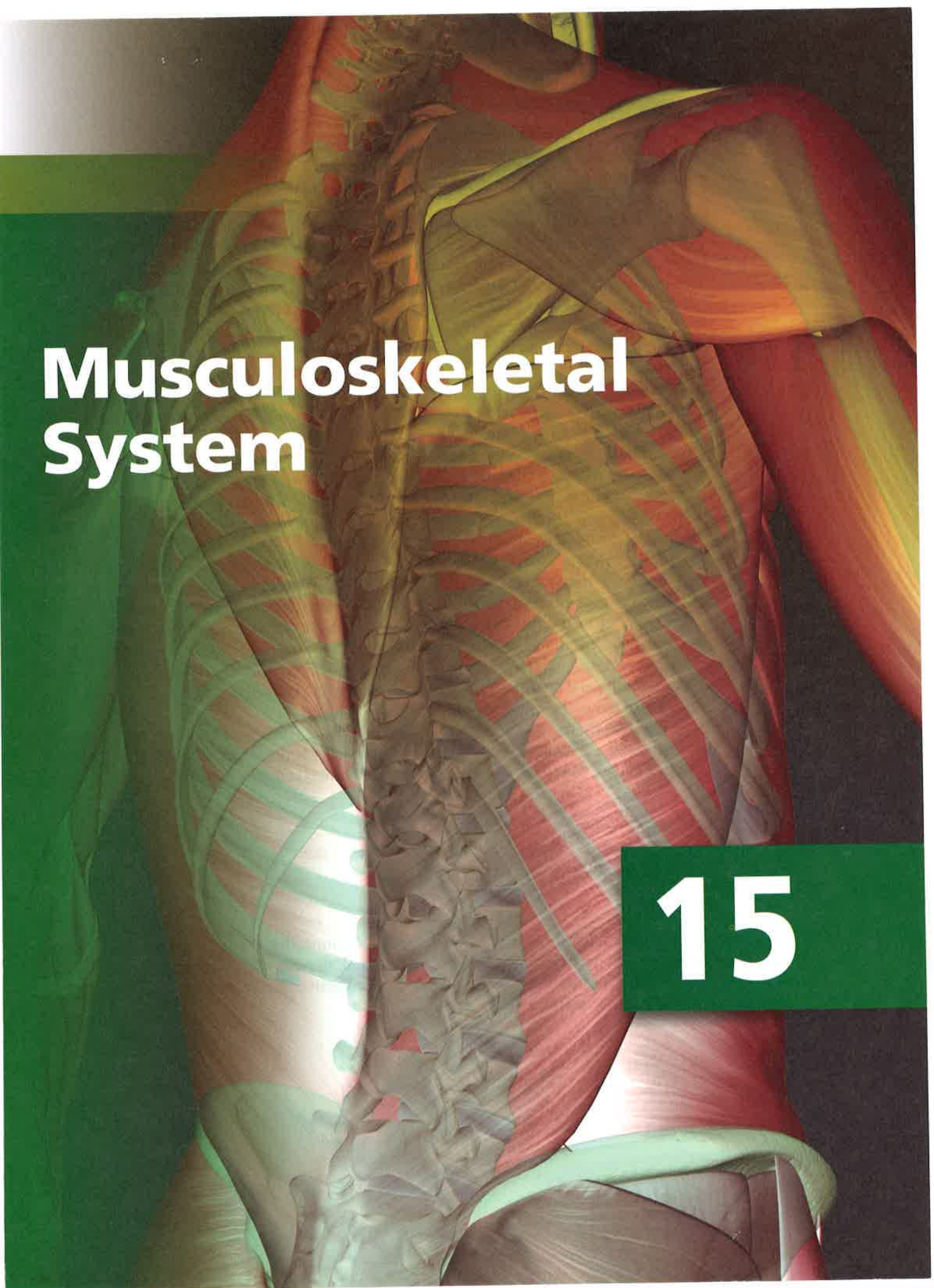

Musculoskeletal System

15

INTRODUCTION

The musculoskeletal system includes the bones, muscles, and joints. All have important functions in the body.

Bones provide the framework on which the body is constructed and protect and support internal organs. Bones also assist the body in movement, because they serve as a point of attachment for muscles. The inner core of bones is composed of hematopoietic tissue (red bone marrow, which manufactures blood cells), whereas other parts of bone are storage areas for minerals necessary for growth, such as calcium and phosphorus.

