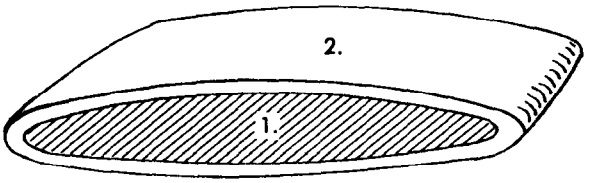
3-5. Serous Cavities of the Body

The term serous refers to a watery-type fluid. Serous cavities are sacs lined with serous membranes. These cavities serve as lubricating devices. They reduce the friction during the motion between organs.

a. Bursa.

(1) A bursa (Figure 3-3) is the simplest of serous cavities. Each bursa is a small sac located between two moving structures, usually a muscle moving over a bony surface. The bursa reduces the friction between the two structures. For example, a bursa prevents excessive friction between the skin and patella (kneecap). This bursa, called the prepatellarbursa, allows the skin to move freely over the patella.

(2) As a fibrous sac, each bursa has a central cavity that is lined with a serous membrane. This membrane is a simple epithelium. The serous membrane secretes a serous fluid into the serous cavity. The serous fluid is the lubricant, minimizing friction.



1. SEROUS (BURSAL) CAVITY:
   a. SPACE CONTAINING JUST ENOUGH SEROUS FLUID TO MOISTEN INNER SURFACE
   b. SPACE ARTIFICIALLY WIDENED FOR DIAGRAMMATIC PURPOSES.
2. (BURSAL) CAPSULE
   a. "BAG-LIKE" — SURROUNDING THE SEROUS CAVITY.
   b. FCT MEMBRANE MAIN STRUCTURAL ELEMENT.
   c. A SEROUS MEMBRANE (SIMPLE SQUAMOUS EPITHELIAL TISSUE) AS AN INNER LINING OF THE CAPSULE. THE SEROUS MEMBRANE INCLOSES THE SEROUS CAVITY AND SECRETES THE SEROUS FLUID.

Figure 3-3. A bursa—the simplest serous cavity.

b. Other Serous Cavities of the Body.

(1) Other important serous cavities are associated with the major hollow organs, referred to as visceral organs. Each lung is encased in a serous cavity called the pleural cavity. The heart lies in a serous cavity called the pericardial cavity. The intestines are allowed to move freely during the digestive processes within the peritoneal cavity.

(2) Each serous cavity has an inner and an outer membrane. The inner membrane is intimately associated with the surface of the visceral organ. The outer membrane forms the outer wall of the cavity. The serous lining of the cavity secretes the serous fluid into the cavity to act as a lubricant between the membranes, allowing freer motion for the organs.

CHAPTER 4

THE SKELETAL/MUSCLE SYSTEM

Section I. THE SKELETAL SYSTEM

4-1. General

The skeletal system (Figures 4-1A and 4-1B) provides a framework for the body, giving it form and protection, and enclosing the vital organs, such as the brain, heart, and lungs. The skeletal system is composed of:

a. *Bones,* 206 in number, which form the hard framework of the body.

b. *Cartilage,* which provides connecting and supporting structures.

c. *Ligaments,* which bind bones together.

4-2. Basic Structure of a Bone

Bones are formed of a protein matrix, which provides growth, and salts (basically calcium phosphate salts), which give bones their characteristic hard texture. Living cells within the matrix constantly repair the structure of bones and play an important role in the healing of fractures. Other cells (the marrow) occupy the cavities within the bones and produce blood cells. Bones are living tissue like muscle, skin, and other tissues; a rich blood supply constantly provides the oxygen (O_2) and nutrients required by the bones. Each bone also has an extensive nerve supply. This is why the fracture of a bone will produce severe pain from irritation of nerves as well as significant bleeding from damage to its blood vessels. Figure 4-2 represents the basic structure of an individual bone.

4-3. Bone Marrow

Two kinds of marrow, yellow and red, are found in the marrow cavities of bones. Red bone marrow is active blood cell manufacturing material, producing red blood cells and many of the white blood cells. Deposits of red bone marrow in an adult are in cancellous portions of some bones—the skull, ribs, and sternum, for example. Yellow bone marrow is mostly fat and is found in marrow cavities of mature long bones. The examination of red marrow deposits is important for diagnostic tests when the condition of developing blood cells must be determined. For microscopic examination, the doctor obtains a small amount of marrow through a special needle puncture, usually in the sternum.

4-4. Shapes of Bones

Bones are classified according to their shape (long, short, flat, or irregular) or according to their embryonic origin (membranous or cartilaginous), and their structure (compact or spongy). Long bones are found in the extremities and include the humerus, radius, ulna, femur, tibia, fibula, and the phalanges. Short bones are found in the wrist and ankles and include carpal and tarsal bones. Flat bones include the ribs, scapula, and some skull bones. Irregular bones include the vertebrae, coccyx, and mandible.

486-923 O - 85 - 2

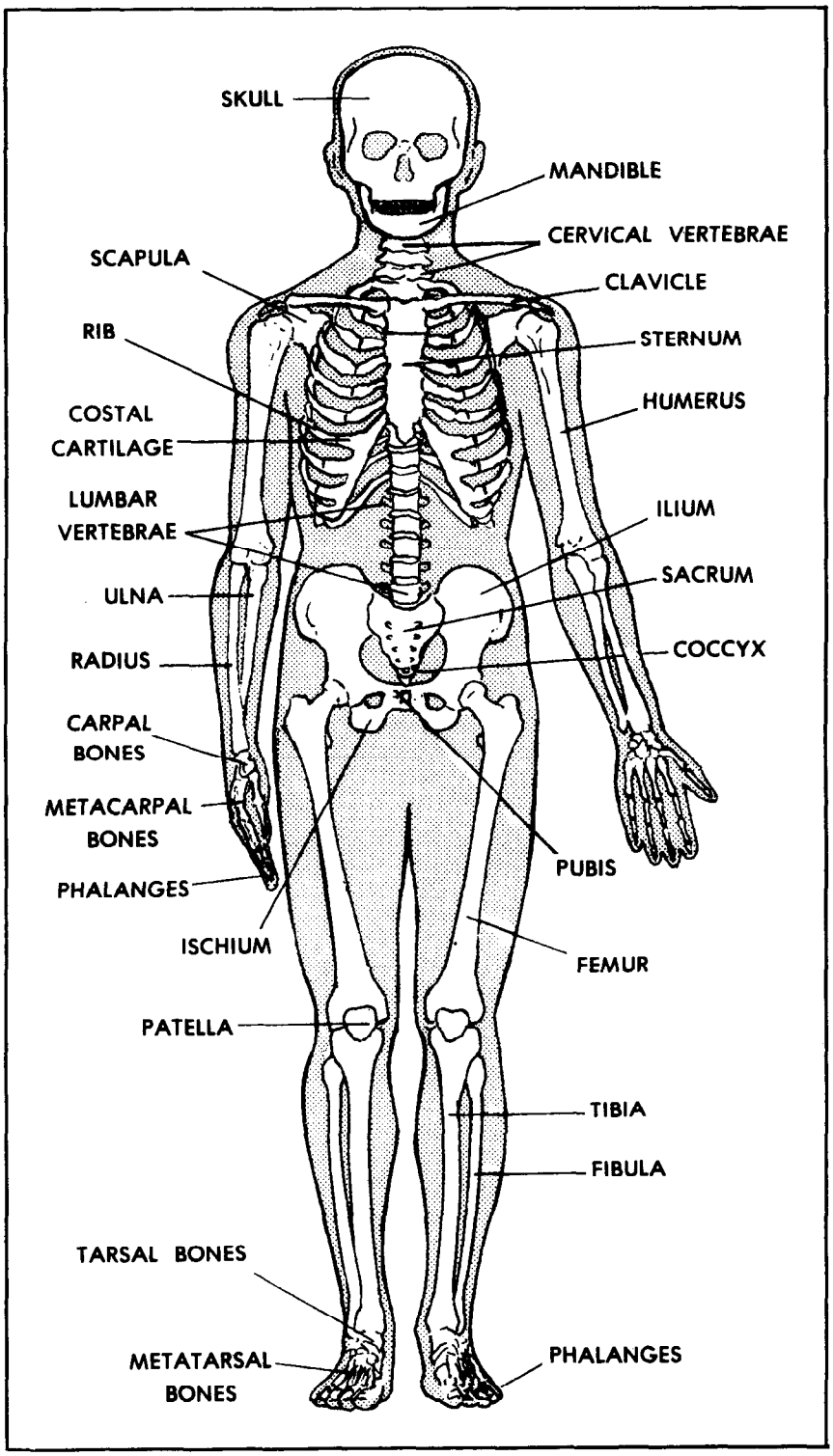


Figure 4-1A. The skeleton (anterior).

