Chapter 12

Introduction to Anatomy, Positioning, and Pathology

Learning Objectives

At the conclusion of this chapter, you will be able to:

- Explain the differences between cells, tissues, organs, and systems
- List the systems of the human body and state the basic components and function of each
- Describe the structure of bone
- List the three classifications of joints and give an example of each
- Use correct terminology to describe joint motions
- Demonstrate anatomic position
- List and define the planes of the body
- Use correct terminology to describe anatomic locations and relationships
- Use correct terminology when referring to radiographic positions and projections
- Given a position/projection description from one of the following chapters, select, mark, and place the image receptor correctly
- Modify standard procedures to produce quality radiographic images of obese patients
- Define common terms used to describe or classify disease processes
- Explain the differences between acute and chronic conditions and between benign and malignant conditions
- Define inflammation and describe its possible consequences

Key Terms

abrasions
acute
anatomic position
anomalies
articulations
atrophy
benign
cartilage
central nervous system (CNS)
chronic
congenital
contusions
degeneration
diagnosis
dislocation
edema
fracture
gastrointestinal (GI) tract
hormones
iatrogenic
idiopathic
infections
inflammation
ischemia
lacerations
lesion
ligaments
lymph
malignant
metastasis
microorganisms
neoplasms
nosocomial
obese
pathology
peripheral
prognosis
projections
signs
sprain
strain
symptoms
syndrome
tendons
trauma
ulcer
vascular insufficiency

This chapter, the first in Part III, introduces the subjects of anatomy, radiographic positioning, and pathology to familiarize the reader with general concepts and terminology. This will improve understanding of the material included in the chapters to follow. Each of the other chapters in Part III discusses the anatomy, radiographic positioning, and common pathology of a particular body part. The term *anatomy* refers to the *structure* of the body. A comprehensive knowledge of the anatomy to be radiographed is essential for accurate radiographic positioning and for correct evaluation of finished radiographs. Physiology, on the other hand, refers to the function of the body. Although the primary emphasis in this text is on anatomy, function is included in the discussion of tissue and of organ systems.

In preparation for the study of radiographic positioning, this chapter includes the terms used to describe body positions and radiographic projections. Also included are details of common tasks performed during radiographic procedures. These include image receptor (IR) selection and use; alignment of radiographic tube, body part, and IR; placement of radiographic markers; and patient instructions.

Pathology is the study of disease that causes abnormal changes in the structure or function of body tissue and organs. A general knowledge of pathology will improve understanding of why many radiographic procedures are performed. This awareness may improve the diagnostic results of the procedure. The performance of radiography is more interesting and rewarding when the results make a positive contribution to the diagnosis and treatment of the patient.

ANATOMY

There are six levels of structural organization of the human body (Fig. 12.1). The body, like all matter, is made up of atoms and molecules. This is referred to as the *chemical level* of organization. The next level is the *cellular level.* Cells are the smallest units of living things. Groups of similar cells that work together to perform a common function are called *tissues.* An *organ* is a group of tissues that act together to perform a special function. A *system* is a group of organs that work together to perform complex functions. The sixth and highest level of structural organization is the *body as a whole.*

Cells

Cells are the smallest units of all living things. The human body is made up of many trillions of living cells. Cells are too small to be seen with the naked eye but can be examined using a microscope. There is great variation among cells with respect to size, shape, and function. For example, the ovum (female sex cell) is more than 100 times the size of a red blood cell. Some cells are flat, some are brick-shaped, some are threadlike, some have irregular shapes, and some are capable of changing shape. Cells function as parts of tissue, so their function is explained under that heading.

The three main parts of a cell are the plasma membrane, the cytoplasm, and the nucleus. The plasma membrane encloses the cytoplasm and forms the outer boundary of the cell. The membrane also serves to provide communication between the cell and the rest of the body. Hormones or other chemical compounds can attach to the cell membrane and affect the activities within the cell. The cytoplasm is a highly specialized living material inside the plasma membrane and surrounding the nucleus. The cytoplasm consists of fluid and a variety of tiny structures called *organelles* that perform the work of the cell. The nucleus of the cell contains the chromosomes, the hereditary structures that contain the "blueprint" for cell structure and function. They are made up of the complex protein, DNA.

Tissues

Four main types of tissue compose the body's many organs: epithelial, connective, muscle, and nervous.

There are a number of types of epithelial tissue, but all perform the basic function of protecting underlying tissues. The skin is made up of epithelial tissue, as are the linings of the stomach and the air passages of the lungs. Some epithelial tissues also absorb and/or secrete substances. For example, the lining of the stomach absorbs nutrients from food and secretes chemicals that aid in digestion.

Connective tissue is the most widely distributed of all tissue and has the greatest variety of form and function. Connective tissue is found between tissues and between organs and serves to hold them together. It also makes up the structure of bone, cartilage, and fat.

Muscle tissue is capable of stretching and contracting. Its function is to produce movement. Different types of muscle tissue serve to move the bones, cause the heart to beat, and provide the movements required by other body organs.

Nervous tissue consists of the nerve cells, called *neurons*, and support cells. Neurons conduct electric impulses, providing rapid communication between body structures and control of body functions.

Organ Systems

Organ systems are the largest and most complex units of the body. The 11 major organ systems that compose the human body are the integumentary, muscular, nervous, endocrine, circulatory, lymphatic, respiratory, digestive, urinary, reproductive, and skeletal systems.

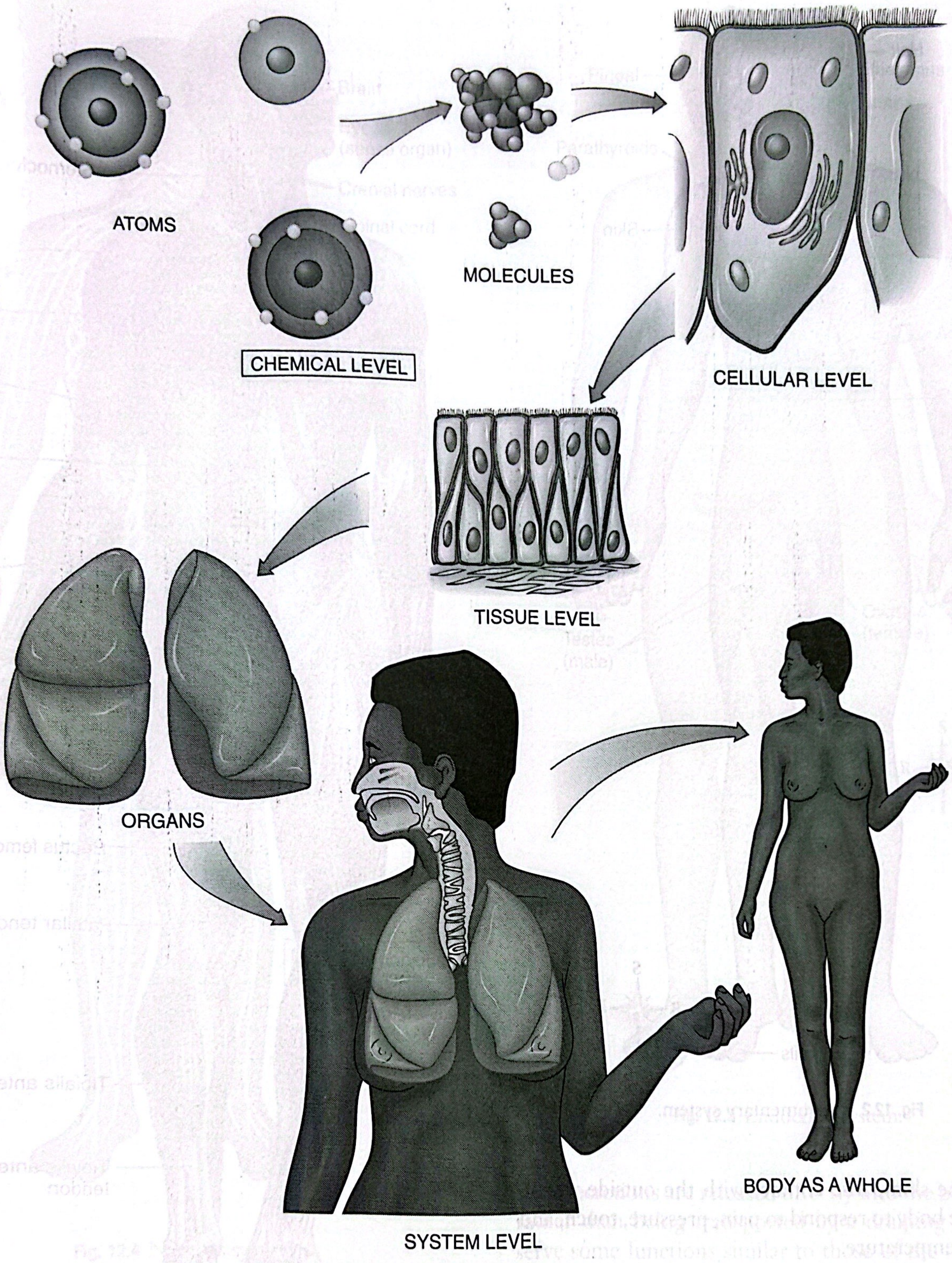


Fig. 12.1 Levels of structural organization.

A brief overview is provided for the majority of the organ systems. The skeletal system is discussed in greatest detail because this is the most common organ system radiographed by the limited operator. The majority of chapters in Part III are concerned with radiography of a particular portion of the bony skeleton. Part III also covers radiography of the chest, which contains the major portion of the respiratory system, and radiography of the abdomen, which contains the major parts of the digestive and urinary systems.

Integumentary

The integumentary system (Fig. 12.2) consists principally of the skin. It also includes the hair and the nails. The glands within the skin that secrete oil and sweat are parts of the integumentary system as well. Special microscopic

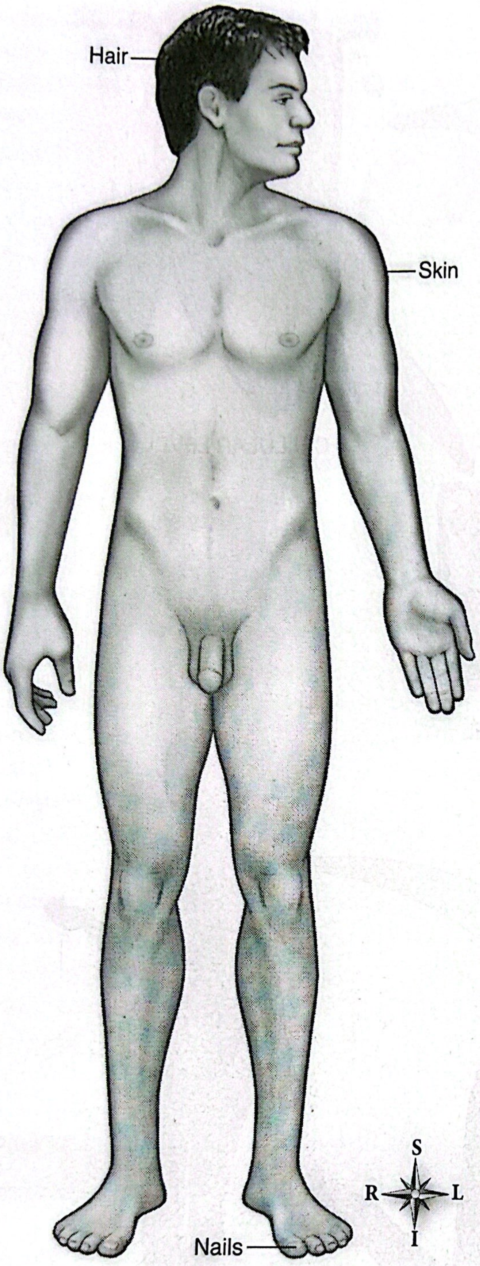


Fig. 12.2 Integumentary system.

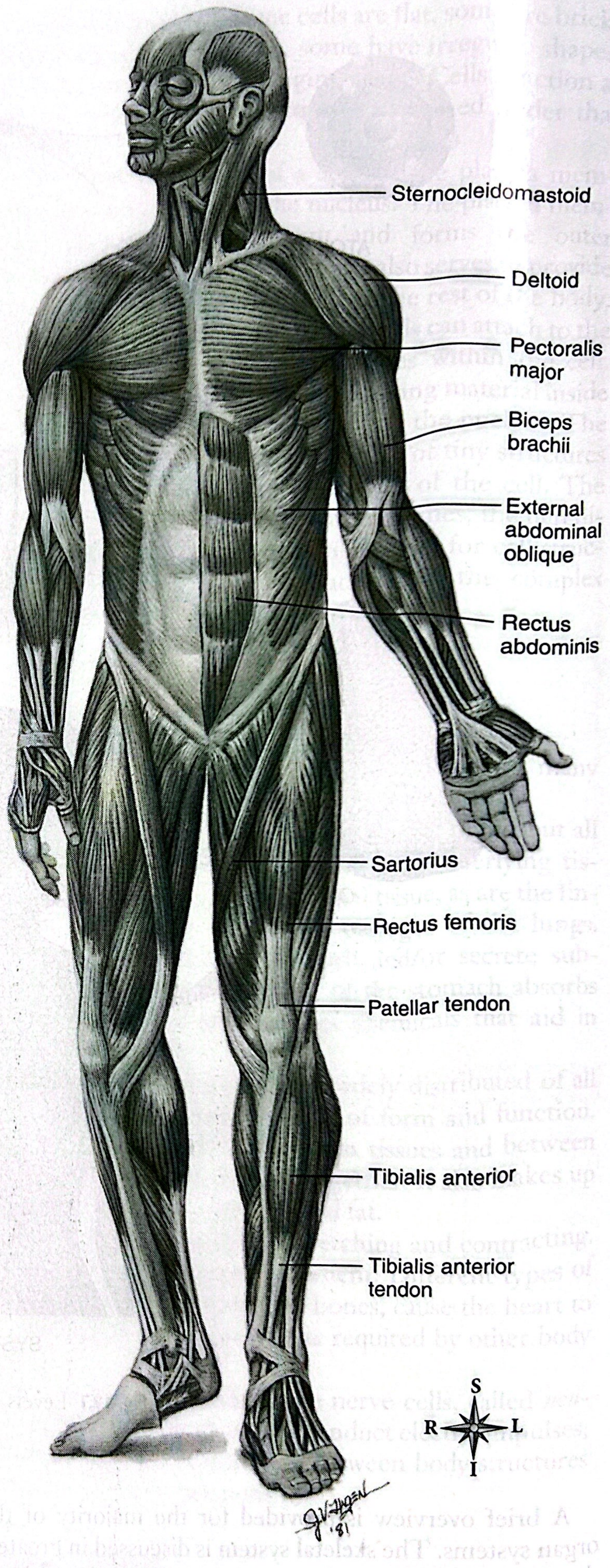


Fig. 12.3 Muscular system.

organs in the skin sense contact with the outside world, enabling the body to respond to pain, pressure, touch, and changes in temperature.

Muscular

The muscular system (Fig. 12.3) consists of the voluntary muscles, which control the movements of the skeleton and are under conscious control, and the involuntary muscles, which function to produce the movements of organs. Muscles produce heat, maintaining a constant body temperature. Some specific muscles will be introduced in Chapter 23 in the discussion on intramuscular injections.