Joints are the places at which bones come together. Several different types of joints are found within the body. The type of joint found in any specific location is determined by the need for greater or lesser flexibility of movement.

Muscles, whether attached to bones or to internal organs and blood vessels, are responsible for movement. Internal movement involves the contraction and relaxation of muscles found in viscera, and external movement is accomplished by the contraction and relaxation of muscles that are attached to the bones.

Orthopedists are physicians who treat (surgically and medically) bone and joint diseases. Originally, orthopedics was a branch of medicine correcting deformities in children (**orth/o** means straight, **ped/o** means child). **Rheumatologists** are physicians (nonsurgical) who specialize primarily in joint problems, such as arthritis; in this context, **rheumat/o,** meaning watery flow, refers to joint fluid.

Both a **medical doctor (MD)** and an **osteopathic physician (DO)** can specialize in orthopedics or rheumatology. MD and DO medical education programs are similar, and both kinds of physicians perform surgery as well as prescribe medication. An osteopath has added training in the musculoskeletal system, with an emphasis on body mechanics to promote good health. A **chiropractor** (**chir/o** means hand) is not a physician but has extensive and specialized training in using physical means to manipulate the spinal column, joints, and soft tissues. Chiropractic medicine considers that disease is related to pressure on nerves by spinal misalignment.

A **physical therapist** is a master's or doctoral degree–prepared healthcare professional who develops a treatment plan based on a physician's diagnosis. The goals of physical therapy (PT) are to restore function, improve mobility, and relieve pain.

BONES

FORMATION AND STRUCTURE

Formation

Bones are complete organs composed chiefly of connective tissue called **osseous** (bony) **tissue,** plus a rich supply of blood vessels and nerves. Osseous tissue consists of a combination of **osteocytes** (bone cells), dense connective tissue strands known as **collagen,** and intercellular **calcium salts.**

During fetal development, the bones of the fetus are composed of **cartilaginous tissue,** which resembles osseous tissue but is more flexible and less dense because of a lack of calcium salts in its intercellular spaces. As the embryo develops, the process of depositing calcium salts in the soft, cartilaginous tissue occurs and continues throughout the life of the individual after birth. The gradual replacement of cartilage and its intercellular substance by immature bone cells and calcium deposits is **ossification** (bone formation).

Osteoblasts are the immature osteocytes that produce the bony tissue that replaces cartilage during ossification. **Osteoclasts** (**-clast** is from the Greek word meaning to break) are large cells that function to reabsorb, or digest, bony tissue. Osteoclasts (also called **bone phagocytes**) digest bone tissue from the inner sides of bones and thus enlarge the inner bone cavity so that the bone does not become overly thick and heavy. When a bone breaks, osteoblasts lay down the mineral bone matter (calcium salts) and osteoclasts remove excess bone debris (smooth out the bone).

Osteoblasts and osteoclasts work together in all bones throughout life, tearing down (osteoclasts) and rebuilding (osteoblasts) bony tissue. This allows bone to respond to mechanical stresses placed on it and thus enables it to be a living tissue, constantly rebuilding and renewing itself.

The formation of bone depends largely on a proper supply of **calcium** and **phosphorus** to the bone tissue. These minerals must be taken into the body along with a sufficient amount of vitamin D. Vitamin D helps calcium to pass through the lining of the small intestine and into the bloodstream. Once calcium and phosphorus are in the bones, osteoblastic activity produces an enzyme that forms calcium phosphate, a substance that gives bone its characteristic hard quality. It is the major calcium salt.

Not only are calcium and phosphorus part of the hard structure of bone tissue, but calcium also is stored elsewhere in bones, and small quantities are present in the blood. If the proper amount of calcium is lacking in the blood, nerve fibers are unable to transmit impulses effectively to muscles, the heart muscle becomes weak, and muscles attached to bones undergo spasms.

The necessary level of calcium in the blood is maintained by the parathyroid gland, which secretes a hormone that signals the release of calcium from bone storage. An excess of the hormone (caused by tumor or another pathologic process) will raise blood calcium at the expense of the bones, which become weakened by the loss of calcium.

Structure

There are 206 bones of various types in the body. **Long bones** are found in the thigh, lower leg, and upper and lower arm. These bones are very strong, are broad at the ends where they join with other bones, and have large surface areas for muscle attachment.