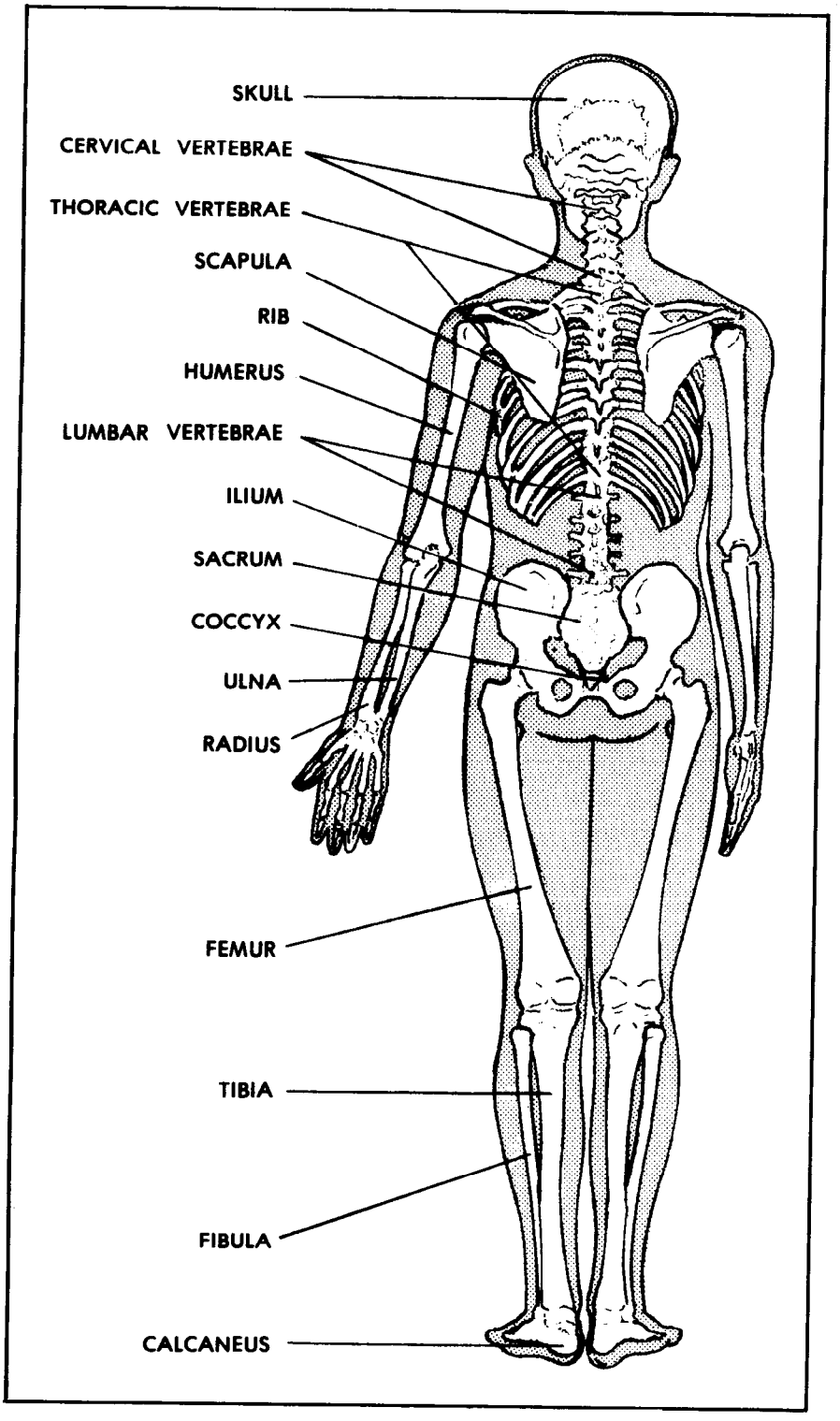


Figure 4-1B. The skeleton (posterior).

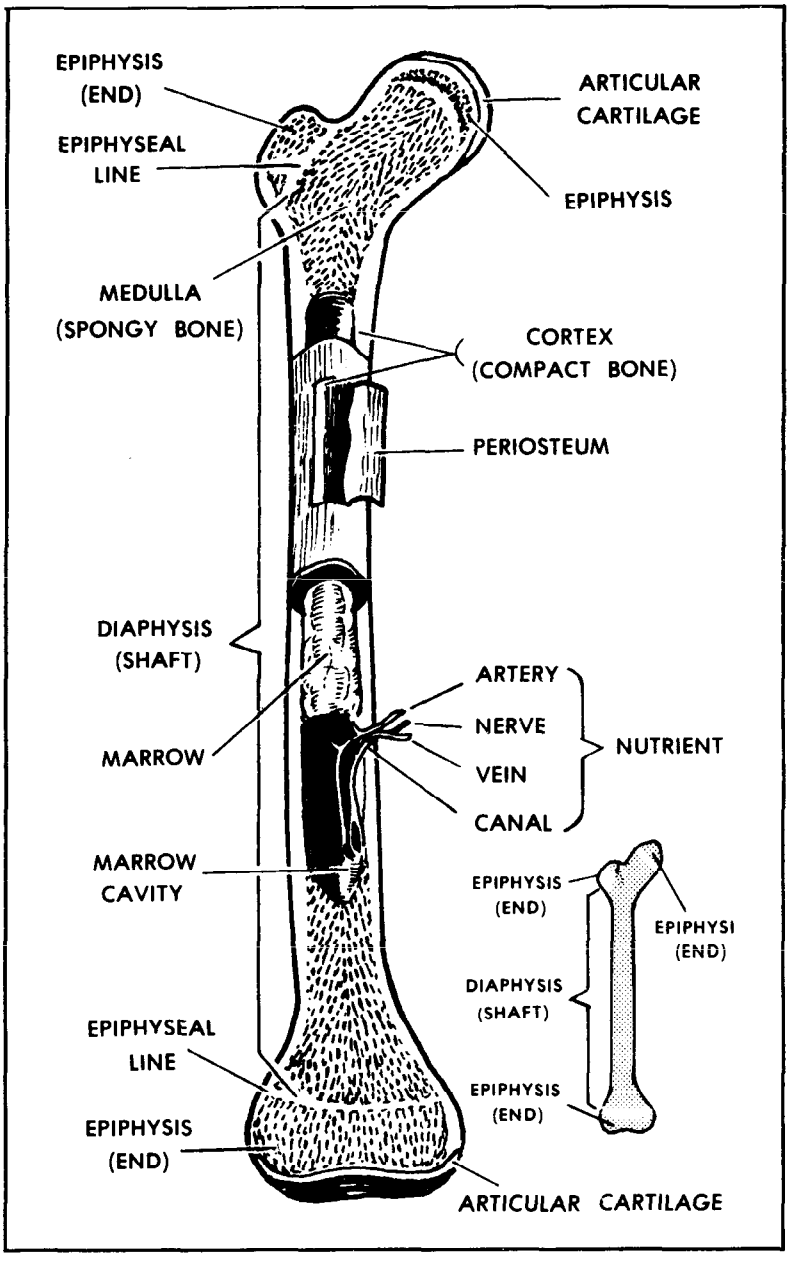


Figure 4-2. A mature long bone (femur).

4-5. Skeletal System

The framework provided by the skeleton permits an erect posture and gives the body its characteristic form (Figure 4-3).

a. The Skull (Figure 4-3). The skull is a bony framework. It has two major subdivisions: the cranium and the facial skeleton. The most important are the cranial bones, including the frontal, occipital, temporal, and parietal, which enclose and protect the brain and the upper jaw, or maxilla, the lower jaw or mandible, and the cheek bones, or zygomatic bones. The mandible is attached to the skull by modified joints that permit the lower jaw to move.

(1) The cranial bones are fused at joints called the *coronal suture.* The bones of the cranium are not fully fused and the sutures are soft at birth. As the baby grows, the bones of the skull fuse firmly, making the skull a rigid box that does not permit expansion. When bleeding occurs within the adult skull, or if brain tissue swells, the increase in intracranial volume will increase pressure and damaged brain tissue can occur.

(2) The facial skeleton consists of bones which surround the nose and mouth and are mainly flat and irregular in shape. The face is composed of bones fused together to provide protection for important structures. For example, the orbit (eye socket) is composed of two facial bones, the maxilla and the zygoma, as well as the frontal bone of the cranium, to form a solid bony rim that protrudes around the eye to protect it. The maxilla contains the upper teeth and forms the hard palate, or the roof of the mouth. The mandible, or lower jaw, is the only movable facial bone that has a joint (the temporomandibular) with the cranium just in front of the ear. The nasal bone is very short and the majority of the nose is composed of flexible cartilage.

(3) Certain bones of the skull have air-filled spaces called the paranasal sinuses.

NOTE

The skull includes the flat bones of the cranium, which are fused, and the facial bones. The mandible (lower jaw) is freely movable.

(4) The upper jaw (maxilla) and the lower jaw (mandible) are parts of the facial skeleton that surround the mouth.

(5) The hyoid bone is located at the junction between the head and the neck. It is held in place—and moved around—by groups of muscles above and below. The root of the tongue is attached to its upper anterior surface. The larynx is suspended from its inferior surface. These three structures, together, form the hyoid complex. This complex is a functional unit for swallowing.