Nervous

The nervous system (Fig. 12.4) consists of the brain, the spinal cord, and the nerves. The brain and the spinal cord are referred to as the **central nervous system (CNS)**. The nerves that carry information between the CNS and all parts of the body comprise the **peripheral** nervous system. Nervous system functions include communication,

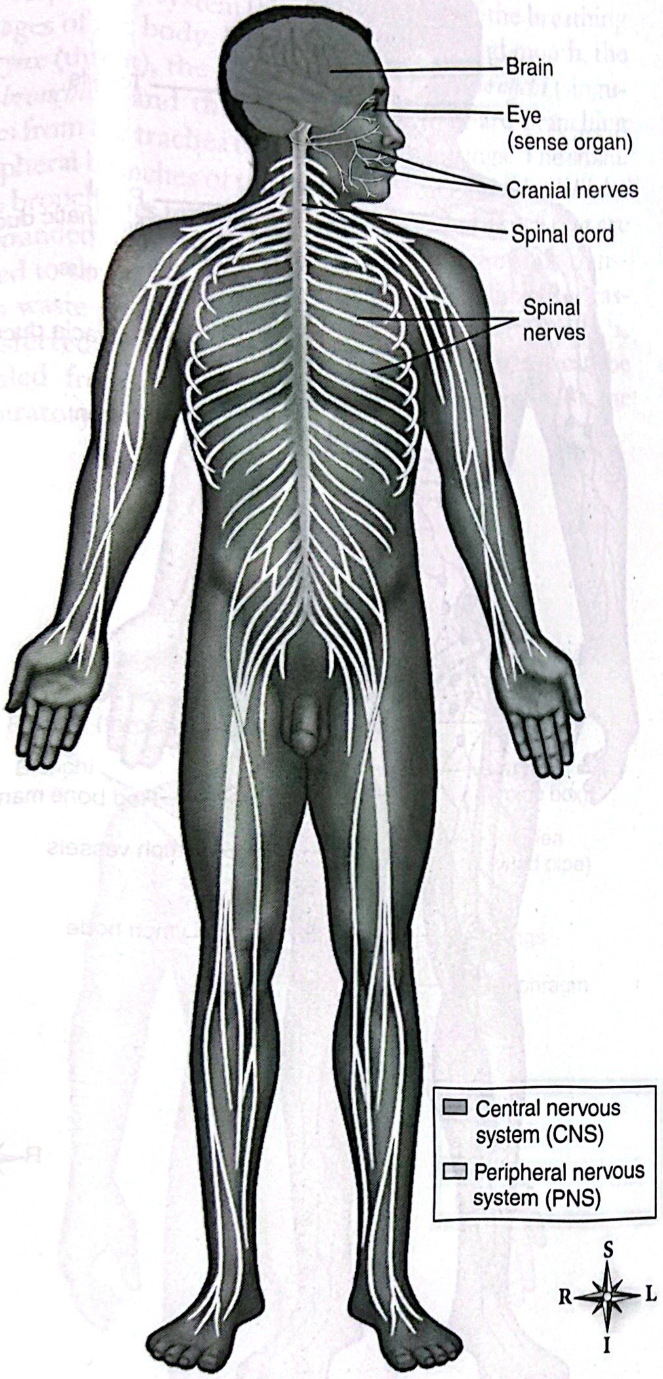


Fig. 12.4 Nervous system.

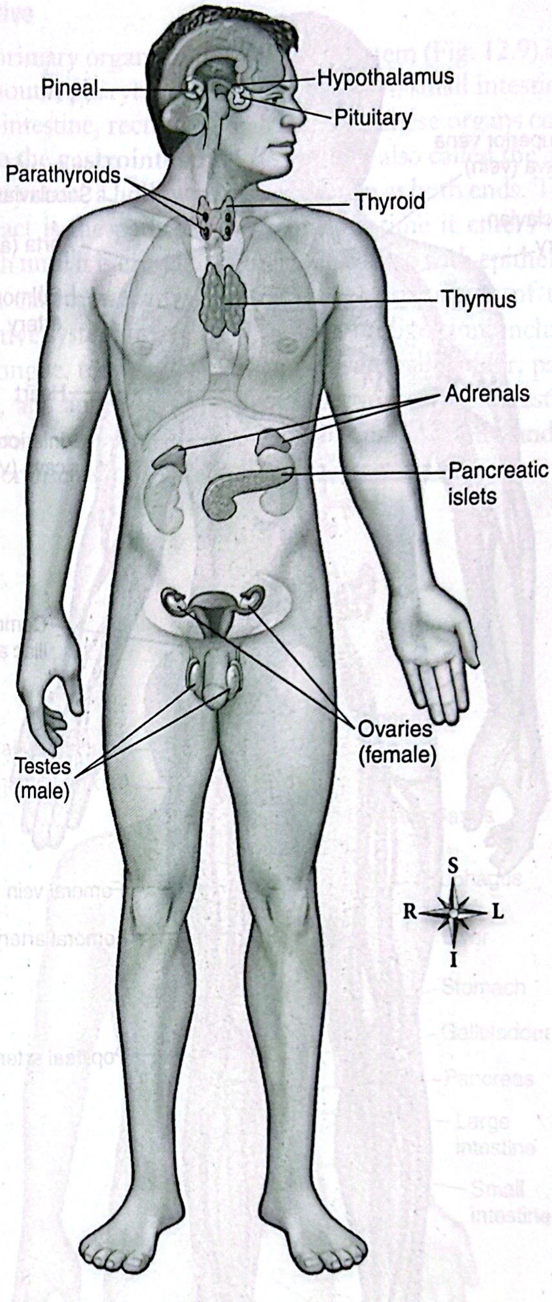


Fig. 12.5 Endocrine system.

integration and control of body functions, and recognition of stimuli. Stimuli are agents, such as light, heat, pressure, and sound, that evoke sensations and perceptions. The functions of the nervous system are accomplished by the transmission of tiny electric impulses along the nerve pathways.

Endocrine

The endocrine system (Fig. 12.5) consists of glands that secrete special chemicals called **hormones.** Endocrine glands are sometimes referred to as *ductless glands* because their secretions are released directly into the bloodstream, rather than being transported by a draining duct. They serve some functions similar to those of the nervous system in that they communicate, integrate, and regulate body functions. The hormones of the endocrine system provide slower, longer-lasting control of body function than the rapid electric impulses of the nervous system.

Circulatory

The circulatory system (Fig. 12.6) is also referred to as the *cardiovascular system*. It consists of the heart and the blood vessels. There are three types of blood vessels: *arteries*, which carry blood away from the heart; *veins*, which carry blood back to the heart; and *capillaries*, tiny vessels between the arteries and the veins that provide oxygen and nutrients to the cells. The heart provides a pumping action to keep

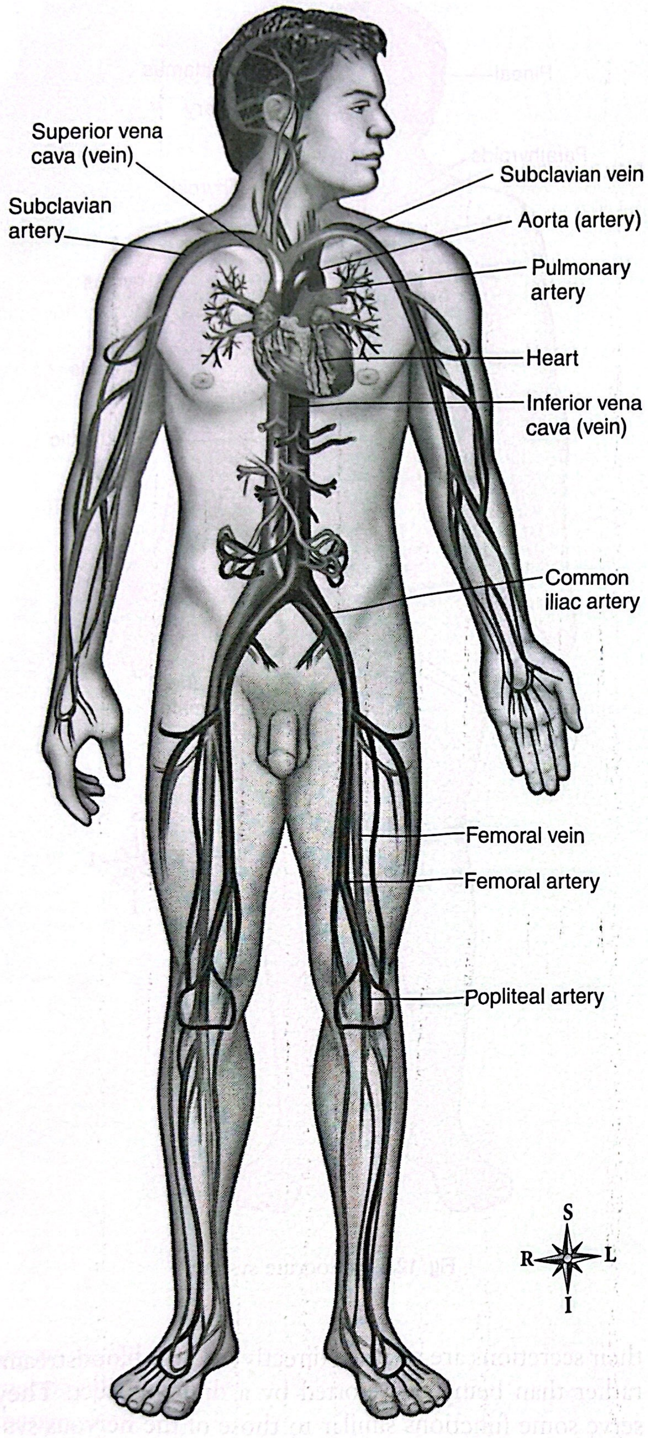


Fig. 12.6 Circulatory system.

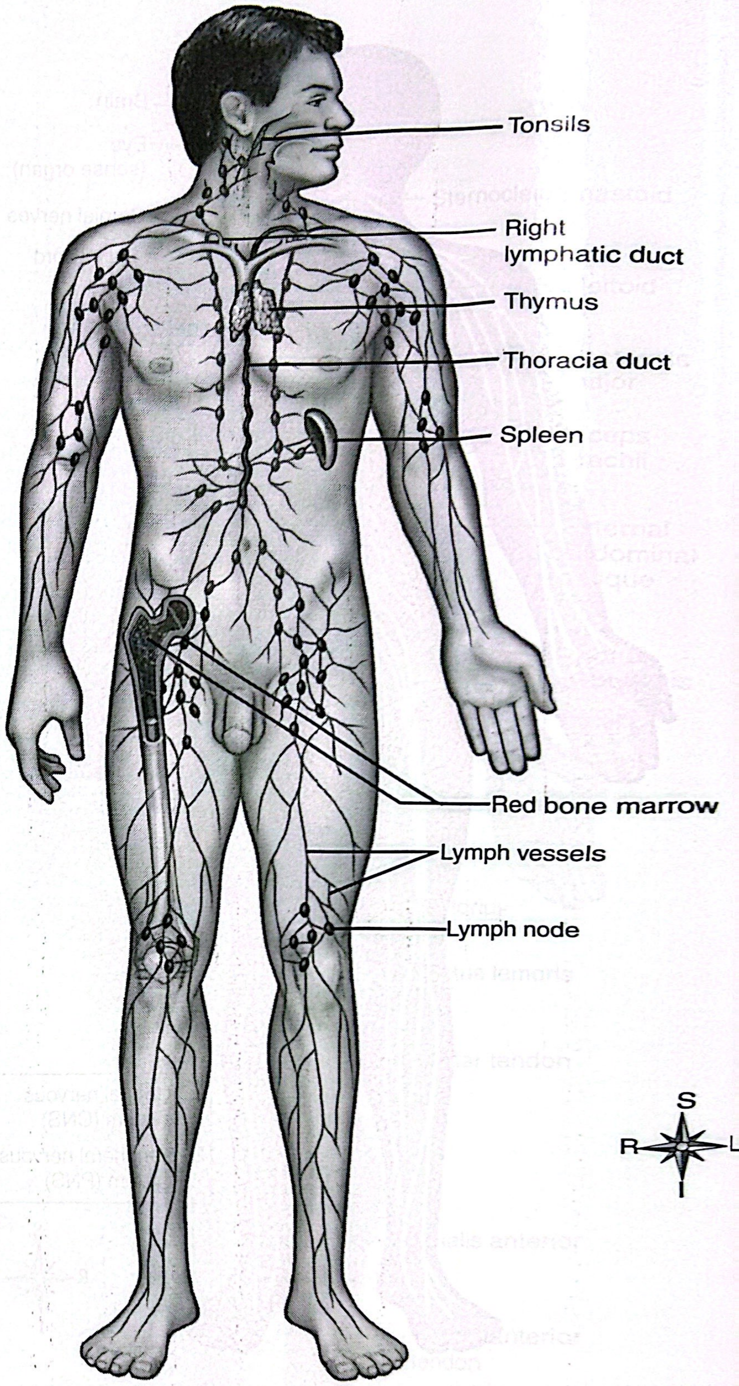


Fig. 12.7 Lymphatic system.

blood flowing throughout the circulatory system. The major portions of the circulatory system will be addressed in more detail with the anatomy of the chest and abdomen in Chapter 16. Specific arteries and veins will be introduced when learning the procedures for taking a pulse in Chapter 22 and for drawing blood samples in Chapter 24.

Lymphatic

The lymphatic system (Fig. 12.7) consists of the lymph nodes and lymph vessels, plus the spleen, tonsils, and thymus gland. The lymphatic system provides the fluid called **lymph** that surrounds the cells and serves to move fluid and certain large molecules from the cells to the circulatory system. The lymphatic system communicates with the circulatory system by means of the thoracic duct in the chest. An important function of the lymphatic system is its role in the immune system, which protects the body from disease.

Respiratory

The respiratory system (Fig. 12.8) consists of the breathing passages of the body. Included are the nose and mouth, the *pharynx* (throat), the *trachea* (windpipe), the *bronchi* (singular, *bronchus*), and the lungs. The bronchi are branching tubes from the trachea to the tissues of the lungs. The small, peripheral branches of the bronchi are called the *bronchioles*. The bronchioles terminate in tiny sacs called *alveoli* that are surrounded by blood vessels. Oxygen from the air is transferred to the blood from the alveoli. Carbon dioxide, a gaseous waste produced when oxygen is used by the body, is transferred from the blood to the alveoli so that it can be exhaled from the lungs. More detailed anatomy of the respiratory system is covered in Chapter 16.

Digestive

The primary organs of the digestive system (Fig. 12.9) are the mouth, pharynx, esophagus, stomach, small intestine, large intestine, rectum, and anal canal. These organs constitute the **gastrointestinal (GI) tract**, also called the *alimentary canal*, a hollow tube that is open at both ends. The GI tract is the path of food from the time it enters the mouth until it is excreted as waste. It is lined with epithelial tissue called *mucous membrane*. Accessory organs of the digestive system, many of which aid in digestion, include the tongue, teeth, salivary glands, liver, gallbladder, pancreas, and appendix. The major portion of the digestive system is contained within the abdominal cavity and is further discussed in Chapter 16.

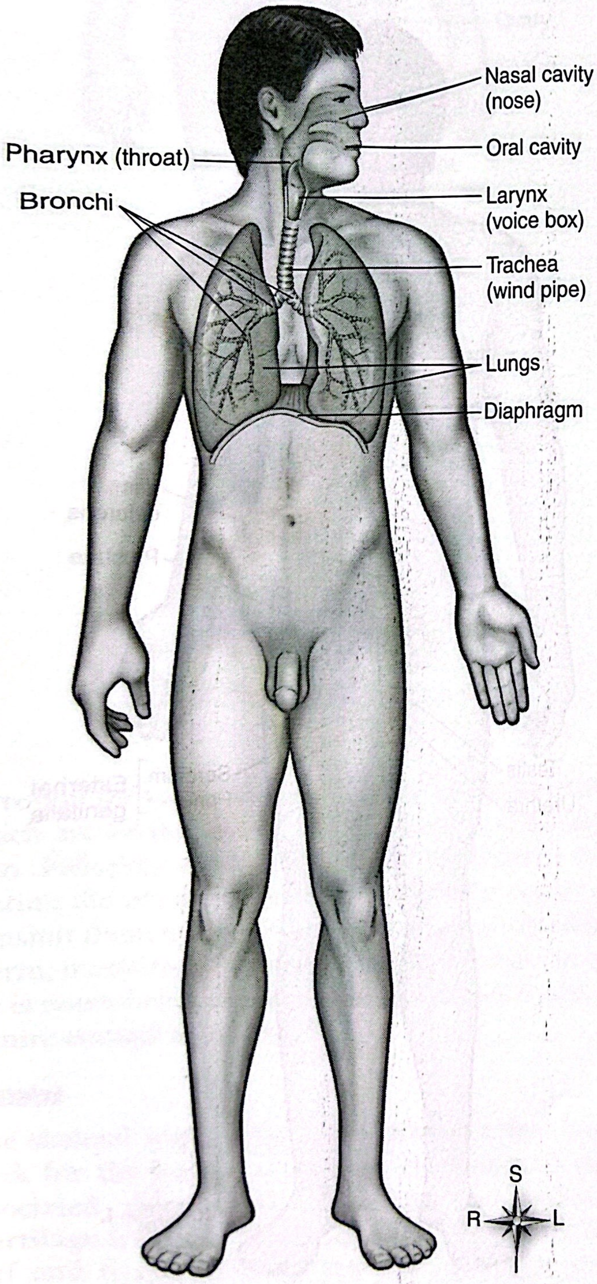


Fig. 12.8 Respiratory system.