Short bones are found in the wrist and ankle and are small with irregular shapes. **Flat bones** are found covering soft body parts. These bones are the skull, shoulder blades, ribs, and pelvic bones. **Sesamoid bones** are small, rounded bones (resembling a sesame seed in shape). They are found near joints, and they increase the efficiency of muscles near a particular joint. The kneecap is the largest example of a sesamoid bone.

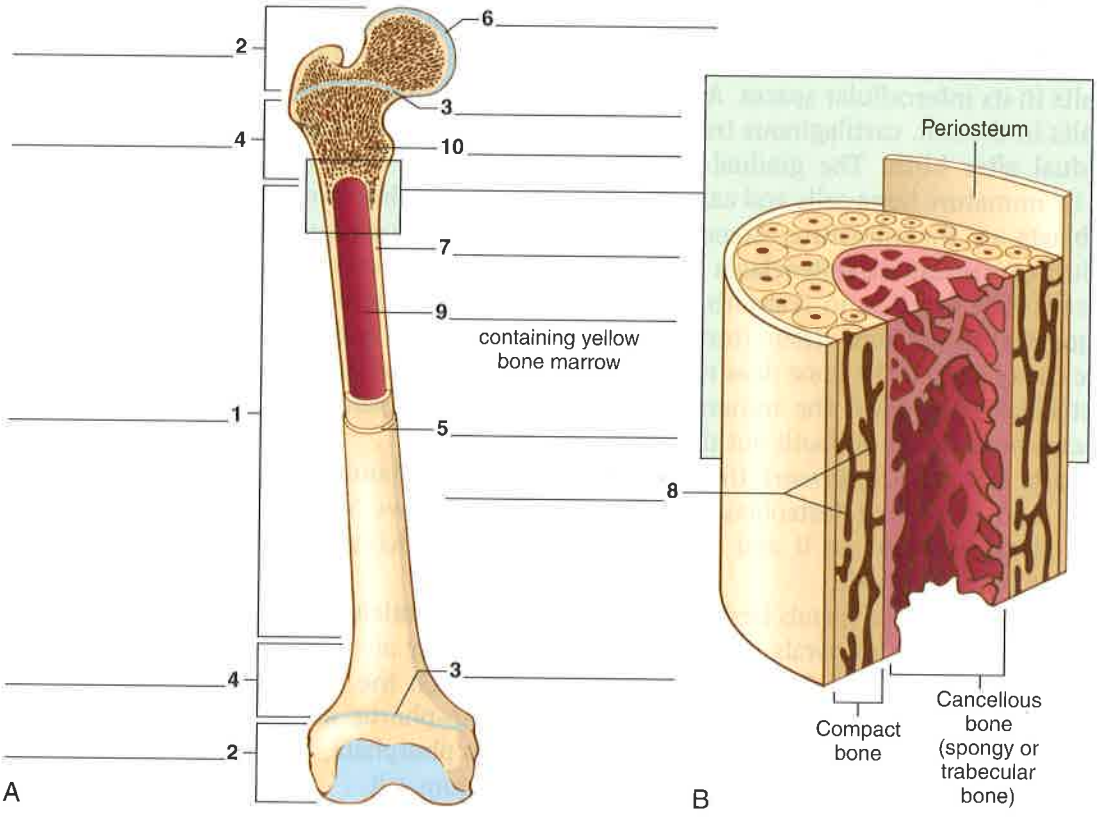

FIGURE 15–1 **(A) Divisions of a long bone and interior bone structure. (B) Composition of compact (cortical) bone.**

Figure 15-1A shows the anatomic divisions of a long bone such as the thigh bone or upper arm bone. Label the figure as you read the following.

The shaft, or middle region, of a long bone is called the **diaphysis** [1]. Each end of a long bone is called an **epiphysis** [2]. The **epiphyseal line** or **plate** [3] represents an area of cartilage tissue that is constantly being replaced by new bone tissue as the bone grows; it also is commonly known as the growth plate. Cartilage cells at the edges of the epiphyseal plate form new bone, which is responsible for lengthening bones during childhood and adolescence. The plate calcifies and disappears when the bone has achieved its full growth. The **metaphysis** [4] is the flared portion of the bone; it lies between the epiphysis and the diaphysis. It is adjacent to the epiphysis plate.

The **periosteum** [5] is a strong, fibrous, vascular membrane that covers the surface of long bones, except at the ends of the epiphyses. It has an extensive nerve supply as well. Bones other than long bones are also covered by periosteum.