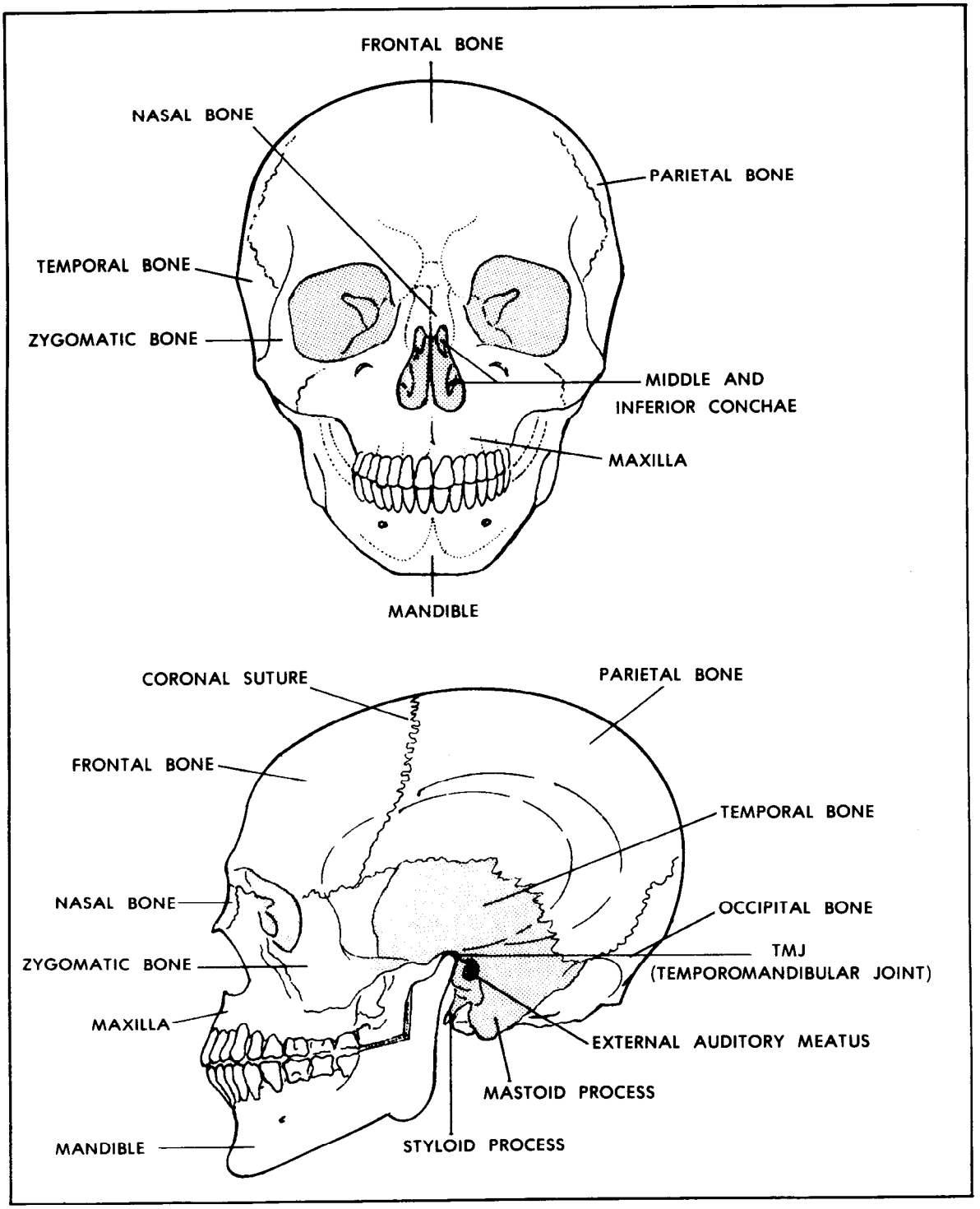


Figure 4-3. The skull (front and side views).

b. The Spinal Column (Figure 4-4).

(1) The spinal column serves as the main axis of the body, providing rigidity but permitting some degree of movement. It also serves as a protective case, inclosing the spinal cord and the roots of the spinal nerves. The spinal column is composed of 33 bones called the vertebrae. The skull rests at the top of the spinal column. From the brain extends the long nerve tracts that form the spinal cord. This cord is an extension of the brain composed of virtually all the nerves carrying messages between the brain and the rest of the body.

(2) The ribs join with the upper vertebrae to form the thorax. The pelvis, with the lower part of the spinal column, or sacrum, form the pelvic girdle. The spinal column is divided into five sections (Figure 4-4)—

- Section 1—Cervical Spine: comprising the first seven vertebrae in the neck region.

- Section 2—Thoracic Spine: consisting of 12 vertebrae in the upper back with which the 12 pairs of ribs join.

- Section 3—Lumbar Spine: made up of five vertebrae in the lower back.

- Section 4—Sacrum: joins with the pelvis at the sacroiliac joint, forming part of the pelvic girdle.

- Section 5—Coccyx (tail bone): consists of the last four vertebrae which are fused together.

(3) The vertebrae are named according to the section of the spine in which they lie and are numbered from top to bottom. The first seven vertebrae form the cervical spine (C_1-C_7). The next twelve vertebrae make up the thoracic or dorsal spine; one pair of ribs articulates (joins) with each of these vertebrae. The next five vertebrae form the lumbar spine, or the lower back.

(4) The five sacral vertebrae are fused together to form the sacrum. The sacrum is joined to the iliac bones of the pelvis with strong ligaments to form the pelvic girdle. The last four vertebrae form the coccyx, or tailbone.

(5) The front part of each vertebrae is a round solid block of bone called the body. The back part of each vertebrae forms a bony arch (Figure 4-5). These series of arches, from one vertebrae to the next, form a tunnel that runs the length of the spine and is called the spinal canal. The spinal canal incloses and protects the spinal cord. Nerves branch off from the spinal cord between each two vertebrae to form the motor and sensory nerves of the body (Figure 4-5).

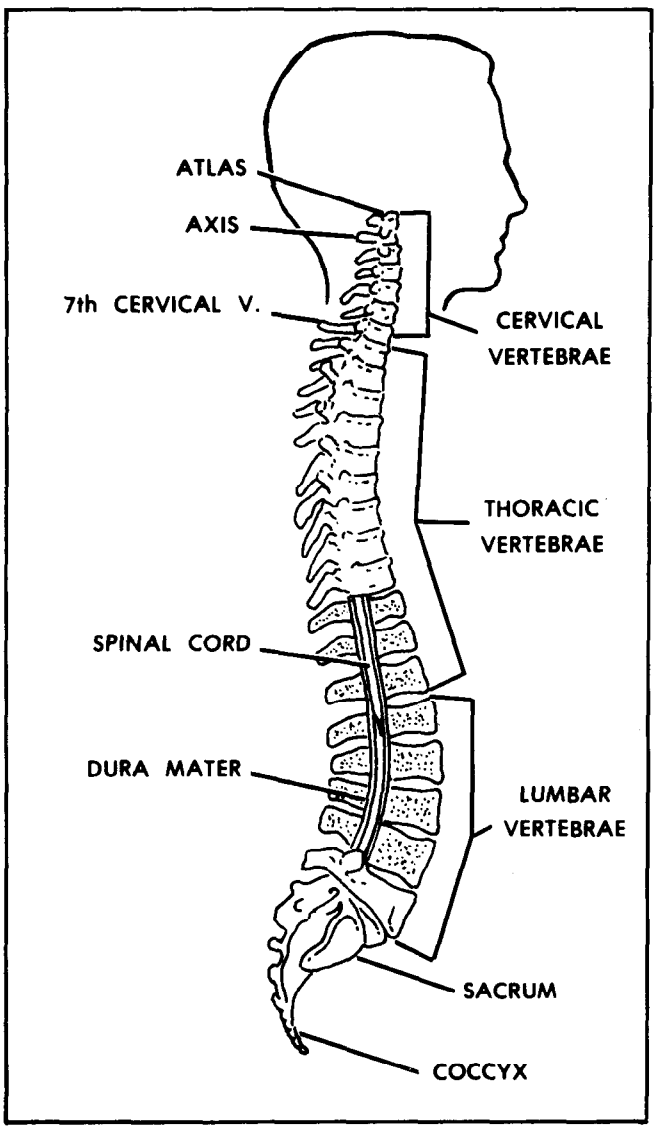


Figure 4-4. The spinal column.

(6) The vertebrae are connected by ligaments, and between each two vertebral bodies is a cushion, the intervertebral disc. These ligaments and discs allow some motion, such as turning the head or bending the trunk forward or backward, but they also act to limit motion of the vertebrae so that the spinal cord will not be injured. When a fracture of the spine occurs, protection for the spinal cord and its nerves may be lost. Until the fracture is made stable, the medical specialist, must guard against further injury to the spinal cord. The spinal column itself is virtually surrounded by muscles; however, the posterior spinous process of each vertebrae can be felt as it lies just under the skin in the midline of the back.

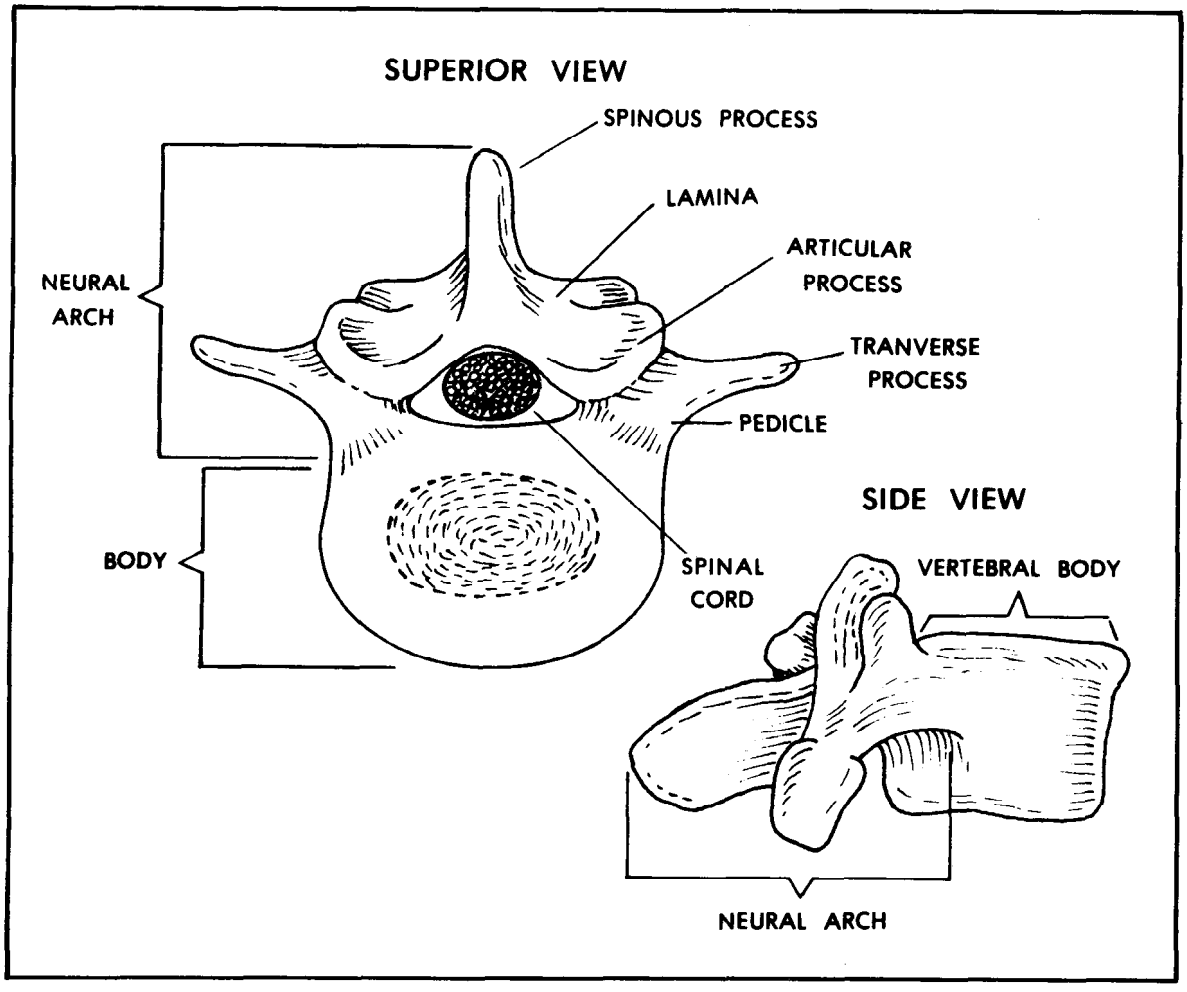


Figure 4-5. Top view of a thoracic vertebrae showing the spinal canal protecting the spinal cord.

c. The Thorax

(1) The rib cage, or thorax, is made up of the ribs, the 12 thoracic vertebrae, and the sternum (breastbone) (Figure 4-6). There are 12 pairs of ribs. Each rib forms a joint with its respective thoracic vertebrae and curves around to form the rib cage. At the front of the rib cage, ribs one through ten connect with the sternum. For the lower five ribs, cartilaginous bridge is formed. The sternum forms the middle part of the front of the thoracic cage. The xiphoid process of the sternum is cartilaginous, pointed, and very tender to palpation.