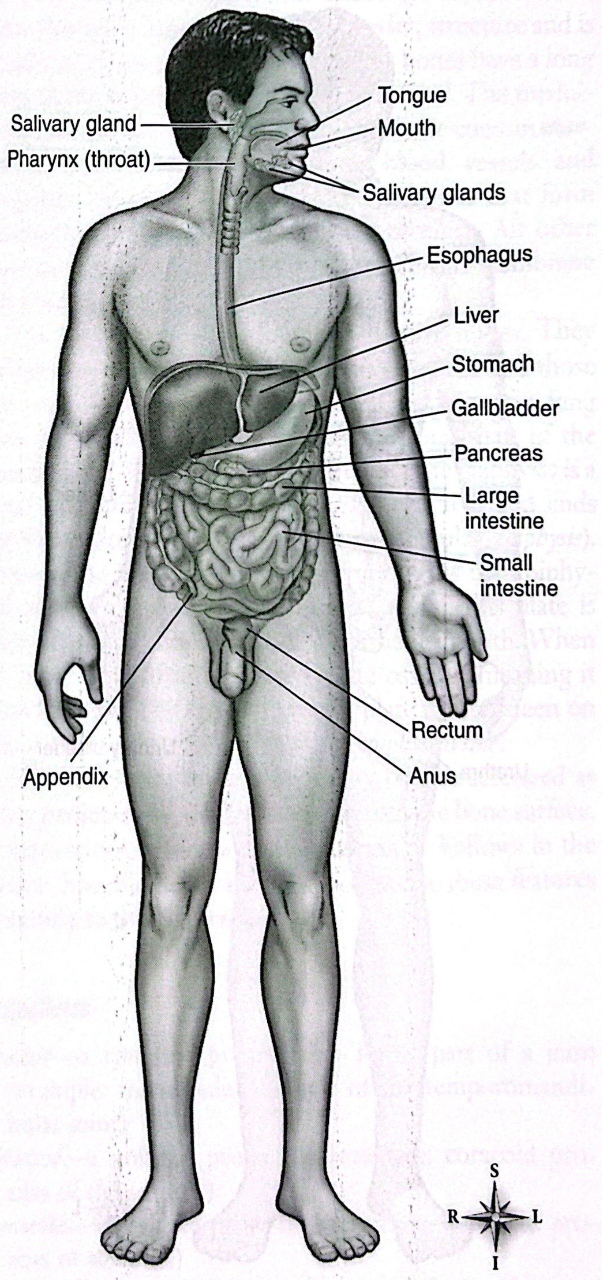


Fig. 12.9 Digestive system.

Urinary

The urinary system (Fig. 12.10) consists of the kidneys, ureters, bladder, and urethra. The function of the urinary system is to eliminate excess fluid and the waste products of cellular activity from the body. The fluid and chemical waste are removed from the blood by the kidneys, forming *urine*. The urine flows through long tubes called *ureters* and into the bladder, where it is stored. Urine empties from the bladder through a tube called the *urethra*.

Reproductive

The reproductive system, unlike other organ systems, does not function for the survival of the individual. Its purpose is the survival of the species; in our case, the human race. Hormones produced by the reproductive organs promote the development of sexual characteristics. External organs or structures of the reproductive system are called *genitalia*. The organs that produce reproductive cells are called *gonads*; they were introduced in Chapter 11.

In the male reproductive system (Fig. 12.11), the external genitalia consist of the scrotum and the penis. The gonads are called *testes* (singular, *testis*). The testes are located within the scrotum. Sperm (male reproductive cells) from the testes travel through the vas deferens (a small, tubular structure) to the urethra, which opens to the outside. In the male, the urethra is a part of both the urinary system and the reproductive system. The prostate gland is an accessory organ of the male reproductive system. It surrounds the urethra at its junction with the bladder.

In the female reproductive system (Fig. 12.12), the external genitalia consist of the vulva, the soft tissues that

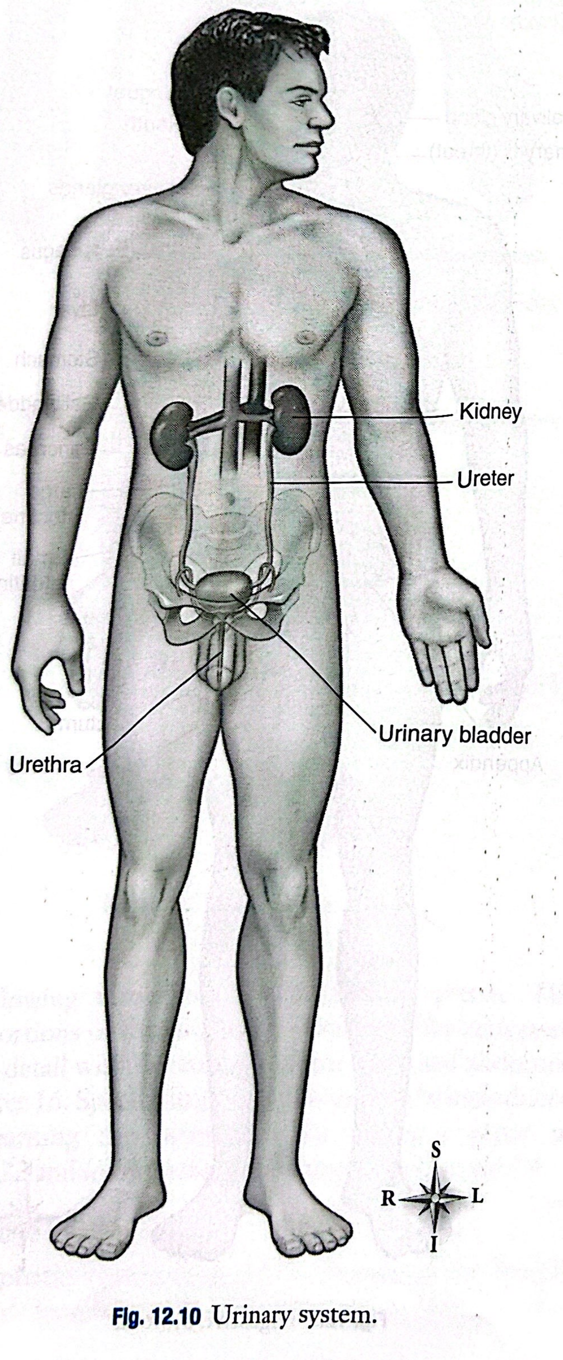


Fig. 12.10 Urinary system.

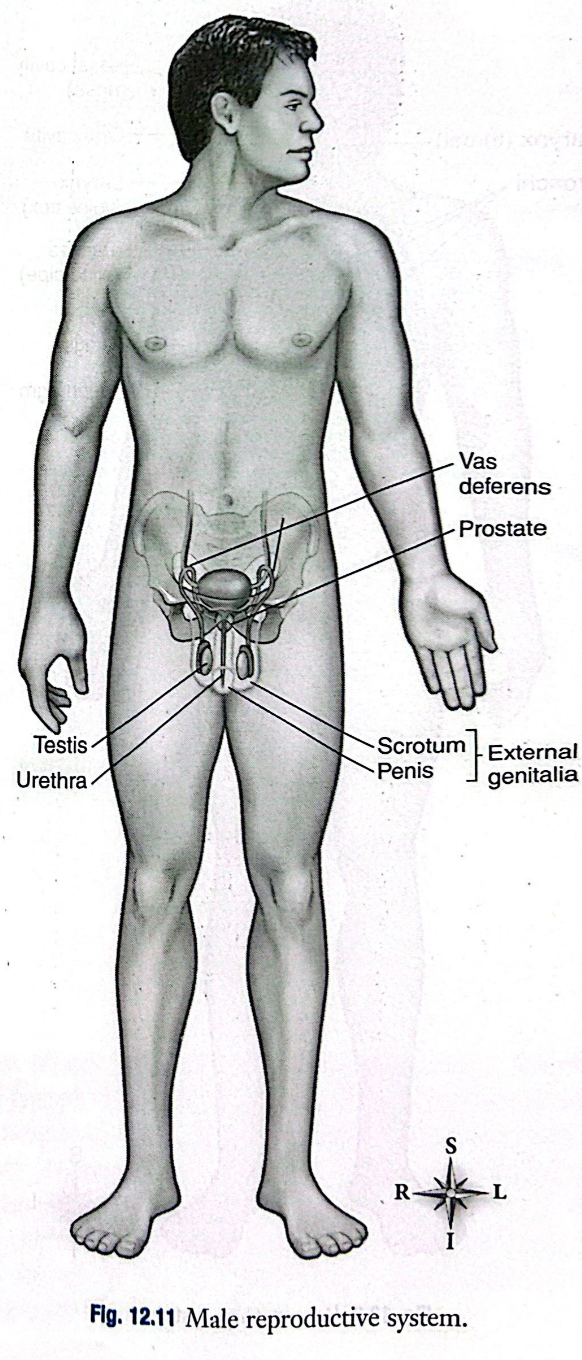


Fig. 12.11 Male reproductive system.

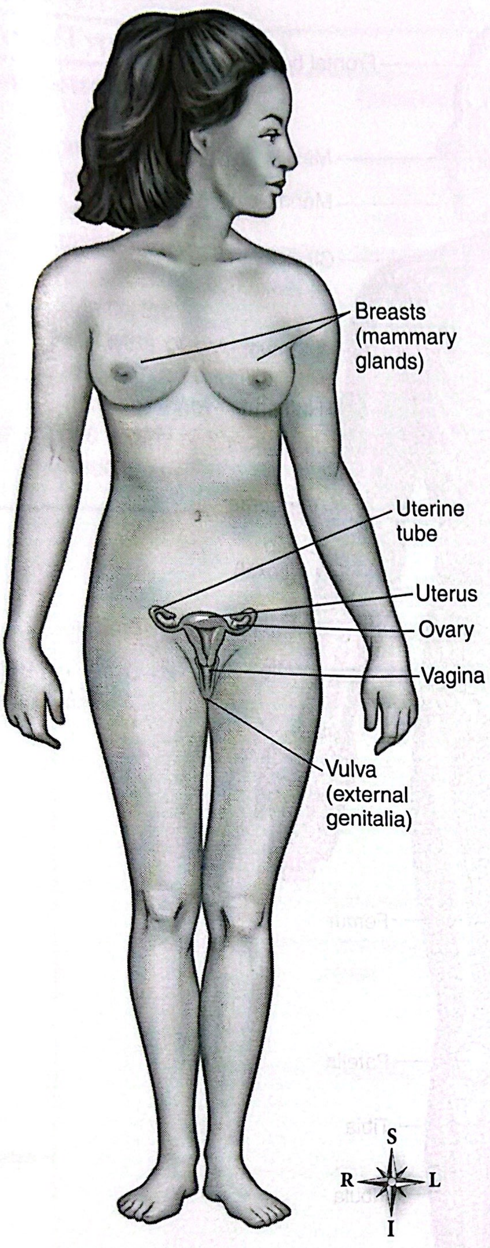


Fig. 12.12 Female reproductive system.

surround the vaginal opening. The gonads are the ovaries, which are located within the pelvic portion of the abdomen. Fallopian tubes, which are also called *uterine tubes*, capture the ova when they are released by the ovaries and transmit them to the uterus. If the ovum is fertilized by a sperm, it attaches to the wall of the uterus, where the new life is nourished and protected as it grows until the fetus is mature enough to be born.

Skeletal

The skeletal system (Fig. 12.13) provides a rigid framework for the body. It consists of 206 bones with other associated tissues, such as cartilage and ligaments. **Cartilage** is a tough, fibrous connective tissue that is both stiff and flexible. The lay term for cartilage is *gristle*. **Ligaments** are flexible bands of fibrous tissue that bind joints together and provide connections between bones and cartilage. **Tendons** are bands of fibrous tissue that attach muscles to bones.

The skeletal system is divided into the axial skeleton and the appendicular skeleton. The axial skeleton consists of the skull, spine, sternum (breast bone), and ribs. The appendicular skeleton includes the bones of the extremities (arms and legs), as well as those of the pelvis and shoulders. The remainder of this section discusses the physical characteristics of bone and the types of joints formed by the joining of particular bones.

Structure of Bone

The structure of bone varies considerably, depending on the specific type of bone. The four basic types are listed and described in Table 12.1.

The outer portion of most bones is a layer of hard, compact bone called the *cortex*. Inside the cortex is bone tissue that has a honeycomb, or *trabecular*, structure and is called cancellous or spongy bone. Long bones have a long cavity in the center called the *medullary canal*. The medullary canal and the spaces within spongy bone contain *marrow*, a fatty substance containing blood vessels and immature blood cells. The surfaces of bones that form moving joints are covered with *joint cartilage*. All other bone surfaces are covered by a tough, fibrous membrane called the *periosteum*.

The long bones are all found in the extremities. They include the major bones of the arms and legs and those that make up the fingers and toes. The parts of a long bone are illustrated in Fig. 12.14. The long shaft of the bone is called the *diaphysis*. At each end of the diaphysis is a flared portion called the *metaphysis*. The rounded ends that form joints are called the *epiphyses* (singular, *epiphysis*). Between the metaphysis and the epiphysis is the epiphyseal plate, or "growth plate." Early in life, this plate is made of cartilage and is the center for bone growth. When the bone is mature, the growth plate ossifies, meaning it turns to bone. The ossified growth plate is often seen on radiographs and is referred to as the *epiphyseal line*.

The features of bone shapes may be characterized as either **projections**, which grow out from the bone surface, or depressions, which are indentations or hollows in the surface. Specific terms are used to describe these features according to their characteristics.

Projections

Condyle—a rounded process that forms part of a joint (example: mandibular condyle of the temporomandibular joint)

Coracoid—a pointed projection (example: coracoid process of the scapula)

Coronoid—a beaklike projection (example: coronoid process of the ulna)

Crest—a bony ridge (example: crest of the ileum, a common positioning landmark)

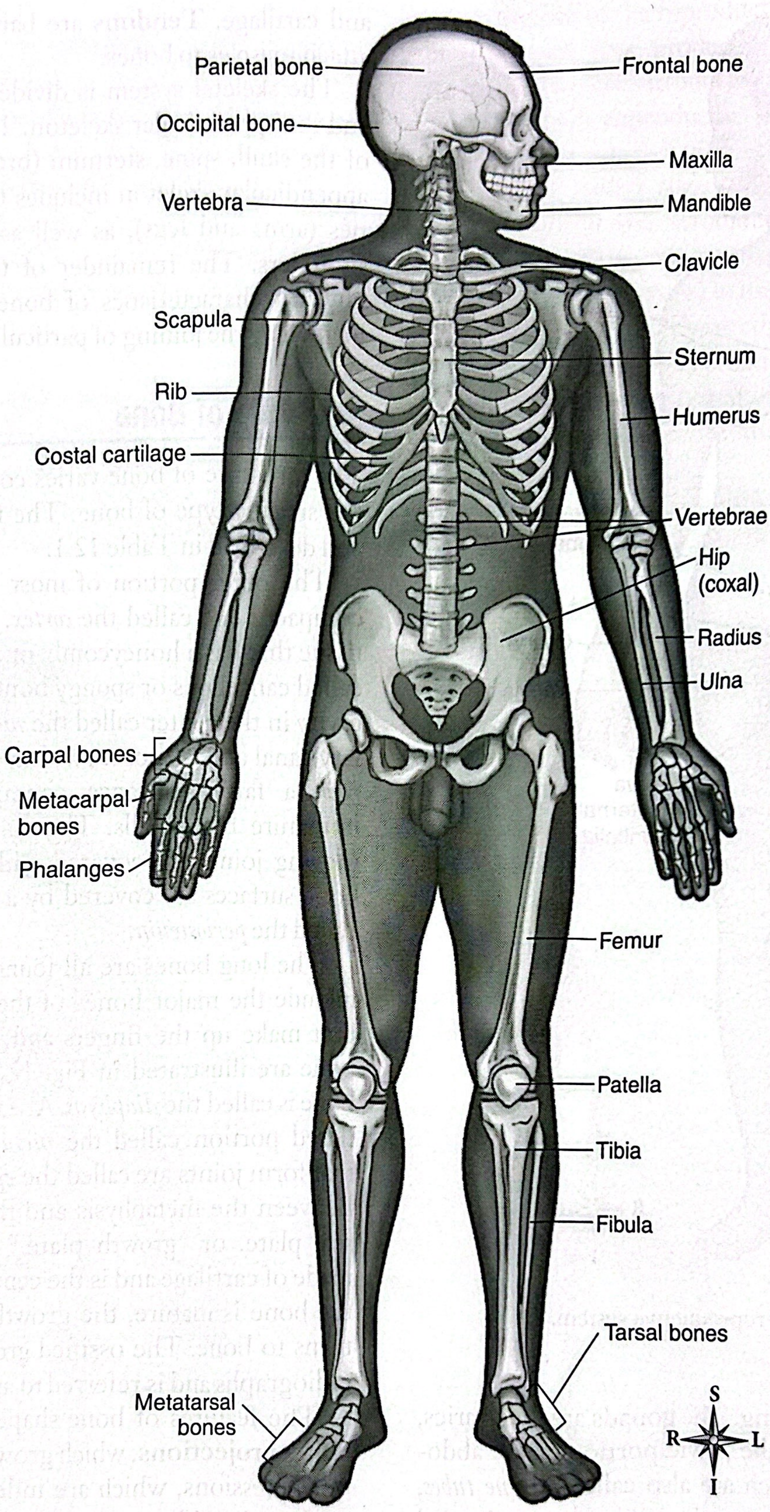


Fig. 12.13 Skeletal system.