The ends of long bones and the surface of any bone that meets another bone to form a joint are covered with **articular cartilage** [6]. When two bones come together to form a joint, the bones themselves do not touch precisely. The articular cartilage that caps the end of one bone comes into contact with that of the other bone. Articular cartilage is a very smooth, strong, and slick tissue. It cushions the joint and allows it to move smoothly and efficiently. Unlike the cartilage of the epiphyseal plate, which disappears when a bone achieves its full growth, articular cartilage is present throughout life.

Compact (cortical) bone [7] is a layer of hard, dense bone that lies under the periosteum in all bones and lies chiefly around the diaphysis of long bones. Within the compact bone is a system of small canals containing blood vessels that bring oxygen and nutrients to the bone and remove waste products such as carbon dioxide. Figure 15-1B shows these channels, called **haversian canals** [8], in the compact bone. Compact bone is tunneled out

in the central shaft of the long bones by a **medullary cavity** [9] that contains **yellow bone marrow.** Yellow marrow is composed chiefly of fat cells.

Cancellous bone [10], sometimes called **spongy** or **trabecular bone,** is much more porous and less dense than compact bone. The mineral matter in it is laid down in a series of separated bony fibers that make up a spongy latticework. These interwoven fibers, called **trabeculae,** are found largely in the epiphyses and metaphyses of long bones and in the middle portion of most other bones of the body as well. Spaces in cancellous bone contain **red bone marrow.** The red marrow consists of immature and mature blood cells in various stages of development.

In an adult, the ribs, pelvic bone, sternum (breastbone), and vertebrae, as well as the epiphyses of long bones, contain red bone marrow within cancellous tissue. Red marrow in the medullary cavity of long bones is plentiful in young children but decreases through the years and is replaced by yellow marrow.

PROCESSES AND DEPRESSIONS IN BONES

Bone processes are enlarged areas that extend out from bones to serve as attachments for muscles and tendons. Label Figure 15-2A and B, which shows the shapes of some of the common bony processes:

Bone head [1]—rounded end of a bone separated from the body of the bone by a neck; usually covered by articular cartilage. In the femur (see Figure 15-2A) the bone head is called the **femoral head.**

Greater trochanter [2]—large process on the femur for attachment of tendons and muscle. The **lesser trochanter** [3] is a smaller process.

Tubercle [4]—rounded process on many bones for attachment of tendons and muscles. A **tuberosity** is another small, rounded elevation on a bone.

Condyle [5]—rounded, knuckle-like process at the joint; usually covered by articular cartilage.

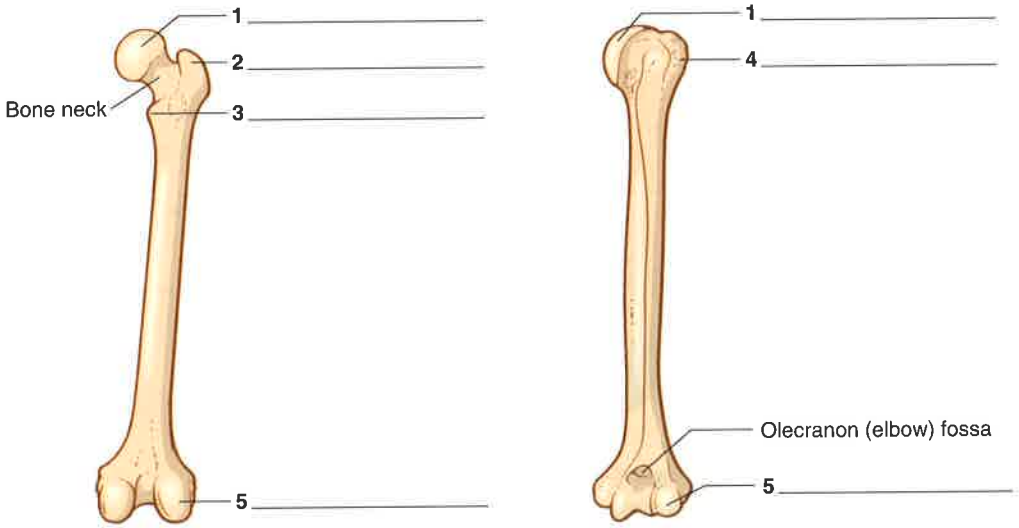

FIGURE 15–2 **Bone processes on the femur** (thigh bone) **(A)** and **humerus** (upper arm bone) **(B).** The **bone neck** separates the bone head from the rest of the bone. A **fossa** is a shallow depression or cavity in a bone. The fossa on the humerus is a space for the olecranon process on the lower arm bone (ulna) when the elbow is extended.