(2) Moderate pivoting of the ribs at their joints with the vertebrae allows expansion of the thorax when one inspires (breathes in). As the ribs pivot upward, the thoracic cavity becomes larger, and air is drawn into the lungs.

(3) The primary function of the rib cage is to protect the vital chest contents from injury.

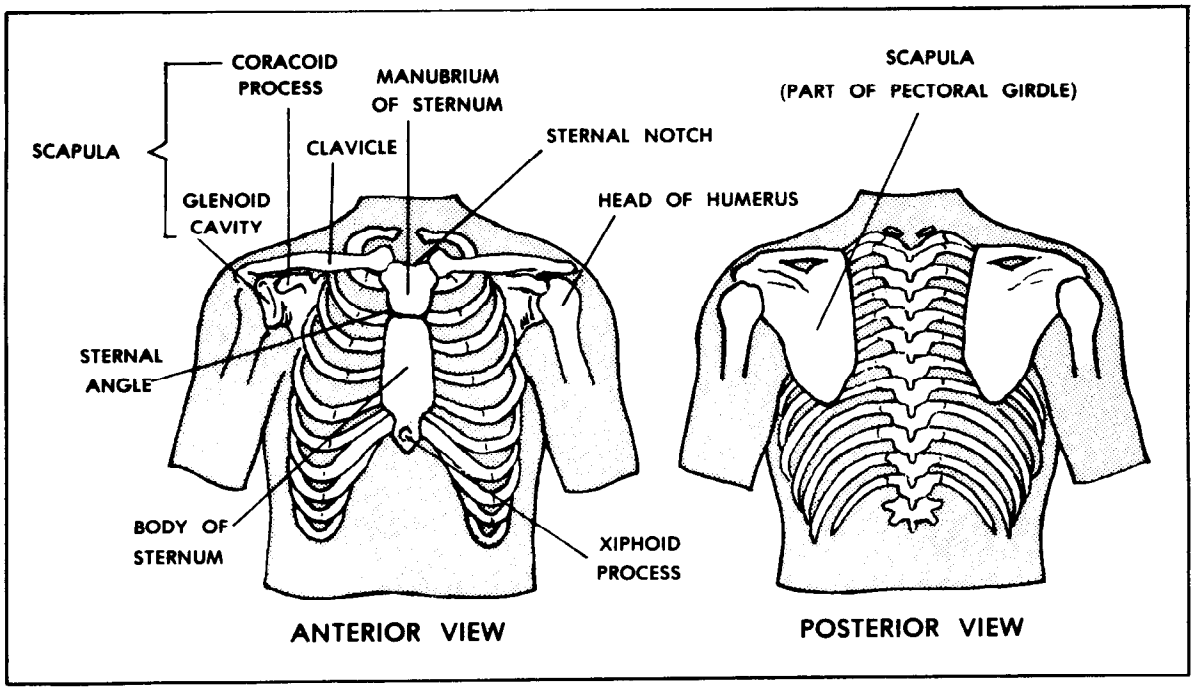


Figure 4-6. The thoracic cage.

d. The Upper Extremities. The upper extremities are composed of the bones of the shoulder girdle (Figure 4-7), arms, forearms, and hands.

(1) The shoulder girdle consists of the scapula (shoulder blade), clavicle (collar bone), and humerus (Figure 4-7).

(a) The shoulder blade, or scapula (Figure 4-7), is a large flat, triangular bone held to the rib cage posteriorly by powerful muscles. The scapula floats freely on the upper posterior ribs, because it is not attached to the ribs beneath it. The upper outer portion of the scapula forms the socket of the joint, where motion is very free in all planes.

(b) The collar bone (clavicle) (Figure 4-7) is a long, slender bone that lies just under the skin and serves as a support or prop for the upper extremity. The collar bone is a somewhat f-shaped bone attached by strong ligaments to the sternum at one end and to the scapula at the other.

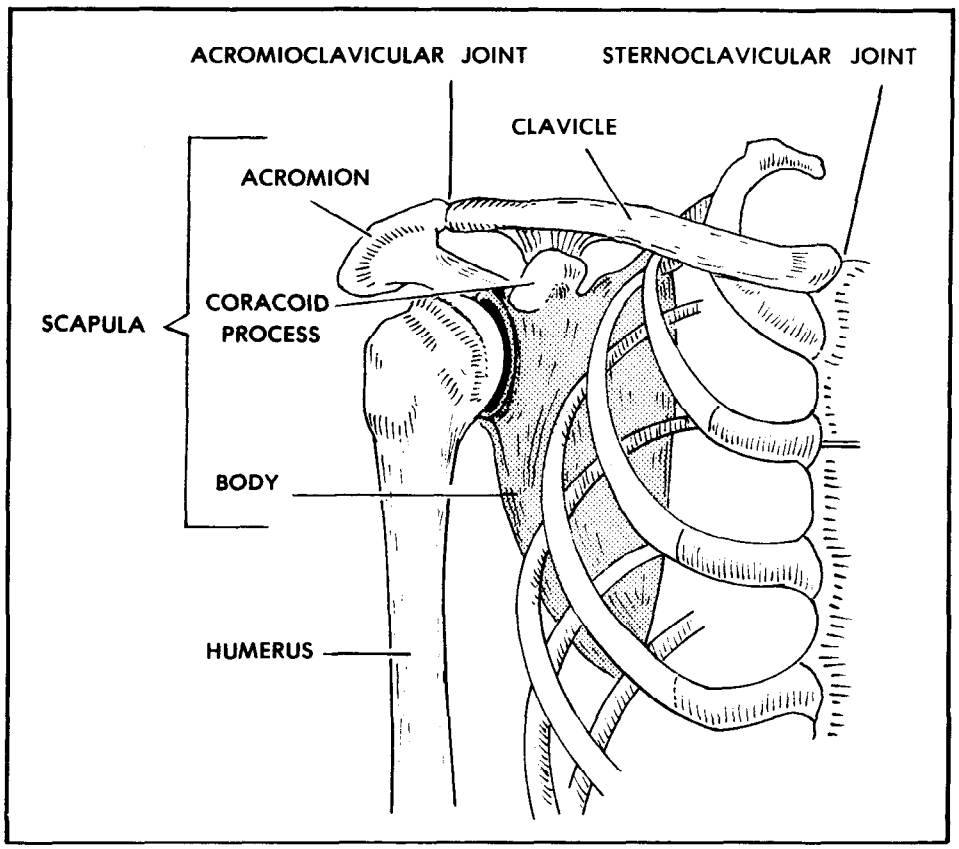


Figure 4-7. The shoulder girdle.

(c) The upper arm, or humerus (Figure 4-8) joins proximally with the scapula and distally with the bones of the forearm—the radius and ulna—to form the (hinged-joint) elbow joint.

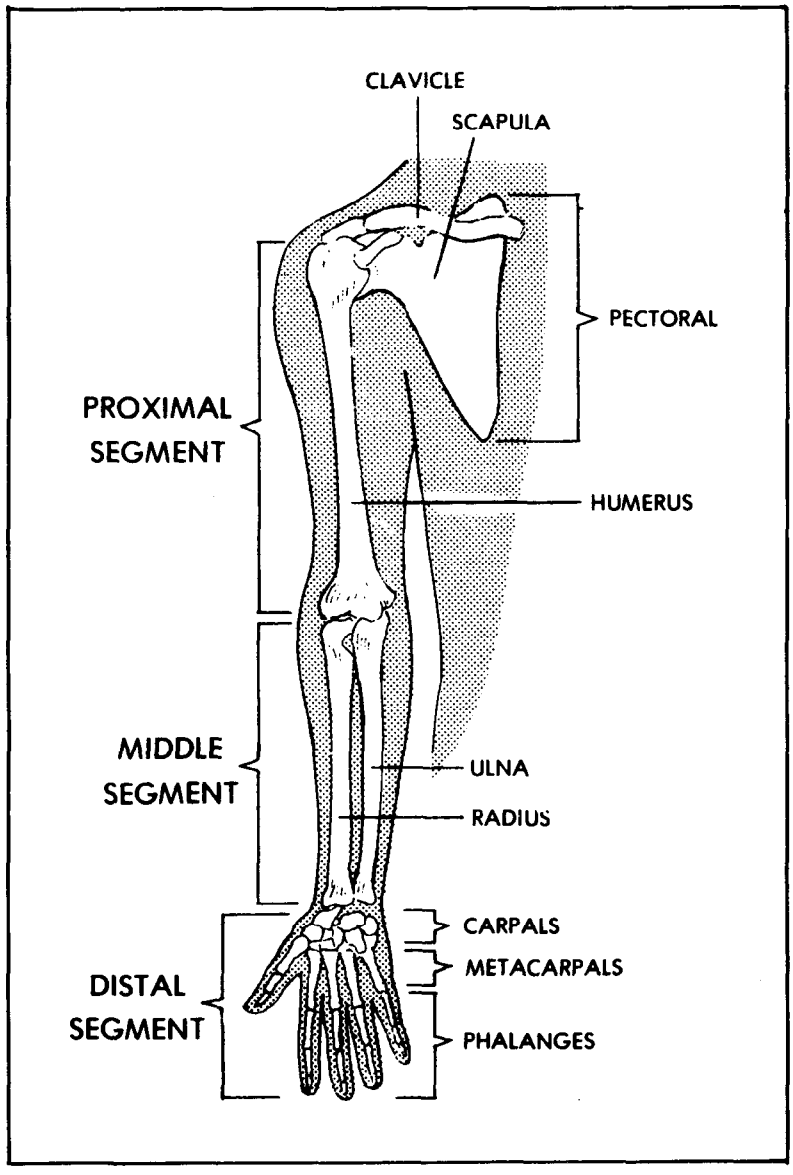


Figure 4-8. The upper and lower arm.