Epicondyle—a projection above a condyle (example: medial epicondyle of the elbow)

Facet—a small, smooth process that forms part of a joint (example: articular surface of the superior articulating process of a vertebra)

Head—the rounded, wide end of a long bone (example: head of the humerus)

Malleolus—a club-shaped projection (example: medial malleolus of the distal tibia)

Process—a general term for a projection (example: coracoid process of the scapula)

Protuberance—a general term for a projection (example: external occipital protuberance of the skull)

Spine—a sharp process or a sharp ridge (example: scapular spine)

Styloid—a long, sharp process (example: ulnar styloid)

Trochanter—one of the large, rounded processes of the femur

TABLE 12.1
Bone Types

Bone Type	Description	Examples
Long	Long shaft with thick cortex and medullary canal; the two ends form joints	Humerus (upper arm), femur (thigh bone)
Short	Small bones made primarily of cancellous bone with a thin cortex	Bones of wrist and ankle
Flat	Two layers of compact bone with a thin cancellous layer between them	Cranium (outer skull), scapula (shoulder blade)
Irregular	Wide variety of shapes and structures	Vertebrae (spine), bones of the face

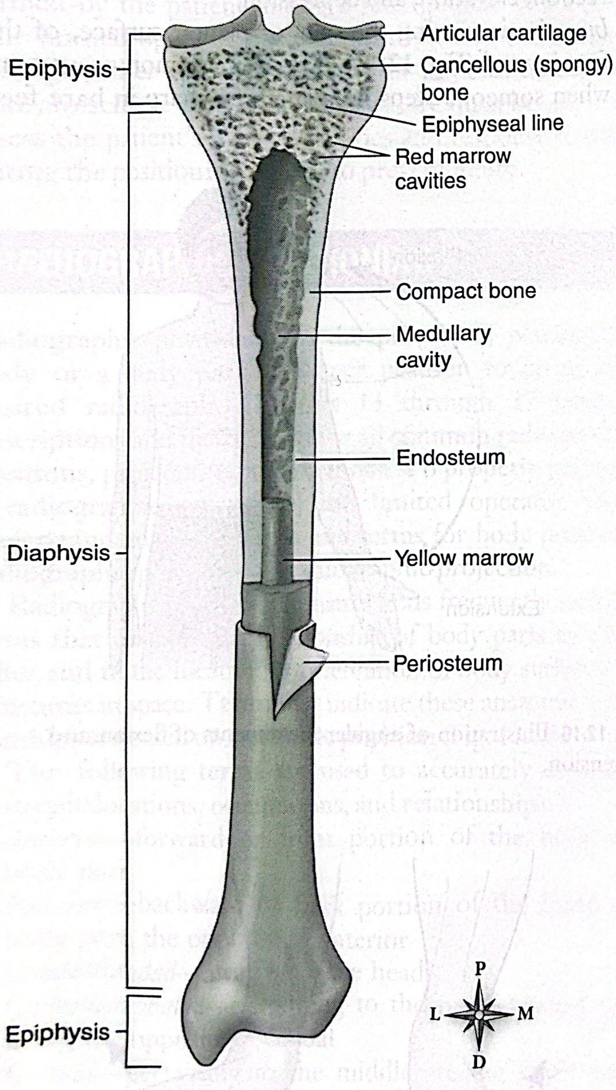


Fig. 12.14 Structure of long bones.

Tubercle—a small, rounded process (example: greater tubercle of the proximal humerus)
Tuberosity—a rounded process larger than a tubercle, although the terms are sometimes used interchangeably (example: greater tuberosity of the proximal humerus)

Depressions

Fissure—a linear depression, a groove (example: orbital fissure)
Foramen (plural, *foramina*)—a hole in a bone for the passage of blood vessels and nerves (example: foramen magnum of the skull base)
Fossa (plural, *fossae*)—a pit or hollow (example: mandibular fossa of the temporal bone)
Groove—a shallow linear depression (example: bicipital groove of the proximal humerus)
Sinus—a cavity or hollow space (example: maxillary sinus)
Sulcus—a trenchlike depression, a deep fissure (example: carotid sulcus of the sphenoid bone)

Joints

The places where bones are joined together are called *joints* or **articulations.** There are three classifications of joints based on their ability to move:

- *Synarthrosis* refers to a joint that does not move. With the exception of the mandible (jaw bone), the joints of the skull are all synarthrodial joints and are called *sutures.*
- *Amphiarthrosis* refers to a joint that has very limited motion. The articular surfaces that form these joints are covered by fibrous cartilage or cushioned by disks of fibrous cartilage. The joints between the bodies of the spinal vertebrae and the sacroiliac joints (between the spine and the pelvis) are examples of amphiarthrodial joints.
- *Diarthrosis* refers to a joint that can move freely. The bones that form these joints are shaped to fit together to accomplish the required movement, and their articular surfaces are covered by articular cartilage. A fibrous capsule that is lined with synovial membrane surrounds the joint. This membrane secretes *synovial fluid,* providing moisture to lubricate the joint.

Some diarthrodial joints have sacs filled with synovial fluid. These are called *bursae* (singular, *bursa*). They serve to cushion the movements of tendons or muscles. Important bursae are located at the shoulder, elbow, hip, and knee.

Joint Movements

Joints allow a number of body movements. The following terms are used to describe these movements. Many are used in the radiographic positioning instructions in this book.

Four types of movement are found in diarthrodial joints:

Circular movement is the arclike rotation of a structure around an axis. Circular movements include rotation, circumduction, supination, and pronation.

- *Rotation* is the pivoting of a bone on its axis. Moving the head from side to side (indicating "no") requires pivoting the first cervical vertebra around the odontoid process of the second cervical vertebra.
- *Circumduction* moves the distal end of a bone in a circle, resulting in a conical-shaped motion. A baseball pitcher's throwing motion requires circumduction of the arm at the shoulder.
- *Supination* is lateral (or external) rotation of the bones of the forearm so the palm of the hand is facing up or anterior. This movement is illustrated in Fig. 12.15.
- *Pronation*, the opposite of supination, is medial (or internal) rotation of the bones of the forearm so the palm of the hand is facing down or posterior.

Angular movement is commonly referred to as bending, resulting in a change in angle between the long axis of the two bones making up the joint. These angular movements include flexion, extension, abduction, and adduction.

- *Flexion* is a bending motion that decreases the angle between two bones. An example would be to bend the arm at the elbow joint so the forearm moves closer to the humerus. This movement is illustrated in Fig. 12.16.
- A specific type of flexion, called *dorsiflexion*, occurs when the foot is moved so the toes are closer to the anterior surface of the lower leg. This decreases the angle between the top, or dorsal surface, of the foot and the anterior lower leg. *Plantar flexion*, the opposite of dorsiflexion, is movement of the foot away from the lower leg so the angle between them is increased.
- *Extension*, the opposite of flexion, is a bending motion that increases the angle between two bones. The arm is extended at the elbow joint when the flexed arm is returned to anatomic position. The term *hyperextension* is used when a joint is extended beyond its usual anatomic position. This is not considered a normal joint movement.

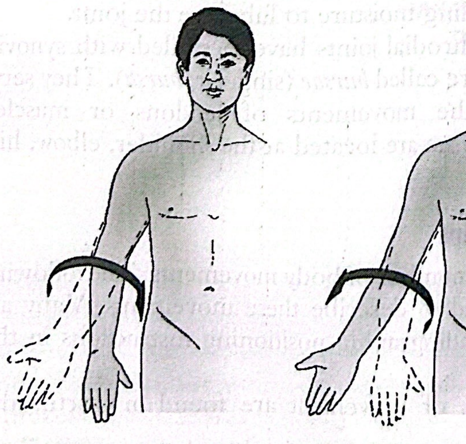


Fig. 12.15 Illustration of the circular movements of pronation and supination.

- *Abduction* is movement of a part away from the middle, or midline, of the body. An example would be movement of the arm or leg straight out to the side of the body, without moving it forward or back.
- *Adduction*, the opposite of abduction, is movement of a part toward the midline.

Gliding movement occurs when one bone slides over another. These simple motions occur without any circular or angular movements. Examples include the movement of the patella over the femur with knee flexion or extension and movement between the articular surfaces of the inferior and superior articular processes of adjacent vertebra.

The final types of diarthrodial joint movements are called *special movements*. They do not fit into the other types and occur in a limited number of joints. Special movements include inversion, eversion, protraction, retraction, elevation, and depression.

- *Inversion* is turning the sole, or plantar surface, of the foot inward (Fig. 12.17). This is a common movement when someone steps on something sharp in bare feet,

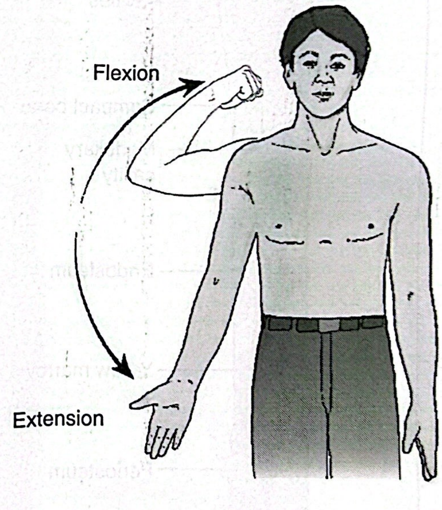


Fig. 12.16 Illustration of angular movements of flexion and extension.

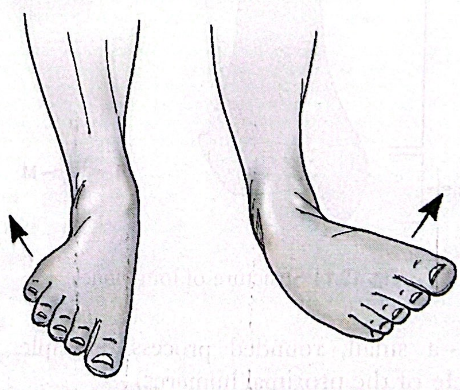


Fig. 12.17 Illustration of the special movements of eversion and inversion.

then checks to see if damage has occurred. Unintentional inversion of the foot is a common cause of a sprained ankle.

- *Eversion*, the opposite of inversion, is turning the sole of the foot outward. Unintentional eversion can also result in a sprained ankle.
- *Protraction* is moving a part forward, or anterior. Holding an arm straight out in front of you requires protraction.
- *Retraction*, the opposite of protraction, is moving a part backwards, or posterior.
- *Elevation* moves a part up, or superior. Moving the top of your shoulder toward your ear requires an elevation movement.
- *Depression*, the opposite of elevation, moves a part down, or inferior.

Many of the body movements just described are performed by the patient during a radiographic procedure. The limited operator must frequently assist the patient, through either verbal instructions or physical manipulations, to achieve these movements. Care must be taken to assess the patient's physical abilities and response to pain during the positioning process to prevent injury.

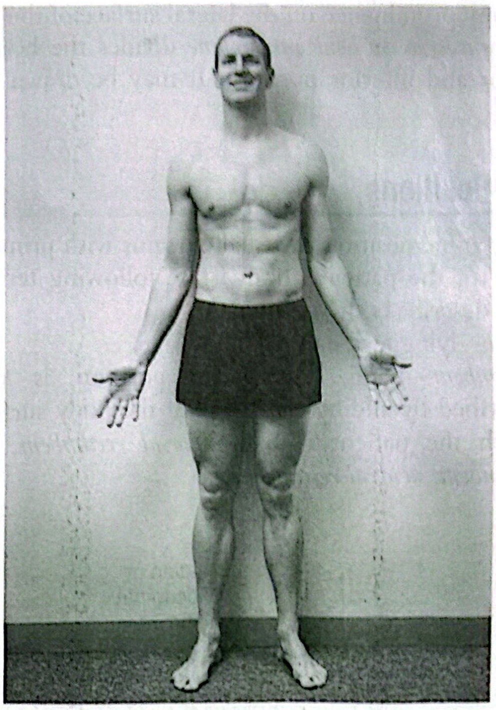


Fig. 12.18 Anatomic position.

RADIOGRAPHIC POSITIONING

Radiographic positioning is the process of placing the body or a body part in proper position to create the desired radiograph. Chapters 13 through 17 contain descriptions and instructions for all common radiographic positions, projections, and methods. To properly perform a radiographic procedure, the limited operator must understand anatomic terms and terms for body position, radiographic position, and radiographic projection.

Radiographic positioning instructions frequently include terms that describe the relationship of body parts to each other and to the location or orientation of body surfaces or structures in space. Terms that indicate these anatomic relationships are based on **anatomic position** (Fig. 12.18).

The following terms are used to accurately describe anatomic locations, orientations, and relationships:

- *Anterior*—forward or front portion of the body or body part
- *Posterior*—backward or back portion of the body or body part; the opposite of anterior
- *Caudal/caudad*—away from the head
- *Cephalic/cephalad*—pertaining to the head; toward the head; the opposite of caudal
- *Central*—pertaining to the middle area or main part of an organ or body part
- *Peripheral*—away from the central mass of an organ, toward its outer limits; the opposite of central
- *Distal*—away from the source or point of origin; for example, the wrist is *distal* to the elbow, being farther from the point of origin of the arm, which is at the shoulder
- *Proximal*—toward the source or point of origin; the opposite of distal
- *Dorsal*—pertaining to the back part or surface of the body or part; the top surface of the foot; or the back of the hand
- *Ventral*—forward, front part; the opposite of dorsal
- *External*—to the outside, at or near the surface of the body or a body part
- *Internal*—deep, near the center of the body or a body part; the opposite of external
- *Inferior*—below, farther from the head
- *Superior*—above, toward the head; the opposite of inferior
- *Lateral*—referring to the side, away from the center to the left or right
- *Medial/mesial*—toward the center of the body or the center of a part; the opposite of lateral
- *Palmar*—referring to the palm (anterior surface) of the hand
- *Plantar*—referring to the sole of the foot
- *Parietal*—referring to the walls of a cavity
- *Visceral*—pertaining to organs

Procedures for radiographic positioning are also described using body planes (Fig. 12.19). The *sagittal plane* divides the body into right and left parts; the *midsagittal* or *median plane* divides the body into equal right and left parts. The *coronal plane* divides the body into anterior and posterior parts. The *midcoronal* or *midfrontal plane* divides the body into relatively equal parts; it passes through the external auditory meatus (the opening of the ear), the center of the shoulder, the greater trochanter (the bony prominence in the lateral hip area), and the lateral malleolus (the bony prominence on the lateral surface of the ankle). The *transverse* or *horizontal plane* divides the body into superior and inferior portions. It may be drawn at any level.