Many bones possess openings or hollow regions that are passageways for blood vessels and nerves. The names of some common depressions, passages, and cavities in bone are as follows:

Fossa—shallow cavity in or on a bone (see Figure 15-2).
Foramen—opening for blood vessels and nerves. See Figure 15-3 for the mental (chin) foramen and Figure 15-4 for the foramen magnum of the skull.
Fissure—narrow, deep, slit-like opening. See Figure 15-5 for the superior orbital fissure in the eye socket.
Sinus—hollow cavity within a bone. See Figure 15-6 for the sinuses of the skull.

CRANIAL BONES

The bones of the skull, or cranium, protect the brain and structures related to it, such as the sense organs. Muscles for controlling head movements and chewing motions are connected to the cranial bones. The cranial bones join each other at joints called **sutures.**

The cranial bones of a newborn child are not completely joined. There are gaps of unossified tissue in the skull at birth. These are called soft spots, or **fontanelles** ("little fountains"). The pulse of blood vessels can be felt (palpated) under the skin in those areas.

Figure 15-3 illustrates the bones of the cranium. Label them as you read the following descriptions:

Frontal bone [1]—forms the forehead and the roof of the bony sockets that contain the eyes.
Parietal bone [2]—the two bones (one on each side of the skull) that form the roof and upper part of the sides of the cranium.

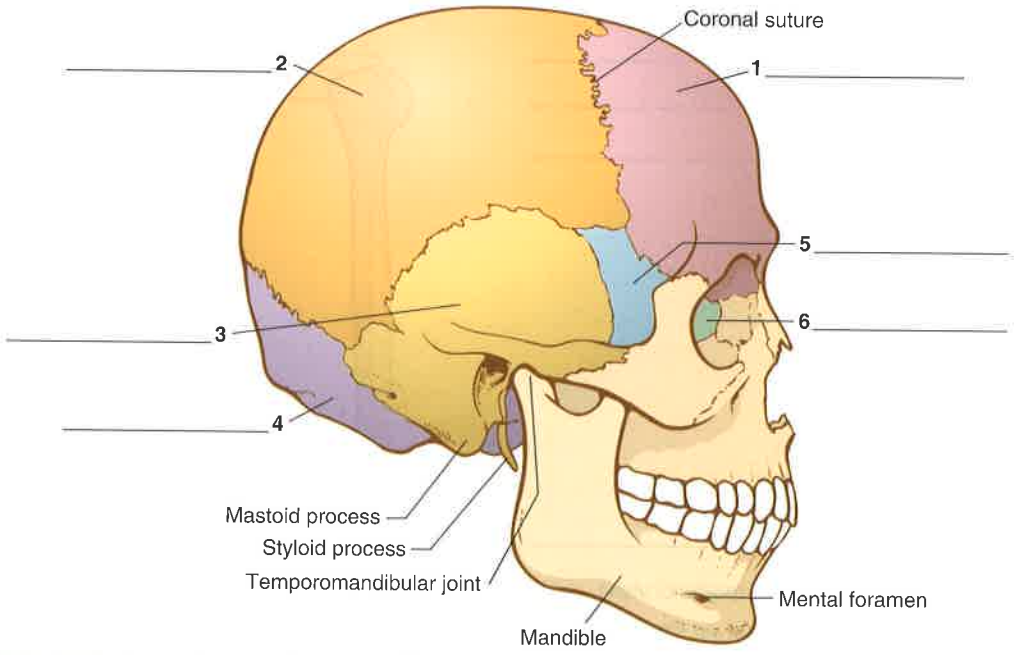

FIGURE 15–3 **Cranial bones,** lateral view. The **mental** (ment/o = chin) **foramen** is the opening in the mandible that allows blood vessels and nerves to enter and leave. The **coronal suture** is the connection across the skull between the two parietal bones and the frontal bone.