(d) The radius and ulna form the forearm. An extension of the ulna, called the olecranon process ("funny bone"), forms part of the elbow joint. The ulna is narrow and is on the same side of the forearm (the ulnar side) as the little finger. The ulna serves as a pivot around which the radius turns to rotate the palm upward (supination) or downward (pronation). At the elbow, the ulna is larger than the radius, but at the wrist the radius is the larger of the two.

(2) The hand (Figure 4-9) includes three groups of bones: the wrist bones (carpals), the hand bones (metacarpals), and the finger bones (phalanges). The back of the hand is referred to as the dorsum and the front, the palm. The thumb side of the hand and wrist is called the radial side (after the radius), and the little finger side is called the ulnar side (after the ulna).

(a) The wrist joint (Figure 4-9) is a modified ball-and-socket joint formed by the radius, ulna, and several small wrist bones (the carpal bones). The wrist can be flexed and extended and also bent to each side and rotated to some degree.

(b) Extending from the carpal bones are five metacarpals,which serve as the base for each of the fingers (Figure 4-9). In the thumb there are two bones beyond the metacarpal, the proximal and distal phalanges. The remaining four fingers of the hand are named in order: the index, the long, the ring, and the little finger. The phalanges join with the metacarpal and with themselves through simple hinge joints (Figure 4-9). The many subtle motions permitted by the joints of the hands and wrist enable us to perform highly skilled tasks.

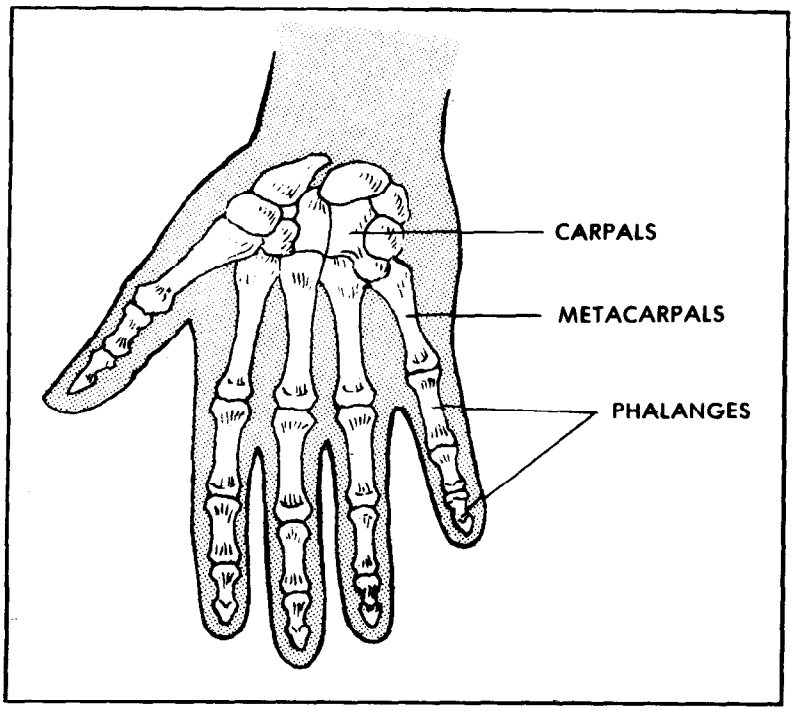


Figure 4-9. The hand.

e. The Lower Extremities. The lower extremities consist of bones of the pelvis, upper legs, lower legs, and feet. The hip bone, or pelvic girdle (Figure 4-10), is in reality three bones—the ischium, ilium, and pubis—fused together to form a bony ring. The two ilial bones join posteriorly with the sacrum. Anteriorly, the three bones unite at a socket-like depression, the acetabulum, which receives the head of the long leg bone, the femur. All three joints allow little motion, because they are firmly held together by strong ligaments. The pelvic ring is strong and stable, designed to support the body weight and protect the structures within the pelvic cavity (the bladder, the rectum, and the female reproductive organs).

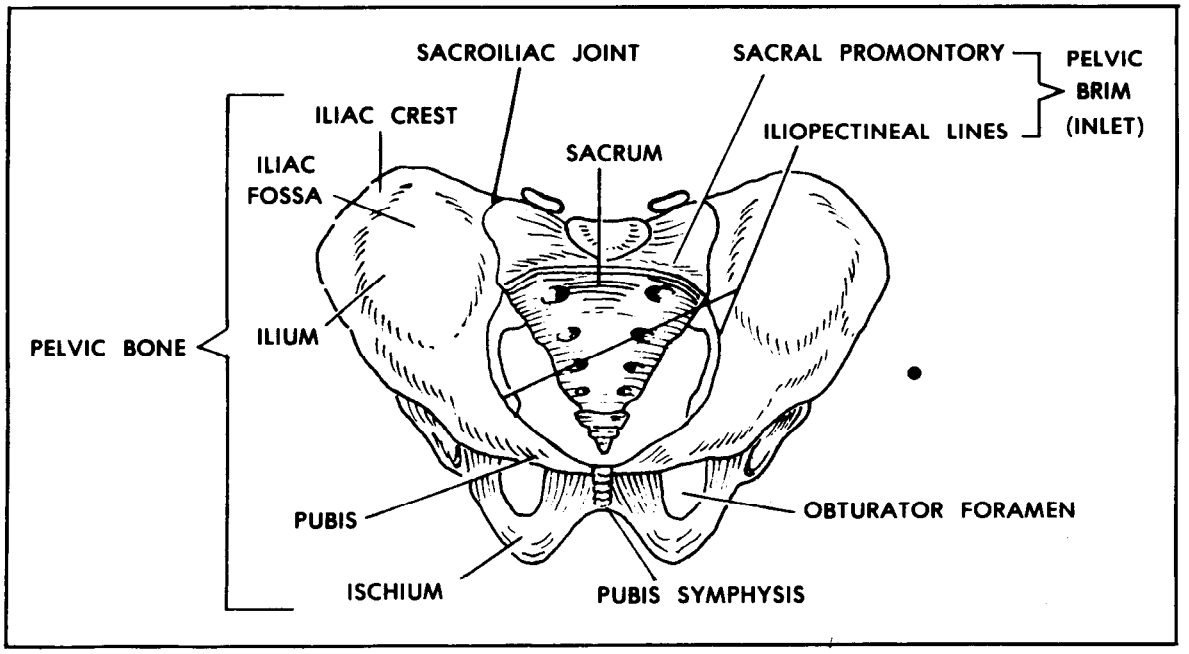


Figure 4-10. The hip bone or pelvic girdle.

(1) The upper leg, or femur (thigh bone) (Figure 4-11) is the longest and one of the strongest bones in the body. The femoral head joins with the acetabulum of the pelvis. This ball-and-socket joint allows flexion, extension, adduction (motion of the limb toward the midline), abduction (motion of the limb away from the midline), as well as internal and external rotation of the lower extremity.

(2) The femur consists of a head, the ball-shaped part that fits into the acetabulum; a neck, which is about 3 inches (7.6 cm) long and is set at an angle; and a shaft. The femoral neck is a common site for fractures, especially in the elderly (Figure 4-11).

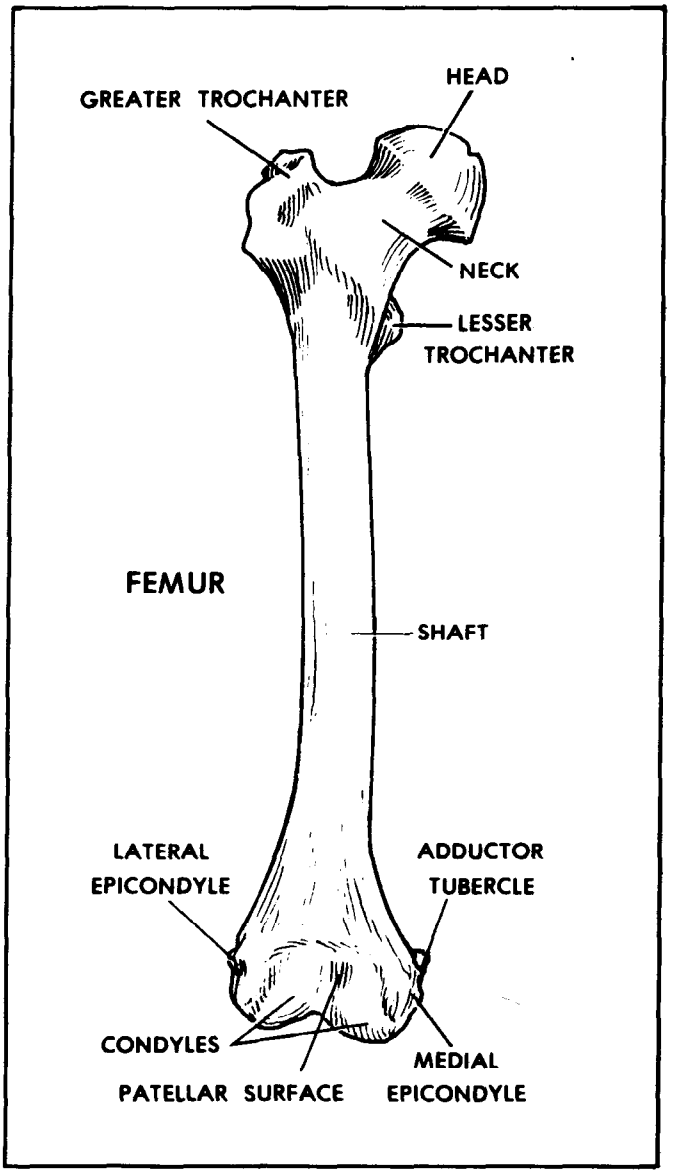


Figure 4-11. The upper leg or femur.