Body Positions

Radiographic positioning usually begins with proper placement of the patient's body. The following terms are used to describe body positions:

- *Prone*—lying face down
- *Recumbent*—lying down; the position is further described by adding the name of the body surface on which the patient is lying: *dorsal recumbent, lateral recumbent, ventral recumbent*

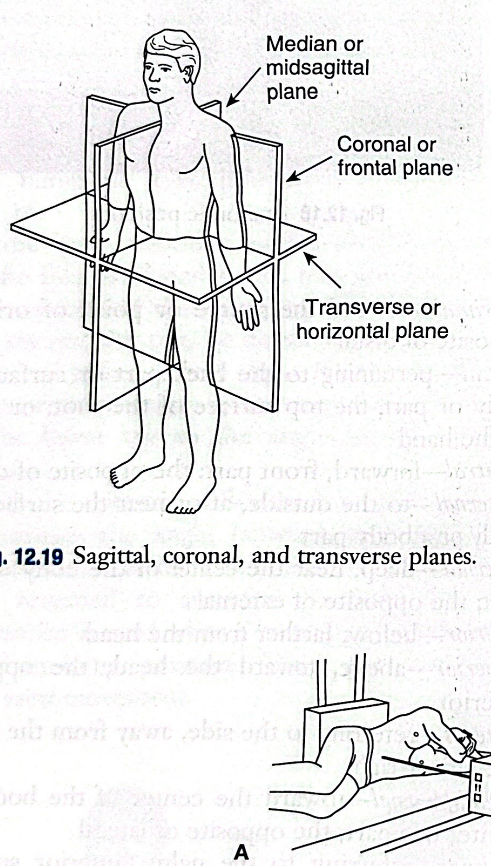


Fig. 12.19 Sagittal, coronal, and transverse planes.

- *Supine*—lying on the back
- *Upright*—erect, standing or seated

Radiographic Positions

Radiographic positions describe the placement of the body part in relation to the radiographic table or IR. The following terms are used to describe radiographic positions.

For a *decubitus* position, the patient is recumbent with the central ray (CR) horizontal, or parallel to the floor. This position is named according to the body surface on which the patient is lying: lateral decubitus (left or right), dorsal decubitus, or ventral decubitus. Fig. 12.20 illustrates the four decubitus positions.

A *lateral* position is achieved by placement of the body or body part with the sagittal plane parallel to the IR. It is named according to the side adjacent to the radiographic table or IR.

A *lordotic* position results in angulation of the coronal plane of the chest with the IR. It is achieved by having the upright patient lean back so that only the dorsal aspect of the shoulders is in contact with the IR.

An *oblique* position is achieved when the body part or entire body is placed so that the coronal plane is not parallel with the radiographic table or IR. The description is usually stated as a degree of rotation, either from a body plane or toward the affected side.

Radiographic Projections

A radiographic projection indicates the path of the CR from the radiographic tube and through the patient to the IR. Most are named, in anatomic terms, by the CR entrance and exit points in the body.

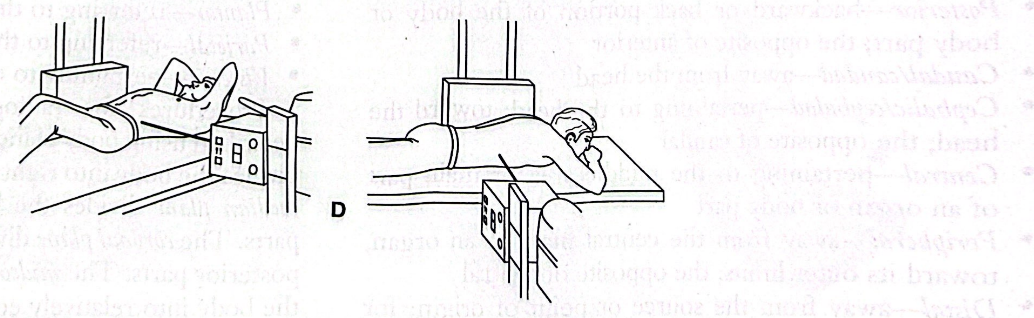


Fig. 12.20 Decubitus positions. Note horizontal orientation of the central ray. (A) Left lateral decubitus position results in an anteroposterior (AP) projection. (B) Right lateral decubitus position results in an AP projection. (C) Dorsal decubitus position results in a lateral projection. (D) Ventral decubitus position results in a lateral projection.

For *anteroposterior (AP) projections,* the CR enters the anterior surface and exits the posterior surface of the body or anatomic structure (Fig. 12.21).

For *posteroanterior (PA) projections,* the CR enters the posterior surface and exits the anterior surface of the body or anatomic structure (Fig. 12.22).

Lateral projections are those in which the sagittal plane of the body or body part is parallel to the IR. Lateral projections are always named for the side of the patient that is nearest the IR (Fig. 12.23). Lateral projections of the extremities are further described with the lateral or medial entrance and exit of the CR: mediolateral or lateromedial.

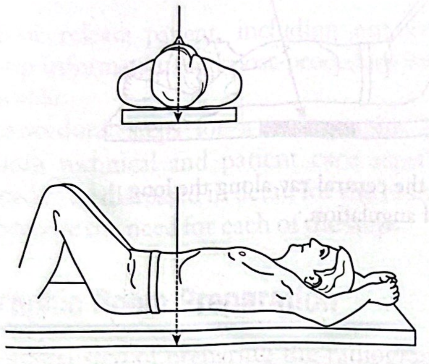


Fig. 12.21 Anteroposterior projection.

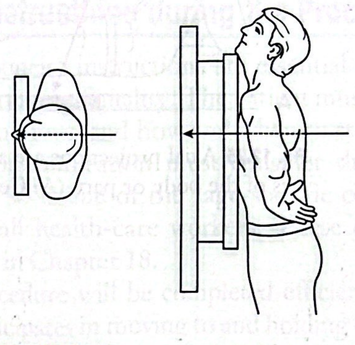


Fig. 12.22 Posteroanterior projection.

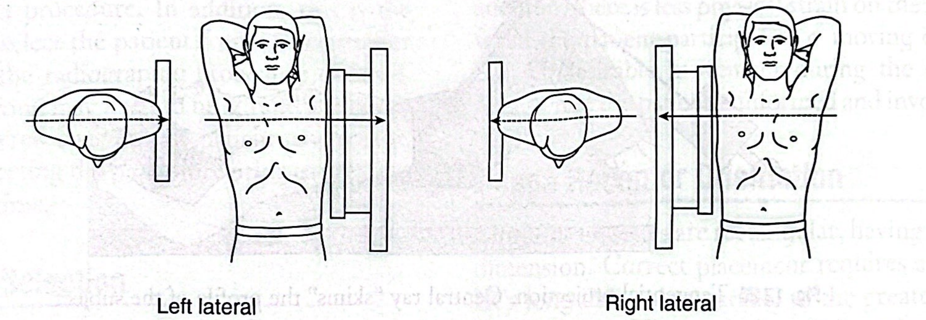


Fig. 12.23 Lateral projections.

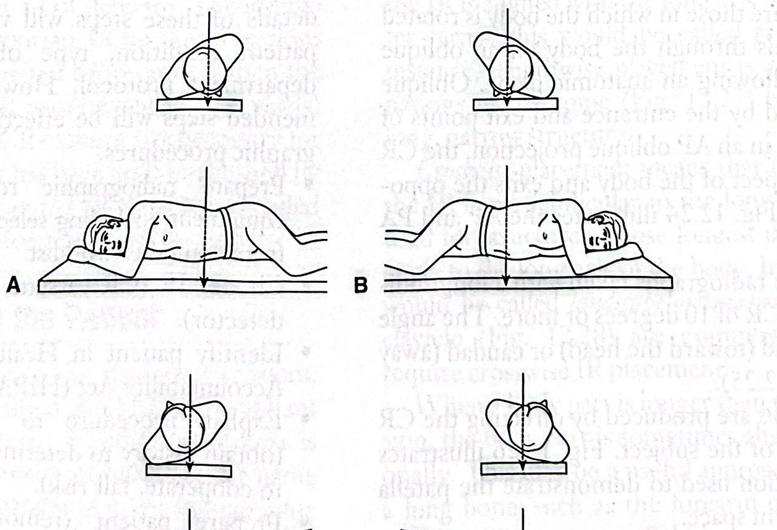


Fig. 12.24 Oblique projections. (A) Posteroanterior (PA) oblique projection, right anterior oblique position. (B) PA oblique projection, left anterior oblique position. (C) Anteroposterior (AP) oblique projection, left posterior oblique position. (D) AP oblique projection, right posterior oblique position.

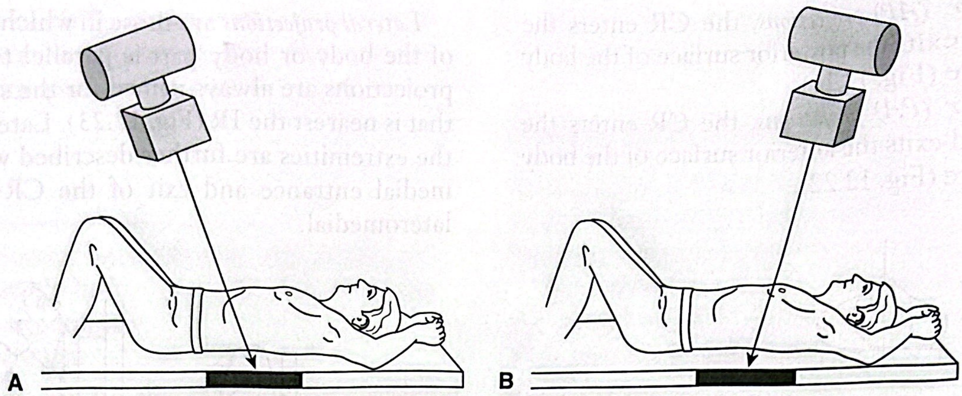


Fig. 12.25 Axial projections are accomplished by angulation of the central ray along the long axis of the body or part. (A) Cephalad angulation. (B) Caudad angulation.

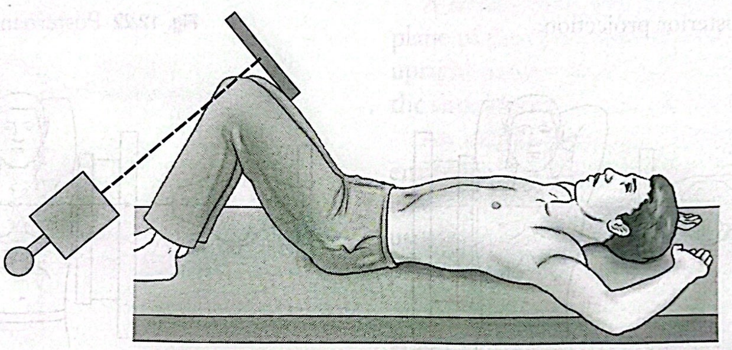


Fig. 12.26 Tangential projection. Central ray "skims" the profile of the subject.

Oblique projections are those in which the body is rotated so that the CR travels through the body on an oblique plane, rather than following an anatomic plane. Oblique projections are named by the entrance and exit points of the CR. For example, in an AP oblique projection, the CR enters the anterior aspect of the body and exits the opposite posterior aspect. Fig. 12.24 illustrates the AP and PA oblique projections

Axial projections are radiographs taken with a longitudinal angulation of the CR of 10 degrees or more. The angle may be either cephalad (toward the head) or caudad (away from the head) (Fig. 12.25).

Tangential projections are produced by directing the CR to "skim" the profile of the subject. Fig. 12.26 illustrates the tangential projection used to demonstrate the patella and patellofemoral joint space.

RADIOGRAPHIC PROCEDURES

All radiographic procedures consist of a set of steps designed to provide an organizational scheme that will ensure safe and effective performance. The order and details of these steps will vary by anatomy of interest, patient condition, type of equipment available, and department protocol. However, the following recommended steps will be effective for most common radiographic procedures.

- Prepare radiographic room and gather accessory equipment, including selection of patient and projection from computer worklist.
- Choose IR (CR cassette or digital radiography [DR] detector).
- Identify patient in Health Insurance Portability and Accountability Act (HIPAA)–compliant manner.
- Explain procedure to patient and assess patient (obtain history to determine correct procedure, ability to cooperate, fall risk).
- Prepare patient (remove clothing and potential artifact items, provide a gown, if needed).
- Set technical factors (e.g., kVp, mAs).
- Position patient.
- Set source–image receptor distance (SID)
- Align IR and CR.
- Position part.
- Collimate.

- Place side marker.
- Shield patient.
- Provide patient instructions (hold still, breathing instructions).
- Expose IR.
- Evaluate radiograph for acceptable appearance, centering, positioning, acceptable exposure indicator value.
- Return or release patient, including exit instructions, follow-up information, and post-procedure instructions, if applicable.

The procedural steps for a radiographic procedure include both technical and patient care aspects. These aspects need to be discussed in detail for the limited operator to appreciate the need for each of the steps.

Radiographic Room Preparation

The procedural step of preparing the radiographic room includes ensuring the room is clean, to protect the patient from possible infection, and gathering all accessory equipment needed for the procedure. In addition, this is the appropriate time to select the patient from the computer worklist and select the radiographic procedure ordered. The procedure selection may need to be altered as a result of information gathered later during patient assessment, but in most cases selecting the procedure prior to greeting the patient will save time.

Image Receptor Selection

After preparing the radiographic room, the IR is selected. This may be a simple matter, since most departments or private practices use only one type of IR: either computed radiography (CR) cassettes or a DR detector. The limited operator will choose the appropriate IR for the projections necessary to complete the ordered procedures. When the situation calls for use of a CR cassette, the correct size(s) must be chosen. Because the CR cassette size necessary for each examination on an adult has been well established by the experience of others, suggested IR sizes are provided with the position/projection descriptions in this text.

Initial Interactions with the Patient

Prior to escorting the patient to the radiographic room, the patient must first be identified in a HIPAA compliant manner. The number and type of patient identifiers is institution-dependent, but usually includes patient name and date of birth. Once the patient is in the radiographic room, the procedure can be explained and the patient assessed to determine that the appropriate procedure was ordered and whether the patient can perform the movements needed during the procedure. This is also the appropriate time to have the patient remove any clothing or jewelry that may cause artifacts on the radiographic images.

Exposure Factor Selection

Setting the appropriate exposure factors for the anatomy to be imaged should be performed prior to positioning the patient and part. This will reduce the likelihood that the patient will move after positioning and prior to making the radiographic exposure.

Patient Instructions during the Procedure

Clear and concise instructions are essential for efficiency and optimum image quality. The patient must be told how and when to move, and how and when to stop breathing. Effective communication must consider the age of the patient and so is one of the "age-specific competencies" needed by all health-care workers. These competencies are covered in Chapter 18.

The procedure will be completed efficiently when the patient participates in moving to and holding each position. Patients often complain that the limited operator "just pushed me around" when not given verbal instructions. In addition, there is less physical strain on the limited operator when the patient participates by moving during positioning. Undesirable movement during the exposure is less likely when the patient is informed and involved.

Image Receptor Orientation

Most CR cassettes are rectangular, having a long and short dimension. Correct placement requires alignment of the IR's long dimension parallel to the greatest dimension of the body part. The terms *lengthwise* and *crosswise* are commonly used to indicate appropriate orientation.

Lengthwise placement means that the long dimension of the IR is aligned with the long axis of the body. In computer terms, this would be called *portrait orientation*. For instance, lengthwise placement is appropriate for examinations of the spine (Fig. 12.27) because the spine is a long, narrow structure.

Crosswise placement means that the long dimension of the IR is perpendicular to the long axis of the body. It is used for structures whose longest dimension is at a right angle to the long axis of the body. In computer terms, this would be called *landscape orientation*. The pelvis and the clavicle (Fig. 12.28) are examples of body parts that require crosswise IR placement.

When a body part is longer than the greatest IR dimension, the body part is sometimes aligned with the IR diagonally. This may be a useful approach for examinations of a long bone, such as the forearm or lower leg, on some patients. The exposure field is oriented and collimated to the diagonally placed body part, rather than parallel to the sides of the IR (Fig. 12.29).