(3) In the proximal thigh, the prominence of the greater trochanter of the femur can be easily palpated. This is sometimes called the "hip bone." The shaft of the femur is surrounded by muscle (the quadriceps anteriorly and the hamstrings posteriorly) and is not easily palpated. Just above the knee, however, the medial and lateral femoral condyles can be felt.

(4) Between the thigh and the lower leg is the knee joint, which is the joint (Figure 4-12) between the femur and the tibia. The knee is the largest joint in the body and is essentially a hinge joint, allowing only flexion and extension. Adduction, abduction, and rotation are resisted by complex ligaments that are quite susceptible to injury.

(5) In front of the knee joint is the patella (kneecap). It lies within the tendon of the quadriceps muscle and acts to protect the front of the knee joint from injury (Figure 4-12).

(6) The leg (Figure 4-12) is the portion of the lower extremity between the knee and the ankle joints. The lower leg consists of two bones, the tibia and the fibula. The tibia (shin bone) is the larger bone. It lies anterior in the leg with its front edge just under the skin and is easily palpable. The fibula is not a component of the knee joint but does make up the lateral aspect of the ankle joint (lateral malleolus). The medial malleolus or body knob on the inner side of the ankle, is the end of the tibia.

(7) The ankle is a hinge joint that allows flexion and extension of the foot and leg. The distal end of the tibia provides a smooth articular surface for the ankle bone (talus).

(8) In the foot, beneath the ankle bone (talus), sits the heel bone (calcaneus or os calcis). The talus and calcaneus (as well as five other bones of the mid-foot) are called tarsal bones. Five metatarsals join with the tarsal bones, and each gives rise to its respective toe (Figure 4-13).

f. Joints (Articulations).

(1) Wherever two bones come into contact, a joint articulation is formed. Some joints allow motion; for example, the hip, knee, or elbow. Other bones fuse with one another at joints so that a solid, immobile bony structure results. The skull is composed of several different bones that fuse as the person grows into adulthood. The infant, whose bones are not yet fused, has soft spots called fontanelles between the bones. Many joints of the body are named by combining the names of the bones forming that joint; for example, the sternoclavicular joint is the articulation between the sternum and the clavicle.

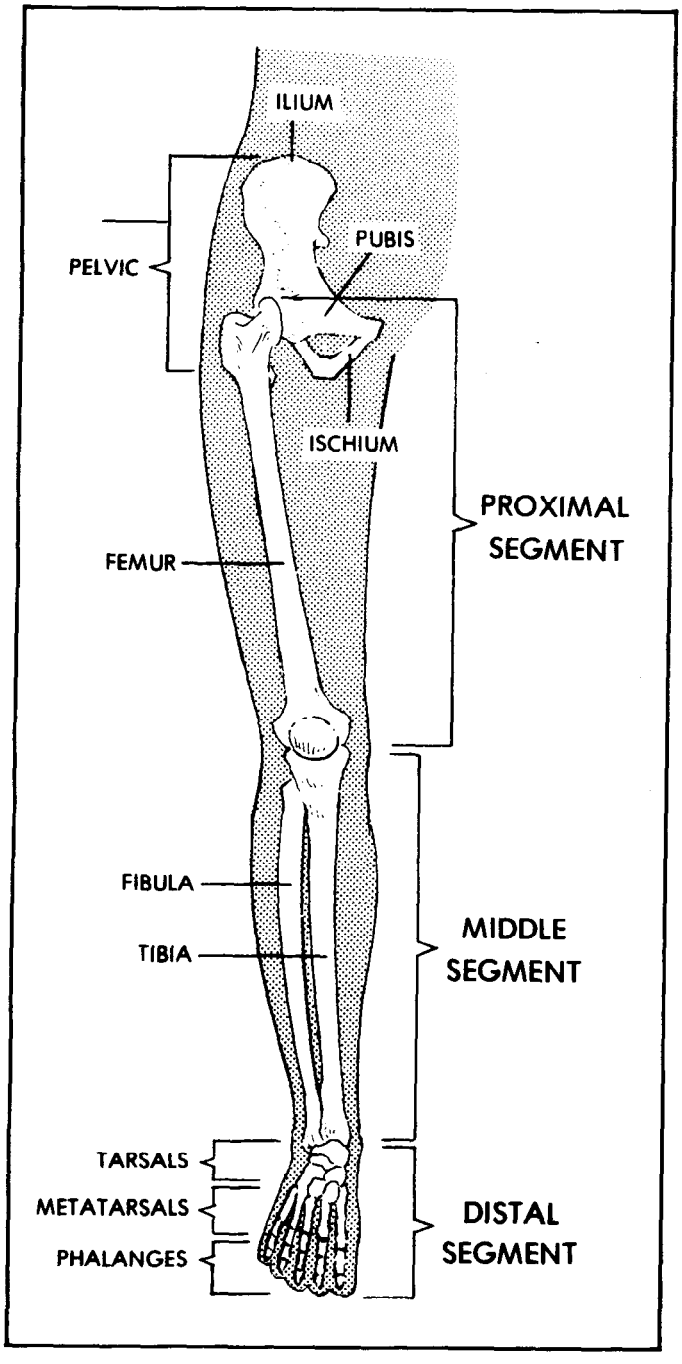


Figure 4-12. The lower extremity.

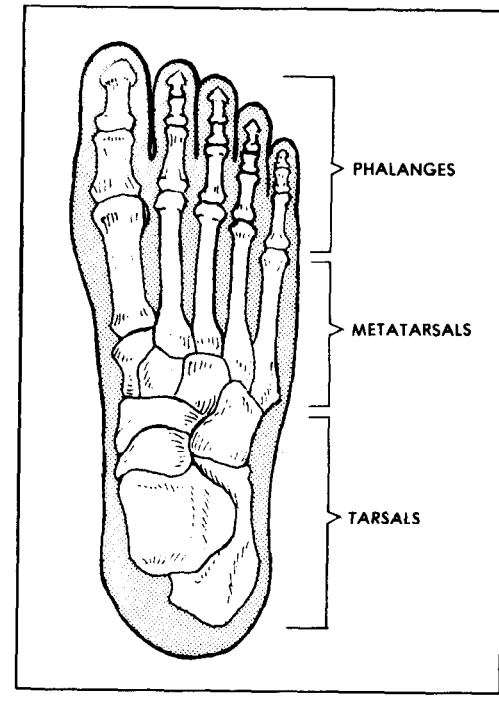
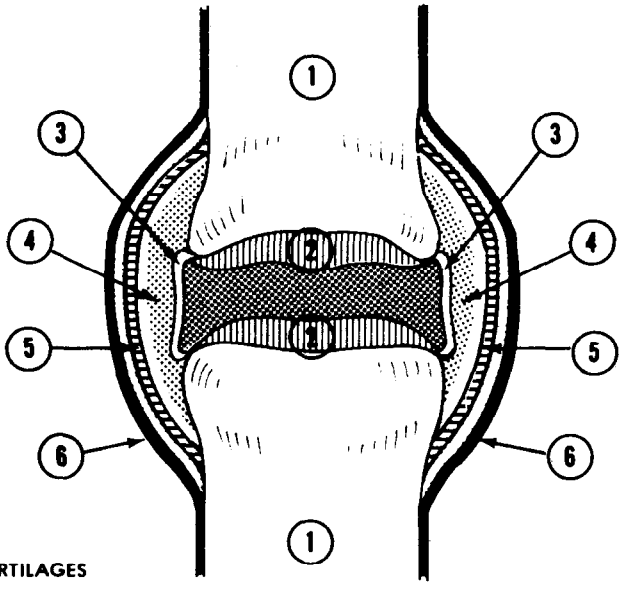


Figure 4-13. The foot.

(2) A joint consists of the ends of the bones that make up the joint and the surrounding connecting and supporting tissues (Figure 4-14). The ends of bones that articulate with each other are covered with a smooth, shiny surface called articular cartilage. Inside some joints, most notably the knee, there are cartilaginous cushions that fill up spaces between the bones and aid in the gliding motion of that joint. Such a cushion is called a meniscus or sometimes simply a cartilage. When injured and torn from its attachments, the meniscus can produce symptoms of locking or catching in the joint.



(1) - BONES

(2) - ARTICULAR CARTILAGES

(3) - SYNOVIAL:

a. SYNOVIAL MEMBRANE ≈ — A SIMPLE SQUAMOUS EPITHELIAL TISSUE LINING THE FIBROUS CAPSULE (4) AROUND THE SYNOVIAL CAVITY AND SECRETING THE SYNOVIAL FLUID. NOTE: DOES NOT COVER THE ARTICULAR CARTILAGE.

b. SYNOVIAL CAVITY ▒ — HERE ARTIFICIALLY OPENED FOR DIAGRAMATIC PURPOSES, NORMALLY THE ARTICULAR CARTILAGES RIDE ON ONE ANOTHER WITH A THIN FILM OF SYNOVIAL FLUID BETWEEN THE ARTICULAR CARTILAGES.

(4) - FIBROUS CAPSULE ⁘ SURROUNDING JOINT CAVITY.

(5) - LIGAMENTS: ≡

a. HOLD BONES FROM BEING SEPARATED.

b. MAY BE SEPARATE STRUCTURES OR THICKENINGS OF THE FIBROUS CAPSULE.

(6) - SKELETAL MUSCLES

Figure 4-14. The typical joint.

(3) In joints that allow motion, the bone ends are held together by a fibrous tissue capsule. At certain points around the joint, the capsule is lax and thin to allow motion in a certain plane, while in other areas it is quite thick and resists stretching or bending. These bands of tough, thick capsule are called ligaments.

(4) A joint that is virtually surrounded by tough, thick ligaments (such as the sacroiliac joint) will have little motion. However, a joint with few ligaments (such as the shoulder) will be free to move in almost any direction (these are more prone to dislocation).

(5) The degree of freedom of motion of a joint is determined by the extent to which the ligaments hold the bone ends together and by the configuration of the bone ends themselves. While the amount of motion varies from joint to joint, all joints have a definite limit of motion. When a joint is forced beyond this limit, damage to some structure will occur such as:

(a) The bones forming the joint may fracture (break).

(b) The supporting capsule and ligaments may be torn. The inner surface of the joint capsule (the synovium) produces a fluid that nourishes and lubricates the articular cartilage. This is called synovial fluid. It is thick—almost oily—and clear yellow in color. Normally, only a few cubic centimeters of synovial fluid are produced to protect the joint. Injury or disease may result in increased production of synovial fluid and swelling inside the capsule; for example, the so-called "water on the knee."

(6) Motion of a joint is produced by the action of muscles. All muscles of the extremities pass through tendons to two bones (Figure 4-15). The muscle originates from one bone, and its other end inserts into the second bone. When the muscle contracts (shortens) (Figure 4-15), the ends of the bones will be brought closer together, with motion occurring at the intervening joint. Muscle on the opposite side of the limb will lengthen (relax) to allow this motion to occur. When motion in the opposite direction is desired, the second group of muscles will contract and the first will relax, pulling the joint back to its original position (Figure 4-15).

g. Synovial Joints. Joints are of several types. They may be fibrous (like those between the skull bones, allowing little motion) or cartilaginous (like the discs between vertebrae, allowing slight motion). Joints may also permit free motion. In a synovial joint, the articulating surfaces are covered with cartilage and surrounded by a fibrous capsule lined with the smooth, slippery synovial membrane. Synovial joints include:

(1) The gliding joint, which allows only short slipping or gliding motion. The joint between the carpal and tarsal bones of the wrist and ankle is a gliding joint.

(2) The hinge joint, which allows only flexion and extension. The finger joints and the knees are typical hinge joints, with motion restricted to one plane.

(3) The ball-and-socket joint, which allows movement in many directions (the hip and shoulder joints).

(4) The pivot joint, which allows only rotation around a long axis. An example of a pivot joint is the joint between the proximal radius and the ulna. As the hand is turned from palm up to palm down (pronated), the head of the radius rotates on the pivot formed by the ulna.

(5) The condylar joint, which allows mainly flexion and extension. The condylar joint has two articulating surfaces. In this joint, flexion and extension movements are combined with gliding and rolling movements with rotation around a vertical axis (the knee joint). Joint motion occurs through the contraction and relaxation of skeletal muscles, which cross joints and attach to bones. The bones serve as levers that enable skeletal muscle to move body parts.

h. Joints and Bursae. At some joint locations, the tendon connecting muscle to bone passes over a joint; *for example,* at the shoulder, elbow, knee, and heel. To reduce pressure, small sacs containing fluid are formed over and around the tendon. The sac is a bursa, an irritated bursa is bursitis. Bursitis can be very painful, and normal movement may be impossible.

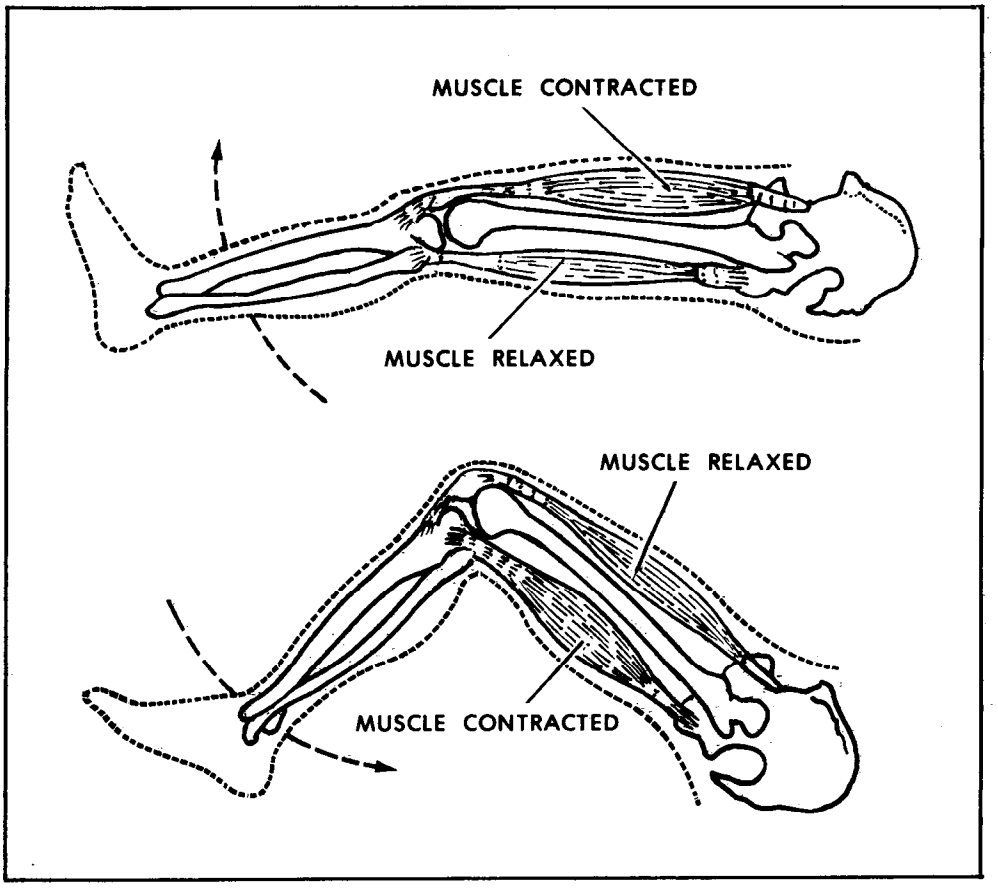


Figure 4-15. The mechanism of joint motion.

Section II. THE MUSCULAR SYSTEM

4-6. General

Muscle is characterized by the ability to contract, or to shorten. The power of contraction enables a muscle to move parts of the body. All movements of the body, whether conscious or unconscious, are due to the action of muscles. Muscle makes up much of the fleshy portions of the body. Muscles vary in shape and structure according to the work they have to do. There are three main types of muscle: voluntary, involuntary (smooth), and cardiac (heart).

4-7. Types of Muscles

a. Voluntary Muscle. Voluntary muscle is so-called because it is controlled by will through the central nervous system. All the skeletal muscles (those attached to the skeleton) are of the voluntary type. Besides the skeletal muscles, those which move the eye, tongue, and pharynx are voluntary.

(1) *Functions.* Voluntary muscles cause movement of the body as a whole and the movements of its parts. They maintain posture, carry on the rhythmic movements of respiration, produce most of the heat generated by the body, and serve to protect certain organs.

(2) *Structure.* Voluntary muscle is made of long, slender fibers held together by connective tissue to form muscle bundles. Groups of muscle bundles, enclosed in a fibrous sheath called fascia, form the individual muscles.

(3) *Parts.* A skeletal muscle has three main parts: belly, origin, and insertion. The belly is the body of the muscles. Tendons extend from each end of the belly and attach to bones. A tendon is a band of tough, nonelastic fibrous tissue. Tendons unite with the periosteum of bones to form secure attachments for the muscles. The origin of the muscle is that portion which accomplishes least movement when the muscle is contracted. The insertion is the most movable end of the muscle.

(4) *Names.* Each muscle has a name. Some muscles are given names derived from their location. Other muscles are named according to function, shape, size, and/or points of attachment.

b. Involuntary (Smooth Muscle). The involuntary muscles are called that because the nerve supply is from the autonomic nervous system, which is not under the control of the will. It is also called smooth muscle. Smooth muscle is found in the walls of the blood vessels, respiratory passages, gastrointestinal tract, ureters and urinary bladder, and certain other organs.

(1) *Functions.* Smooth muscle performs many varied functions. It regulates the size of blood vessels, which is essential to the maintenance of blood pressure. It moves food through the intestinal tract. It regulates the bronchioles (small air passages) in the lungs. Still another function of smooth muscles is the movement of urine from the kidneys to the urinary bladder.

(2) *Structure.* Smooth muscle is made of spindle-shaped fibers of cells. The fibers are arranged in bundles or sheets to form a layer in the walls of blood vessels and other viscera.

c. Cardiac Muscle. Cardiac, or heart, muscle is involuntary muscle, but is found only in the heart. The structure of cardiac muscle is different from that of other muscles. Cardiac muscle forms the walls of the heart. The whole heart works together because all parts are connected with special bands of cardiac muscle.

d. Action of Voluntary Muscles.

(1) A muscle seldom works alone in carrying out movement. Usually the performance of a movement, even a simple motion, requires the combined action of a group of muscles. Many skeletal muscles are arranged in pairs; for each muscle producing one motion, there is another muscle which produces the opposite motion. One muscle must relax in part while the other contracts.

(2) At all times, muscle is in a state of partial contraction called tone or tonus. Because of this, when a muscle is cut, the two ends pull apart like the cut ends of a stretched rubber band. Tone in skeletal muscle is maintained by a reflex and therefore depends on nerve connections to a functioning spinal cord.

(3) Muscle contraction uses food and oxygen and produces acids and heat. Muscle activity is the major source of the body's heat. Acids accumulating as a result of continued activity cause fatigue. Muscle fatigue occurs most rapidly when contractions are frequent; it occurs slowly if rest periods are taken between contractions. Exercise causes muscles to become larger, stronger, and better developed. This increase in size is called hypertrophy. Inactivity results in wasting away of muscles called atrophy.