The orientations for cassette-based IRs are provided with the position/projection descriptions in this text. In addition, collimated radiation field sizes are included. These are especially important when DR IRs are used because these

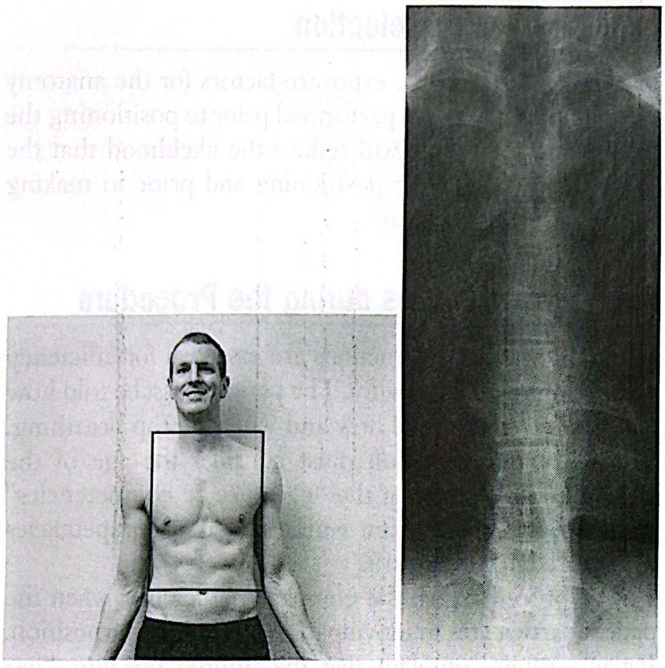


Fig. 12.27 Lengthwise image receptor placement. Long dimension is parallel to long axis of the body.

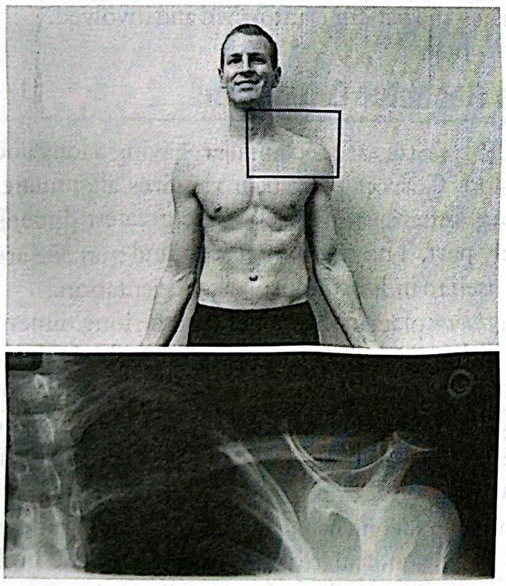


Fig. 12.28 Crosswise image receptor placement. Long dimension is perpendicular to long axis of the body.

receptor units are a fixed size, frequently 14 × 17 inches or 17 × 17 inches. Because the anatomy of interest can be placed nearly anywhere on these IRs, careful attention to proper collimation of the radiation field is essential.

Alignment of Central Ray, Body Part, and Image Receptor

Radiography requires precise alignment of the CR, the body part, and the IR. There is more than one possible sequence for accomplishing this alignment.

For tabletop (nongrid) exposures, such as those of the extremities, the IR is placed on the tabletop in a convenient location for the patient. The IR may be either a CR cassette or a nonfixed (tethered or wireless) DR detector. The body part is then placed and appropriately oriented on the IR. The x-ray tube is adjusted to the correct SID, which should be a minimum of 40 inches in most cases. Longer SIDs of 42 to 44 inches are common, with 48 inches desirable if equipment configuration allows. The CR is aligned to the center of the body part, using the crosshairs of the collimator field light, and the exposure field is collimated to the body part. It is important that the edges of the collimated exposure field be parallel to the edges of the IR, if possible. In addition, all four edges of the exposure field should be placed within the boundaries of the IR (Fig. 12.30).

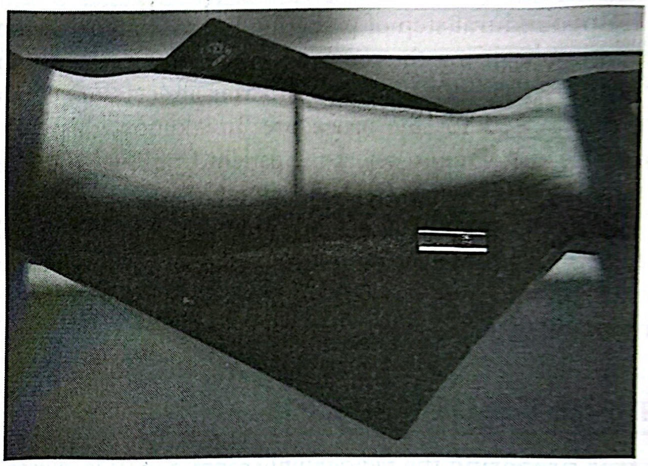


Fig. 12.29 Forearm placed diagonally across image receptor.

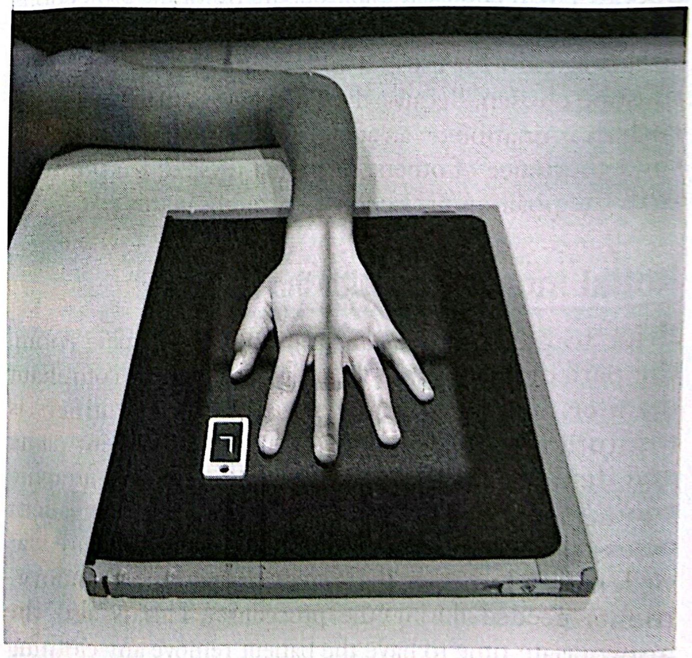


Fig. 12.30 Proper alignment of collimated exposure field, body part, and image receptor, for tabletop (nongrid) exposures.

When an exposure is made using an upright (Fig. 12.31) or table Bucky, the IR is placed in the Bucky tray and latched firmly into the center of the tray. If the IR is rectangular, it should be placed lengthwise or crosswise depending on the shape of the anatomy to be imaged. If the upright unit or radiographic tabletop is not movable, the body part is adjusted to the right or left so that it is aligned with the center of the long axis of the grid. The tube must also be aligned with the center of the grid and the SID adjusted to the correct distance. For longitudinal alignment, the tube may be aligned with the center of the body part. The Bucky tray is then aligned with the tube, using the centering light from the collimator. On the other hand, it is sometimes more convenient to align the Bucky tray with the patient and then center the tube to the tray. This is often the case when alignment depends on the location of an outer portion of the body part rather than its center.

When a table with a floating tabletop is used, the tube is transversely aligned with the center of the grid and IR, using the center or detent feature of the tube hanger. The Bucky tray is placed in a convenient location along the length of the table, and the x-ray tube is aligned with it at the correct SID. The tabletop is then released and moved so that the center of the body part is in the center of the exposure field (Fig. 12.32).

For some procedures, the CR must be angled. To accomplish this, the tube is first adjusted to the proper SID, then lowered 1 inch for each 5 degrees of tube angulation. The tube is then angled to the correct degree, and finally the CR is aligned with the body part and/or the IR (Fig. 12.33). The resulting SID will be the same as the original. For example, if the tube is to be angled 30 degrees while maintaining a 40-inch SID, the perpendicular distance is reduced by 6 inches (30 degrees ÷ 5 degrees = 6 inches). The perpendicular distance in this case would be 40 inches minus 6 inches, or 34 inches (Fig. 12.34).

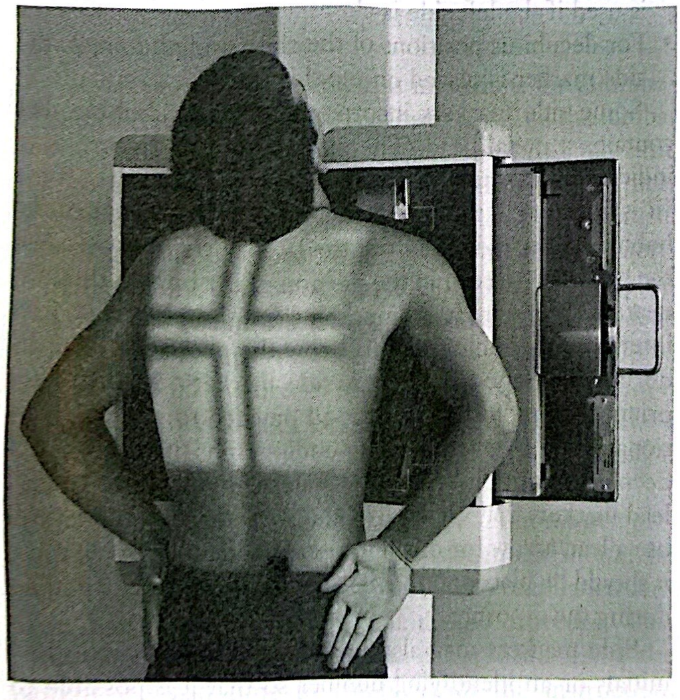


Fig. 12.31 Proper alignment of collimated exposure field, body part, and image receptor, for upright Bucky exposures.

Collimation of the Radiation Field

The size and orientation of the collimated radiation field are important in radiography for several reasons. Restricting the radiation field to the anatomy of interest improves image quality by minimizing production of scatter radiation. In addition, radiation dose to the patient is minimized. Collimated field size is easy to determine when the IR is placed on the tabletop. The field should be restricted to the anatomy of interest and include approximately 1 inch of field light beyond the shadow cast on the

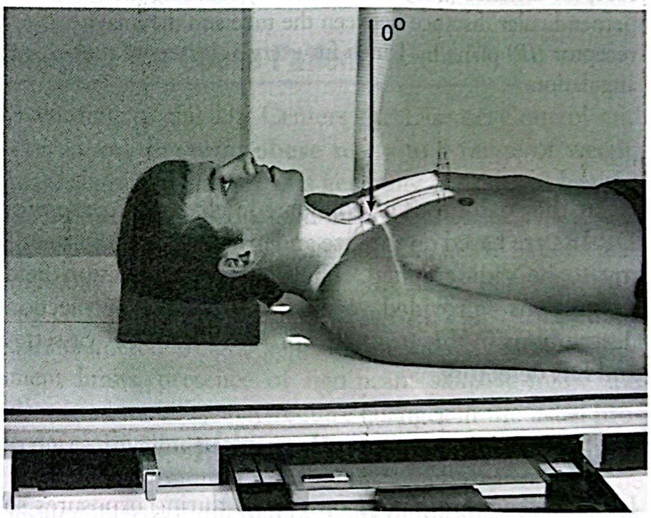


Fig. 12.32 Proper alignment of collimated exposure field, body part, and image receptor, for floating tabletop Bucky exposures.

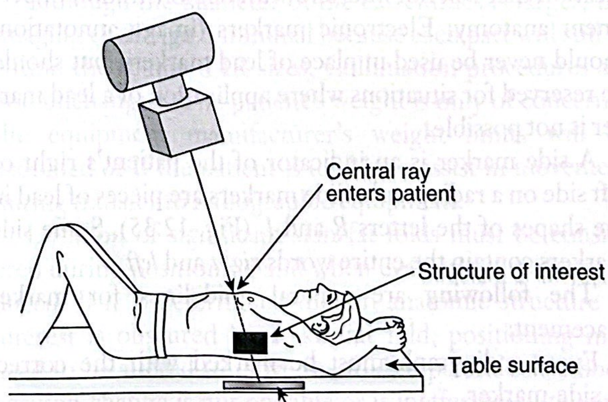


Fig. 12.33 When the tube is angled, take care that both body part and image receptor are aligned with the path of the central ray. *IR*, Image receptor.

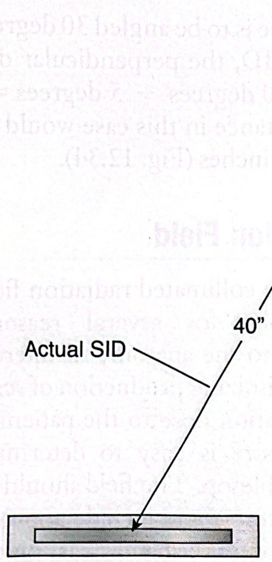


Fig. 12.34 When angling the tube, maintain source–image receptor distance *(SID)* at 40 inches by reducing the perpendicular distance between the tube and the image receptor *(IR)* plane by 1 inch for every 5 degrees of tube angulation.

IR by the anatomy. The collimated field sizes for use with DR IRs are based on the size and orientation of the anatomy to be radiographed. The collimated radiation field suggestions provided with the position/projection descriptions in this text will work with both CR cassettes and DR detectors.

Radiographic Marker Placement

Lead markers are placed on the IR during exposures so that their images become a part of the radiographic image. They are usually held in place with tape. When it is impractical to place a lead marker directly in the IR, some facilities allow the marker to be placed on the patient, in a location that will not interfere with demonstration of pertinent anatomy. Electronic markers (image annotation) should never be used in place of lead markers, but should be reserved for situations where application of a lead marker is not possible.

A side marker is an indicator of the patient's right or left side on a radiograph. Side markers are pieces of lead in the shapes of the letters *R* and *L* (Fig. 12.35). Some side markers contain the entire words *right* and *left*.

The following are general guidelines for marker placement:

- Every radiograph must be marked with the correct side marker.
- Markers are placed within the radiation field.
- Markers should be placed to prevent superimposition on structures of clinical interest.
- A right marker must never be placed to the left of the body's midline and vice versa.

Fig. 12.35 Proper placement of lead side marker for anteroposterior projection of the left ankle. The L marker was placed directly on the image receptor, lateral to the ankle area, and within the light field (radiation field).

- For AP and PA projections that include both sides of the body, a right marker is typically used.
- For oblique projections that include both sides of the body, the side closest to the IR is marked; for example, a right marker is used for a right posterior oblique position.
- For lateral projections of the head and trunk, the side closest to the IR is marked; for example, a left marker is used if the left side is closest.
- For decubitus positions of the chest and abdomen, the side marker is placed on the side up.

Some side markers incorporate a plastic bubble that contains a metal bead. The purpose of this feature is to indicate the position of the IR during the exposure. If the IR is horizontal, the bead will appear in the center of the bubble on the radiograph. If the IR is upright or on edge, the bead will be seen in the portion of the bubble that was nearest the floor. It is important for the physician who interprets the radiograph to know the position of the IR during the exposure. When side markers do not have orientation indicators, it is good practice to add an additional marker when making radiographs in upright or decubitus positions. Some x-ray departments have special lead markers that say *upright* and *decubitus*. Some facilities use a lead arrow for this purpose. When an arrow is used, it should be placed so that it is pointing toward the ceiling during the exposure.

Side markers may also include the limited operator's initials or an identifying number so that it is possible to determine who took the image by looking at the radiograph. A facility may have other lead markers as well, depending on the procedures performed and the preferences of the physician who reads the radiographs. The limited operator is responsible for knowing the accepted procedure for marker use in the workplace and for marking images accordingly.

Patient Instructions Prior to Image Receptor Exposure

The success of a radiographic procedure is dependent, in part, on the cooperation of the patient. Patient movement or breathing during an exposure degrades image quality. The patient should be reminded to remain still and suspend breathing during the radiographic exposure.

Patient breathing during an exposure can result in body movement that may cause blurring of the radiographic image. For this reason, it is usual to instruct the patient to suspend breathing during radiography of structures in or near the trunk, including procedures involving the head or shoulder.

For examinations of the trunk, the respiratory phase is also important. The positioning instructions in this text include patient breathing instructions for each position or projection when they are necessary. Because inspiration (breathing in) expands the lungs and lowers the diaphragm, the patient is usually instructed to hold in a deep breath for radiographs of the chest and for structures lying in the thorax above the diaphragm, such as the upper ribs and sternum (breastbone). When maximum lung expansion is essential, as in chest radiography, it is wise to instruct the patient to take two deep breaths and to hold on the second inspiration. This practice usually results in greater lung expansion and also provides a warning to the limited operator if deep inspiration is likely to cause a cough.