(4) Voluntary muscle activity results from impulses which arise in the cortex of the brain and are transmitted to the muscle by the spinal cord and the motor nerves. Interruption of any part of this pathway will cause paralysis.

e. Principal Groups of Skeletal Muscles. A description of each of the skeletal muscles of the body can be found in any of the standard anatomy books. This manual gives a general discussion of the principal groups of skeletal muscles and describes individually some of the more important muscles of the extremities (Figures 4-16A and 4-16B).

(1) *Head and face.* The muscles of the head and face are small and numerous. They are involved in the movement of the eye and face, making possible facial expression, talking, chewing, and swallowing.

(2) *Neck.* The muscles of the neck move the head from side to side, forward and backward, and rotate it. Some of them also assist in respiration, speaking, and swallowing.

(3) *Arm.* Among the muscles which cause movement of the arms are the deltoid, biceps, and triceps.

(a) The deltoid is a triangular-shaped muscle located on the shoulder and upper arm. This muscle lifts the arm forward, sideways, and to the rear.

(b) The biceps muscle is a long muscle located on the front of the arm. Its action bends the arm at the elbow.

(c) The triceps muscle is located on the back of the upper arm. This muscle works against the biceps muscle to extend the lower arm at the elbow.

(4) *Back.* The muscles of the back are large and some are broad. Attached to vertebrae, they keep the trunk in erect posture and aid it in bending and rotating. In the thoracic region, these muscles assist in respiration and in the movements of the neck, arm, and trunk.

(5) *Abdominal.* The abdominal muscles form broad thin layers which support the internal organs, assist in respiration, and help in flexion and rotation of the spine. The diaphragm separates the thoracic and abdominal cavities. It is an important muscle used in breathing.

(6) *Perineal.* The muscles of the perineum form the floor of the pelvic cavity.

(7) *Thigh.* The muscles located on the front and rear of the thigh cross two joints, the thigh and knee. When they contract, they extend one joint and flex the other.

(a) The quadriceps femoris, a group of muscles located on the front of the thigh, extends the leg.

(b) Muscles located to the rear and above the thigh extend, rotate, or abduct the thigh. Among them are the gluteal muscles: the gluteus maximus, gluteus medius, and gluteus minimus.

(8) *Leg.* The most important muscles of the leg are the anterior and posterior groups. An important member of the anterior group is the anterior tibiales, which flexes the foot. The most superficial, and largest, muscle of the back of the leg is the gastrocnemius. The gastrocnemius is commonly called the calf muscle.

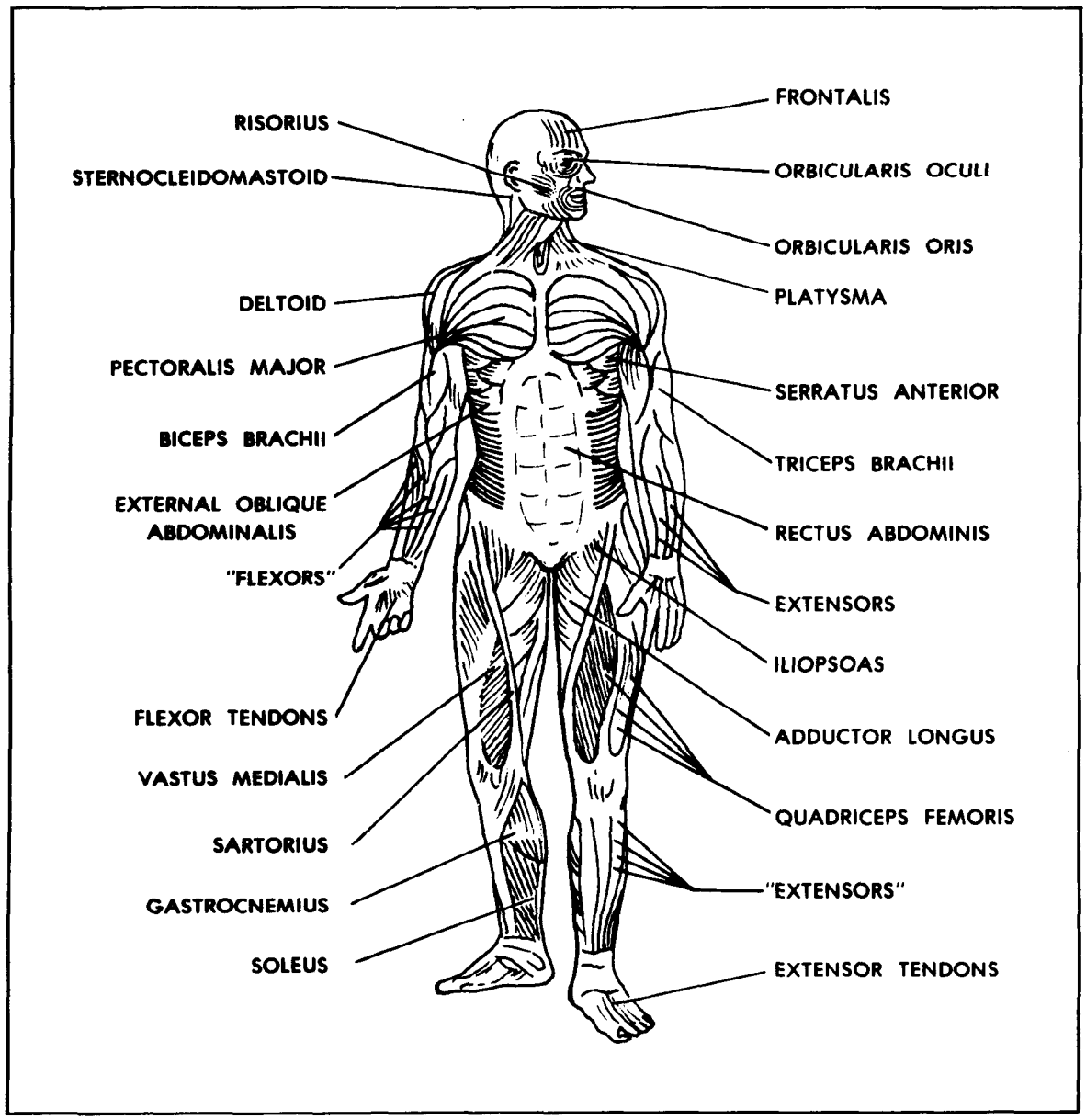


Figure 4-16A. Superficial muscles of the body (anterior).

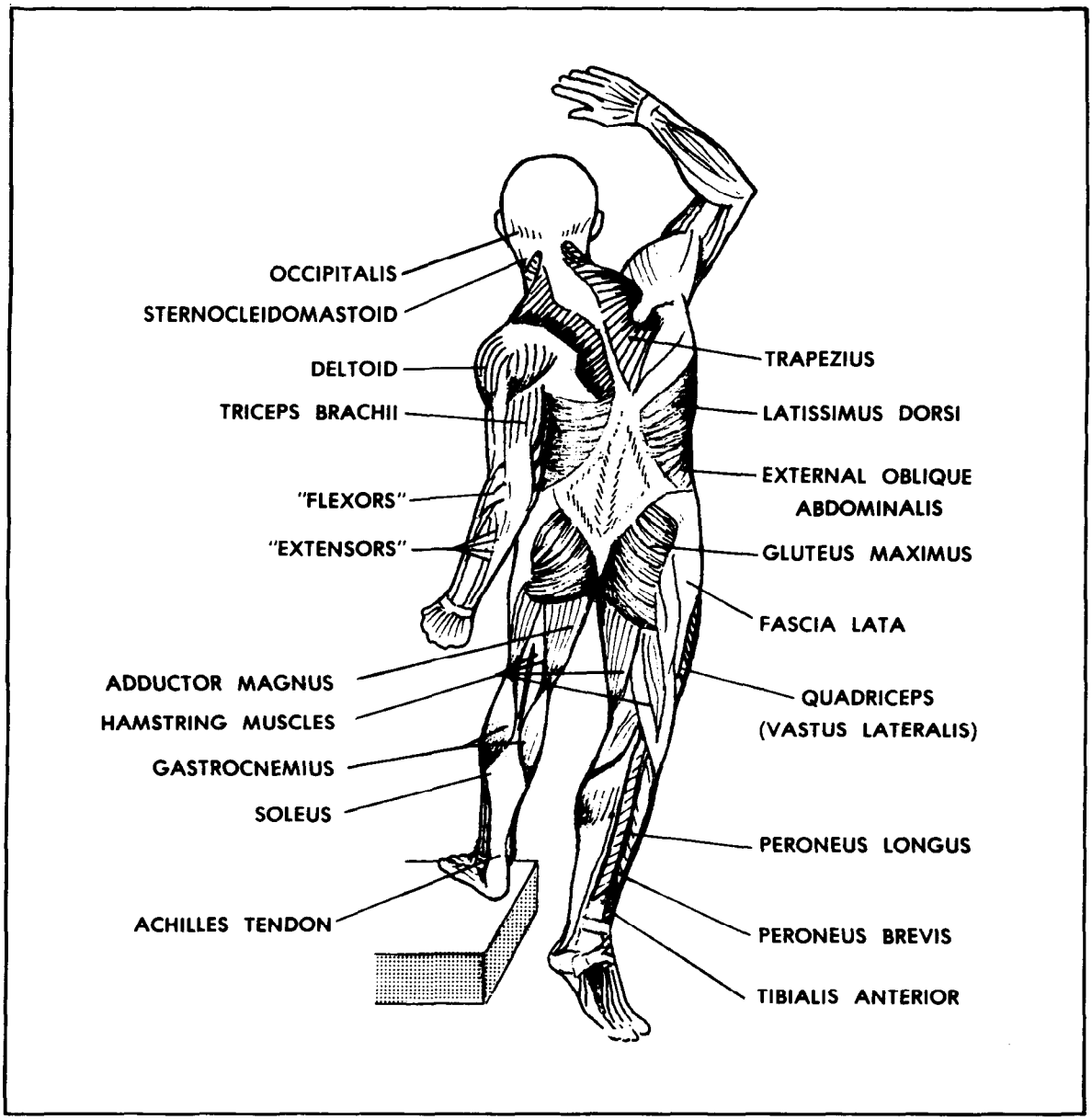


Figure 4-16B. Superficial muscles of the body (posterior).