Elevation of the diaphragm is important for radiography of the supine abdomen, the lower ribs, and the lumbar spine. Expiration (breathing out) raises the diaphragm, preventing superimposition of lung tissue over structures of interest, and reduces the thickness of the abdomen, reducing radiation exposure and improving image quality. When a patient is instructed to hold the breath on expiration, it is important first to tell the patient to take a deep breath. This ensures that the patient has taken in ample oxygen to hold the breath on expiration for the duration of the exposure. In this case, the instruction is, "Take a deep breath. Now blow your breath all out and hold it out."

It is important to have the patient's attention when giving breathing instructions. The instructions should be given clearly and slowly to allow time for compliance with each instruction and before making the exposure. This practice ensures that the exposure is not made before the patient has had time to comply with the instruction. When patient hearing or comprehension may be a problem, it is wise to explain the breathing instructions in advance to allow for demonstration or practice before proceeding to the exposure.

In some circumstances, patient breathing is desirable. A *breathing technique* is a method that uses breathing motion to blur the rib and lung structures when they might otherwise interfere with the visualization of structures of interest. Breathing technique is used to enhance visualization of the thoracic spine in the lateral projection, of the sternum in the oblique projection, and of the upper humerus in the transthoracic lateral projection, in cases of shoulder trauma. The patient is instructed to breathe in and out during the exposure while holding the body as still as possible. An exposure time of 2 seconds or longer is necessary for the breathing technique to be fully effective. This is achieved by using a low milliamperage (mA) setting to allow the long exposure time. Computerized controls that do not permit direct setting of the mA will usually allow lengthening of the exposure time, which adjusts the mA automatically to provide the proper exposure.

Imaging the Obese Patient

According to the US Centers for Disease Control and Prevention, the term **obese** refers to a range of weight that is "greater than what is generally considered healthy for a given height." In addition, an obese adult has a body mass index (BMI) of 30 or higher. The obese patient may present a significant challenge to the limited operator during performance of radiographic procedures. Large body part diameter, weight approaching or exceeding equipment limits, presence of significant skin/fat folds, and decreased mobility may require changes in the usual procedures. Imaging of the trunk poses the greatest challenge, because the common positioning landmarks may not be located by palpation. Radiography of the abdomen is most challenging because the pubic symphysis, indicating the inferior aspect of the abdominal cavity, cannot be located easily. In addition, proper radiation field collimation is more difficult because of abdomen thickness.

Although the diameter of the extremities is larger, the imaging challenge is minimal because each part will still fit within the standard IR sizes. Collimation procedures are also unchanged. The patient's weight is only of concern if the equipment manufacturer's weight limits will be exceeded or if the patient is unable to assist in movement during transfer to radiographic equipment.

Location of significant skin/fat folds must be considered during positioning and when evaluating images produced. If it is determined that an anatomic structure of interest is obscured by a skin/fat fold, positioning may need to be altered to move the fold, if possible. If a body position change is not possible or is ineffective in moving the skin/fat fold, it may need to be moved manually. The patient may need to help hold the skin away from the area of interest.

The limited operator must keep in mind that most of the increased size of an obese patient is because of excess fat accumulation. The underlying skeleton is no larger than an average-sized patient and organs are not significantly displaced from the customary locations. Using this knowledge, positioning strategies have been developed to allow accurate placement of anatomy, even when landmarks cannot be felt.

Radiography of the abdomen is most challenging in the obese patient because the usual visual and palpable clues as to structure location are not present. However, effective abdomen positioning is possible with the following procedure. Locate the jugular notch, which is easily located at the superior aspect of the sternum, and tape a visible marker at that location. Using a tape measure or ruler, the location of the pubic symphysis can be determined by measuring from the jugular notch along the midsagittal plane. The distance of the pubic symphysis from the jugular notch depends on patient height, as follows:

Shorter than 5 ft: 21 inches
5 to 6 ft: 22 inches
Taller than 6 ft: 23 inches

Taping another visible marker at the measured level of the pubic symphysis will present the limited operator with visual clues as to the location of anatomic structures mentioned in a variety of positioning descriptions for anatomy of the trunk (Fig. 12.36). Table 12.2 describes the relationship of a variety of external landmarks with locations along the axial skeleton.

Another challenging aspect of trunk anatomy radiography is proper collimation. The field light visible on the abdomen of an obese patient will appear small, compared with the actual size of the radiation field when it reaches the IR. This phenomenon is illustrated in Fig. 12.37. It occurs because the skin surface is closer to the x-ray tube, resulting in less light beam divergence. The limited operator will be tempted to increase the light field to cover the entire abdomen, but this will result in a radiation field that extends beyond the dimensions of the IR. The field light scales on the x-ray tube collimator must be set to the IR size or desired radiation field size.

PATHOLOGY

The term *pathology* refers to the study of disease processes. Disease may be defined as any abnormal change in the structure or function of the body. A localized area of destructive change in body tissue is called a **lesion.** Wounds, rashes, and tumors are all examples of lesions.

Disease Identification

Diagnosis is the process of identifying a disease. Diseases are identified by means of their manifestations; the changes in the patient that are caused by the disease. There are three types of manifestations: symptoms, signs, and syndromes. **Symptoms** are the patient's reported perceptions of the condition. Symptoms are *subjective*, such as pain or dizziness, and can only be identified by the patient. **Signs**, on the other hand, are objective manifestations that can be observed by the examiner. Swelling, fever, and discoloration of the skin are examples of signs. A **syndrome** is a group of manifestations that, taken together, are typical of a specific condition. Marfan syndrome, for example, is a disease characterized by elongation of the bones, weakness of the ligaments, and changes in the circulatory system.

The process of making a diagnosis begins with taking a history (Fig. 12.38)—making a record of the patient's symptoms and other information about the patient's life and health, past and present, that may be relevant. The next step is physical examination (Fig. 12.39). This process may involve observing; palpating (feeling); listening with a stethoscope; measuring temperature, pulse, respirations, and blood pressure; and other specific procedures. If the

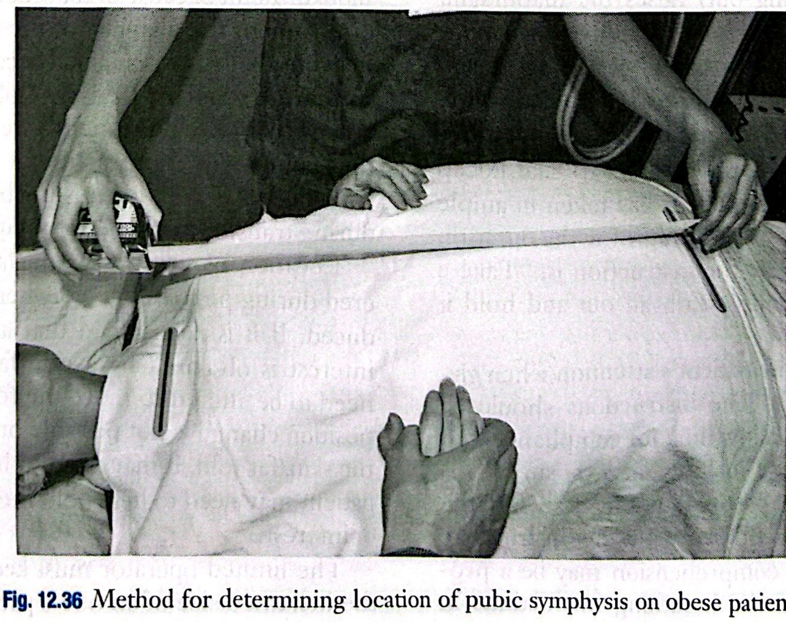


Fig. 12.36 Method for determining location of pubic symphysis on obese patient.

TABLE 12.2
External Landmarks Indicating Location of Internal Body Structures at the Same Level

Body Structures	External Landmarks
Cervical Area	
C1	Mastoid tip
C2, C3	Gonion (angle of mandible)
C3, C4	Hyoid bone
C5	Thyroid cartilage
C7, T1	Vertebra prominens
Thoracic Area	
T1	Approximately 2 inches (5 cm) above level of jugular notch
T2, T3	Level of jugular notch
T4, T5	Level of sternal angle
T7	Level of inferior angles of scapulae
T9, T10	Level of xiphoid process
Lumbar Area	
L2, L3	Inferior costal margin
L4, L5	Level of superiormost aspect of iliac crests
Sacrum and Pelvic Area	
S1, S2	Level of anterior superior iliac spine (ASIS)
Coccyx	Level of pubic symphysis and greater trochanters

From Long B, Rollins J, Smith B: *Merrill's atlas of radiographic positioning and procedures*, ed 13, St Louis, 2016, Saunders.

history and physical examination do not provide a definitive diagnosis, the next step is the ordering of additional tests. A great variety of diagnostic tests are available to assist the physician in confirming or ruling out possible diagnoses. These tests may include laboratory analysis of blood or other body fluids and radiography or other imaging studies.

When the diagnosis has been made, the physician formulates a treatment plan. The information gathered is also used to determine the **prognosis,** a prediction of the course of the disease and the prospects for the patient's recovery.

Disease Classification

Diseases may be classified in a number of different ways. Many classifications divide diseases into two groups, depending on whether or not they fit a certain criterion. The structure/function classification, discussed next, has to do with whether the disease has any structural manifestations. Diseases may be labeled either *acute* or *chronic*, depending on the course of the disease process. *Contagious* and *noncontagious* classifications are determined by whether or not the disease may be transmitted from one person to another. Other categories are based on the cause of the disease or on the nature of its manifestations. Depending on the classification system used, one disease may logically fall into several categories.

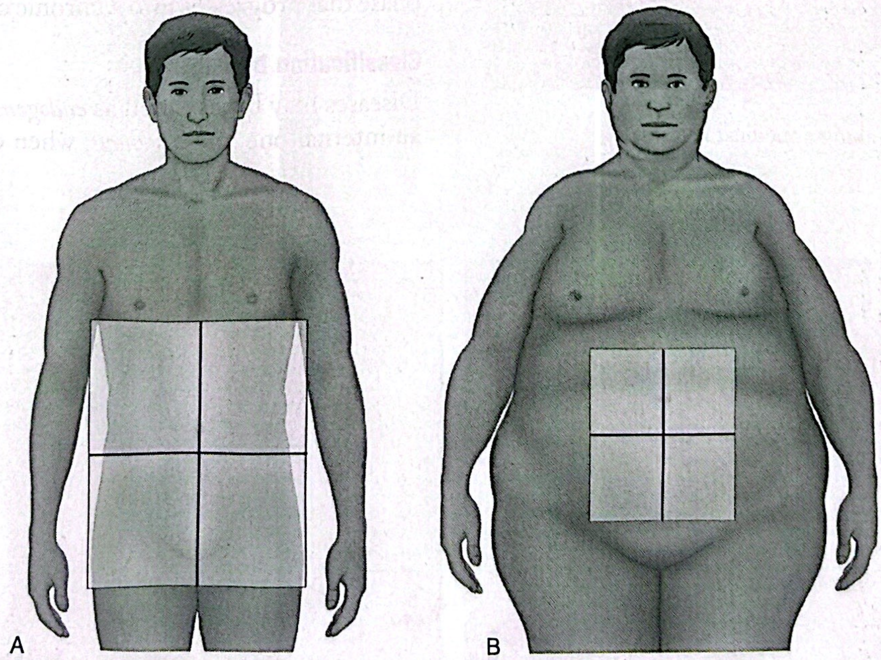


Fig. 12.37 Appearance of a 14 × 17-inch (34 × 43-cm) collimator field light on (A) a normal-size patient with a 21-cm abdomen anteroposterior thickness and (B) an obese patient with a 45-cm abdomen anteroposterior thickness. Although the light field appears much smaller in **B**, the radiation field size at the image receptor will be the same for both patients.

Structural Versus Functional Disease

An organic disease involves changes to the cells of the body and may be referred to as a *structural disease*. On the other hand, a *functional disease* is characterized by an abnormal change in function with no structural change. A typical example of a functional disease is a migraine headache. Because limited operators are concerned with the identification of conditions that produce physical changes, the discussion of pathology in this text is limited to those involving structural changes.

Hereditary and Congenital Disease

Hereditary diseases are those that are caused by abnormalities in the genetic makeup of the individual and are inherited from a parent. Diseases that are not hereditary are classified as *acquired* diseases.

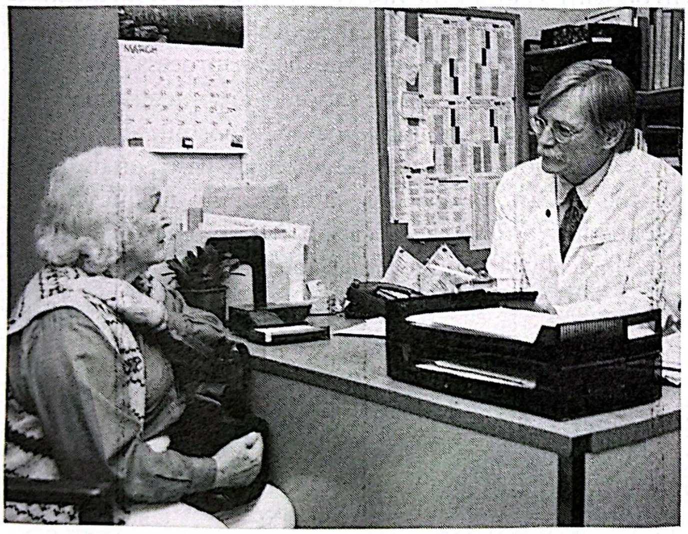


Fig. 12.38 Taking a medical history.

Conditions that are present at birth are said to be **congenital**. Congenital diseases are usually hereditary but may also be caused by events that occur before birth. Fetal alcohol syndrome is an example of an acquired congenital disease.

An example of a hereditary congenital disease is trisomy 21, also known as Down syndrome, a condition marked by mental retardation and physical defects. Some hereditary diseases are not manifested until later in life. Diabetes mellitus is an example of a disease that may be inherited but is not present at birth. Some hereditary disorders are more accurately classified as "tendencies." Both hereditary and environmental factors may affect the manifestation of these diseases. Heart disease may fall into this category for some individuals. For example, an inherited tendency to heart disease is more likely to produce serious illness in an obese, sedentary individual with uncontrolled high blood pressure than in an individual who has normal weight and blood pressure and is physically fit.

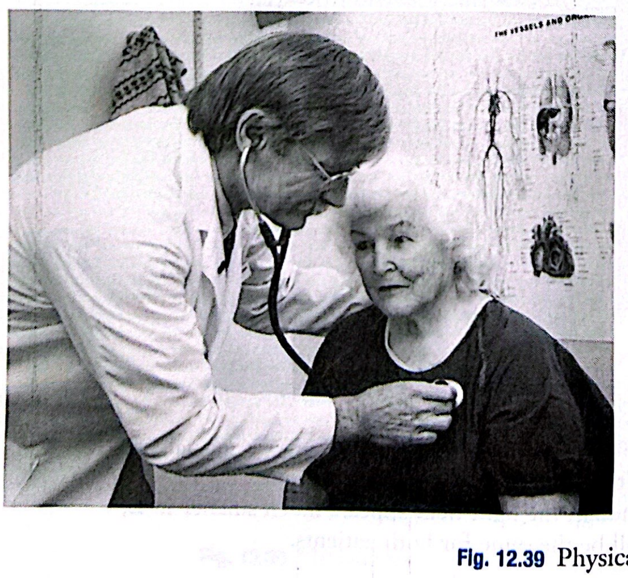
Congenital conditions that cause abnormal variations in the shape or form of a body part are called **anomalies**. Anomalies in the circulatory system are not uncommon. Extra ribs, extra toes, or extra spinal vertebrae are anomalous structures.

Acute Versus Chronic Disease

Acute conditions are characterized by a sudden onset. They are relatively severe and have a short duration. **Chronic** conditions are of long duration. They may come and go, in which case they are described as *recurrent*, or they may exist constantly at a low level and tend to flare up occasionally. Some diseases typically begin with an acute phase that progresses into a chronic condition.

Classification by Cause

Diseases may be classified as *endogenous*, when the cause is an internal one, or *exogenous*, when caused by an external



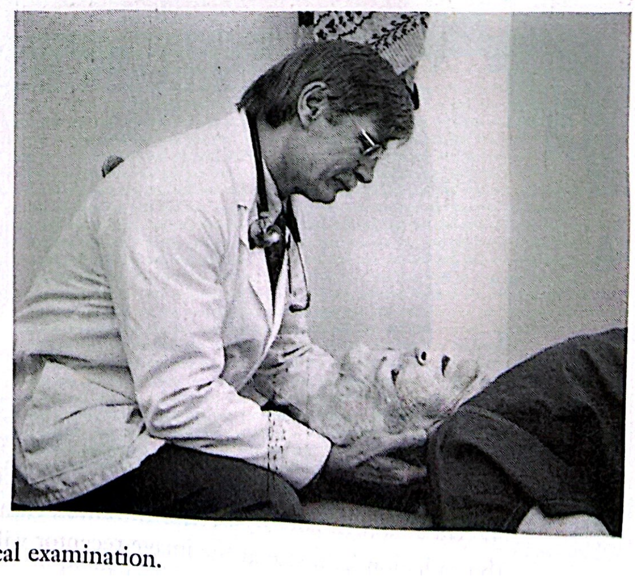


Fig. 12.39 Physical examination.

agent. Internal causes of disease may be further classified as *circulatory*, *deficiency*, or *autoimmune*.

The most common endogenous diseases are related to problems in the circulatory system. Problems in arteries may result in loss of blood supply to an organ or tissue caused by restriction or obstruction of the blood supply or by bleeding. Lack of adequate blood flow is called **vascular insufficiency.** This term describes the condition of the circulatory system itself. Lack of adequate blood supply is called **ischemia.** This term describes the condition of the tissues that are deprived of blood supply. Ischemia may cause the death of tissue, which is called *necrosis*. An area of tissue that has undergone necrosis is called an *infarct*. Strokes and heart attacks are typical diseases associated with vascular insufficiency.

Deficiency is any condition that compromises body function as a result of lack of required substances, such as vitamins, minerals, or proteins. Scurvy, pellagra, and rickets are vitamin-deficiency diseases. Goiter (thyroid gland enlargement) may be caused by iodine deficiency. Some deficiencies compromise the function of the immune system. When immunity is low, resistance to infection is decreased, and the patient is vulnerable to infectious disease.

Autoimmune conditions are a group of diseases that occur when the immune system attacks the body's own tissues. The cause is not known but may be related to previous viral infection. Rheumatoid arthritis (Fig. 12.40), lupus erythematosus, and ankylosing spondylitis are examples of autoimmune conditions.

Fig. 12.40 Rheumatoid arthritis is a crippling autoimmune disease that affects joints.

External causes of disease may be further classified as *physical*, *chemical*, or *microbiologic*. Physical injury caused by an object is called **trauma.** Physical injury may also occur as a result of exposure to extreme temperatures, electricity, and radiation. Radiography is often used to evaluate the extent of trauma, and various manifestations of trauma are addressed throughout this section of the text.

Trauma to the skeletal system may result in fracture, dislocation, or sprain. A **fracture** is a bone injury in which the tissue of the bone is broken (Fig. 12.41). Fractures

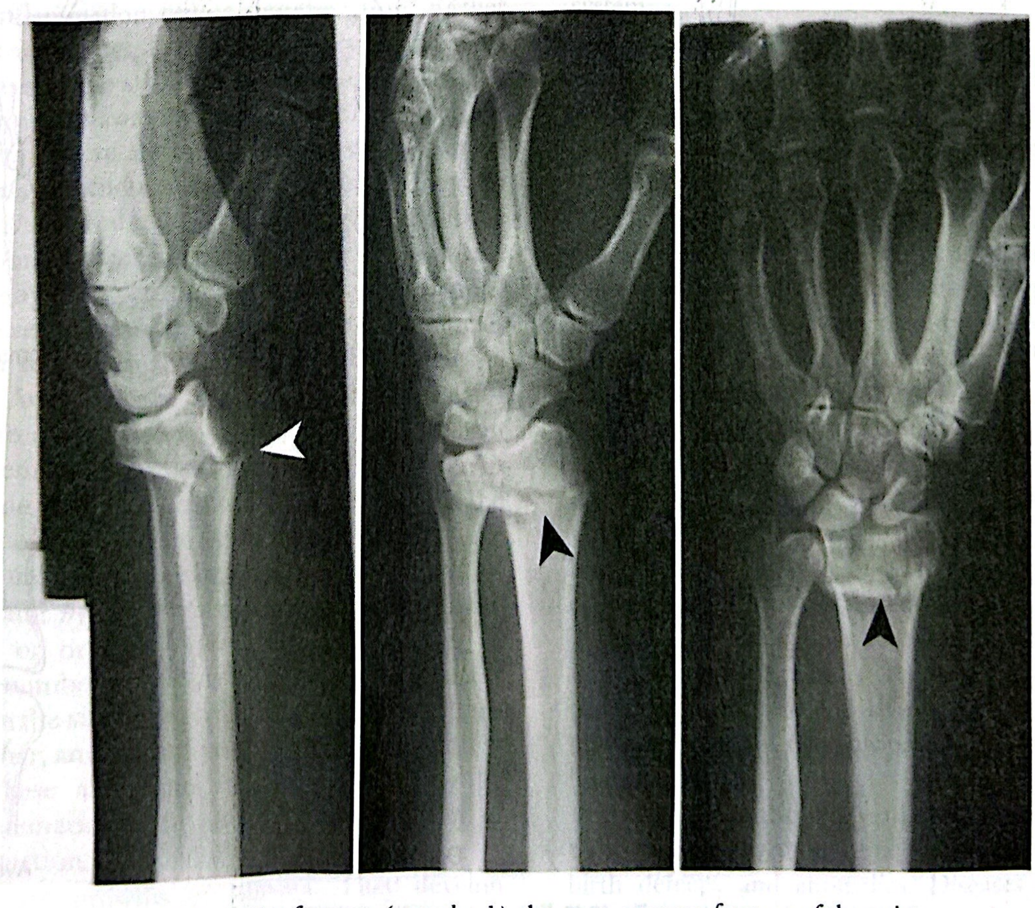


Fig. 12.41 Colles fracture *(arrowheads)*, the most common fracture of the wrist.

may be classified in several ways, most commonly by the pattern in which the bone breaks (Fig. 12.42). They can also be classified by presence or absence of an associated wound. A closed fracture has no external wound. If a portion of the broken bone penetrates the skin, it is called an open or compound fracture.

Dislocation is the movement of a bone from its normal location within a joint (Fig. 12.43). A **sprain** is injury to the ligaments, tendons, and muscles that surround a joint. Muscle damage from excessive physical effort or force is called a **strain**. Other types of soft-tissue trauma include **lacerations**, cuts or tears through the skin and underlying tissues; **abrasions**, scraping wounds to the skin; and **contusions**, closed wounds that cause bleeding under the skin and are commonly called *bruises*.

The principal chemical causes of disease are poisonings and drug reactions. Inhalation of toxic fumes or the absorption of toxic substances through the skin may also cause chemical injury to the body.

Exogenous diseases caused by microbiologic agents are called **infections**. Infections may occur in almost any part of the body but are most likely to affect structures that are in some way in contact with the outside world. The most common infections are those that occur in wounds and those that involve the respiratory system. Microbiologic agents are living organisms too small to be seen with the naked eye and are termed **microorganisms.** Many of these agents cause contagious diseases. Microorganisms are discussed in Chapter 21, which deals with infection control.

A crater-like sore on the skin or a mucous membrane is called an **ulcer**. There are many possible causes. Ulcers in the lining of the stomach, for example, may be caused by chemical injury from the acids produced by the body to aid in digestion.

When the cause of a disease is unknown, it is said to be **idiopathic**. Diseases that occur as the result of treatment by health professionals are termed **iatrogenic.** The term **nosocomial** refers to diseases that are acquired in hospitals.

Classification by Disease Process

Diseases are often classified according to the nature of the disease process itself. The disease process may involve inflammation, degeneration, or alterations in tissue growth.

Inflammation is the immune system's response to cellular injury. It is the initial part of the healing process. Inflammation is characterized by swelling, reddening, heat at the site, and pain. During this process, the blood

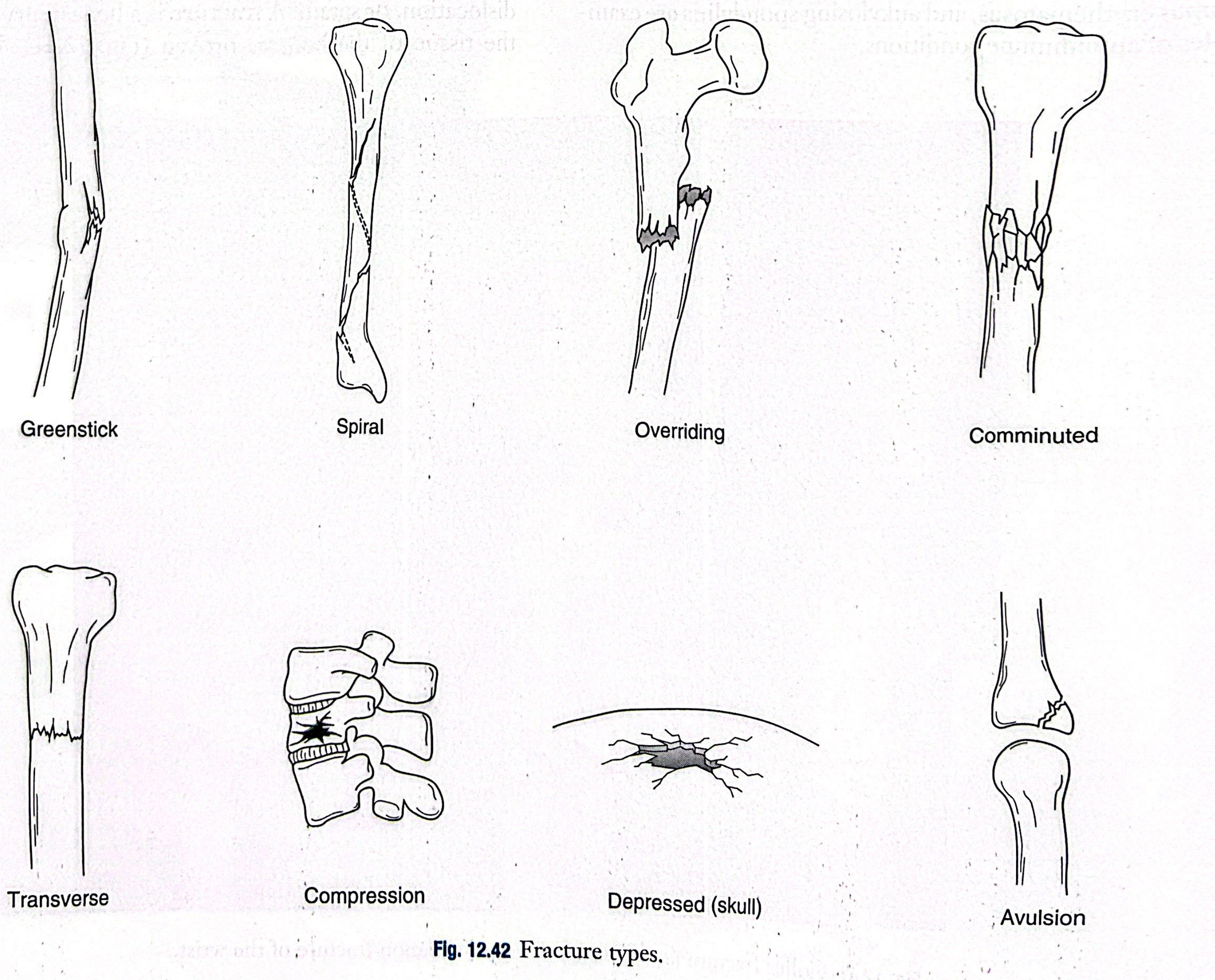


Fig. 12.42 Fracture types.

Fig. 12.43 Elbow joint dislocation.

supply to the injured area is increased. The term for swelling caused by vascular congestion is **edema**. White blood cells attack microorganisms and clean up dead tissue and other debris of injury. The terms used to define inflammatory conditions all end in *itis*. For example, *arthritis* refers to inflammation of a joint and *sinusitis* is the term for inflammation of the sinuses.

Chronic inflammation causes **degeneration**, further injury to cells and tissues. Degeneration may lead to **atrophy**, a decrease in the size or number of cells. Atrophy causes tissue to waste away and also causes impairment or loss of function. There are four types of atrophy: senile, disuse, pressure, and endocrine. Senile atrophy occurs as a result of age. Decreased muscle mass and strength in the elderly are manifestations of senile atrophy. Disuse atrophy occurs to any body part that is not used. For example, when a cast is used to treat a fracture of a limb, the muscles within the cast tend to shrink during the period that the cast is in place. An example of pressure atrophy is the deterioration of skin and underlying tissues that may occur in bedridden patients, causing bedsores, which are a form of ulcer. Endocrine atrophy is caused by a decrease in the supply of hormones. An example is the shrinkage of the ovaries and the uterus after menopause.

Hyperplasia and *hypertrophy* are both increases in the size of tissues or organs. *Hyperplasia* is defined as an increase in the number of cells, whereas *hypertrophy* refers to an increase in the size of the cells. These two conditions may exist together, and the two terms are often used interchangeably. These alterations in cell growth may be caused by inflammation or by an excess or deficiency of endocrine production.

Neoplasms are growths or tumors. They develop when changes in cells cause failure of the mechanisms that control normal cell growth. The names of neoplasms usually end with *oma*. Some examples include *carcinoma*, *sarcoma*, *melanoma*, *lipoma*, *lymphoma*, and *adenoma*. Most neoplasms can be classified as either benign or malignant. **Benign** neoplasms are single masses of cells that remain at one location and are limited in their growth. **Malignant** neoplasms are cancers. They tend to invade surrounding tissue and are capable of **metastasis**, that is, they may be transplanted to other locations in the body. Metastasis may occur through "seeding," the migration of cells through the cavities of the body, or the tumor may be spread through either the lymphatic system or the circulatory system.

SUMMARY

The human body is a highly organized and complex structure. Its fundamental units are cells. Groups of similar cells form tissues. Organs are combinations of tissues with a special function. Groups of organs form each of the 11 organ systems of the body. Each system has a unique structure that is suitable for its special functions. The limited operator should be familiar with the general structure and function of all body systems.

The limited operator requires a deeper understanding of the skeletal system because of its significance in radiography. An understanding of the structure of bones and joints and the names of their parts prepares the limited operator for a deeper study of each part of the skeletal system.

The terminology of body positions, radiographic positions, and radiographic projections is the essential language of radiographic positioning. Body positions include recumbent, prone, supine, and upright. Radiographic positions describe the placement of the body or body part in relation to the radiographic table. The radiographic positions are decubitus, lateral, lordotic, and oblique. Radiographic projections indicate the path of the CR from the radiographic tube through the patient to the IR. The CR entrance and exit points in the body most frequently name these projections. For example, the CR for the AP projection enters the body on the anterior surface and exits the posterior surface. All radiographic procedures consist of a set of steps designed to ensure patient safety and optimum diagnostic results. Each procedure has patient care aspects, including assessment, communication, and both physical and radiation safety concerns. Technical aspects include selection and orientation of the IR; placement of exposure fields on the IR; alignment of the tube, body part, and IR; placement of radiographic markers; selection of appropriate exposure settings; and image evaluation.

Pathology is the study of disease. It includes many topics not usually thought of as diseases, such as injuries, birth defects, and anomalies. Diseases may be caused by circulatory system problems, by deficiencies or autoimmune conditions within the body, or by trauma, chemical injury, or infection from outside the body. Fractures, dislocations, and sprains are injuries caused by trauma to the skeletal system. Strains, lacerations, abrasions, and contusions are soft-tissue injuries.

The response of the immune system to cellular injury is called *inflammation*. Chronic inflammation causes degeneration and atrophy of tissues, resulting in loss of function. Inflammation or endocrine imbalance may cause hype plasia or hypertrophy, an increase in the size of an orga or structure. Neoplasms are tumors that may be benign malignant. Benign neoplasms are self-limiting, but malig nant neoplasms may invade surrounding tissue or sprea to other parts of the body through a process calle *metastasis*.