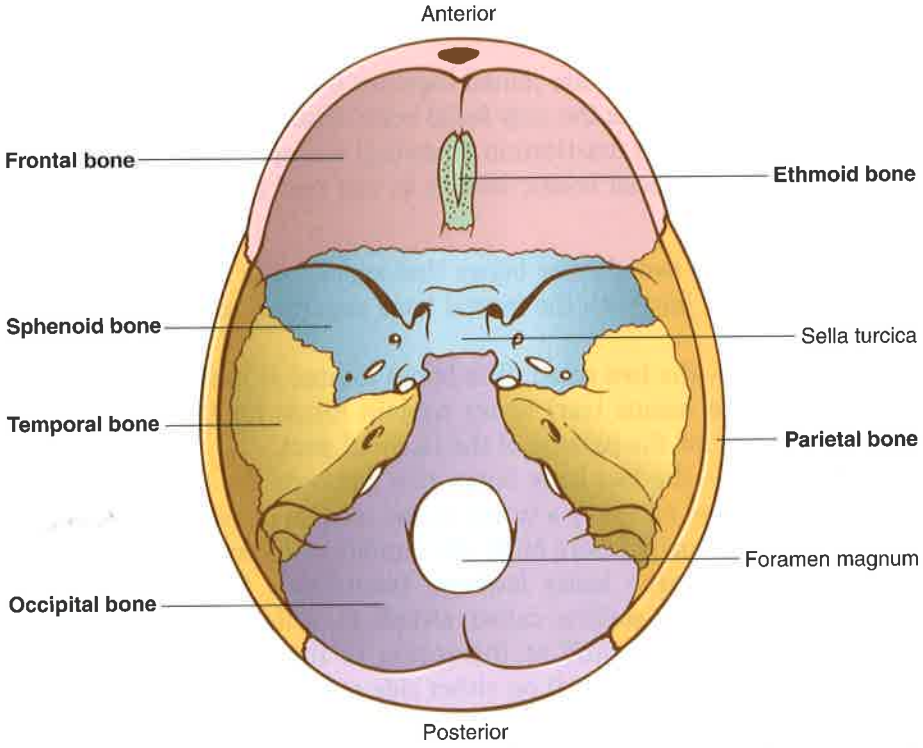

FIGURE 15–4 **Cranial bones,** viewed from above downward, to the floor of the cranial cavity.

Temporal bone [3]—the two bones that form the lower sides and base of the cranium. Each bone encloses an ear and contains a fossa for joining with the mandible (lower jawbone). The **temporomandibular joint (TMJ)** is the area of connection between the temporal and mandibular bones. The **mastoid process** is a round (**mast/o** means breast) process of the temporal bone behind the ear. The **styloid process** (**styl/o** means pole or stake) projects downward from the temporal bone.

Occipital bone [4]—forms the back and base of the skull and joins the parietal and temporal bones, forming a suture. The inferior portion of the occipital bone has an opening called the **foramen magnum** through which the spinal cord passes (see Figure 15-4).

Sphenoid bone [5]—the bat-shaped bone that extends behind the eyes and forms part of the base of the skull. Because it joins with the frontal, occipital, and ethmoid bones, it serves as an anchor to hold those skull bones together (**sphen/o** means wedge). The **sella turcica** (meaning Turkish saddle) is a depression in the sphenoid bone in which the pituitary gland is located (see Figure 15-4).

Ethmoid bone [6]—the thin, delicate bone that supports the nasal cavity and forms part of the orbits of the eyes. It is composed primarily of spongy, cancellous bone, which contains numerous small holes (**ethm/o** means sieve).

Study Figure 15-4, which shows these cranial bones as viewed from above downward, toward the floor of the cranial cavity.

FACIAL BONES

All of the facial bones except one are joined together by sutures, so they are immovable. The mandible (lower jawbone) is the only facial bone capable of movement. This ability is necessary for activities such as mastication (chewing) and speaking.

Figure 15-5 shows the facial bones; label it as you read the following descriptions of the facial bones:

Nasal bones [1]—the two slender bones that support the bridge of the nose (**nas/o** means nose). They join with the frontal bone superiorly and form part of the nasal septum.

Lacrimal bones [2]—the two small, thin bones located at the corner of each eye. The lacrimal (**lacrim/o** means tear) bones contain fossae for the lacrimal gland (tear gland) and canals for the passage of the lacrimal duct.

Maxillary bones [3]—the two large bones that compose the massive upper jawbones **(maxillae).** They are joined by a suture in the median plane. If the two bones do not come together normally before birth, the condition known as **cleft palate** results.

Mandibular bone [4]—the lower jawbone **(mandible).** Both the maxilla and the mandible contain the sockets called **alveoli** in which the teeth are embedded. The mandible joins the skull at the region of the temporal bone, forming the temporomandibular joint (TMJ) on either side of the skull.

Zygomatic bones [5]—the two bones, one on each side of the face, that form the high portion of the cheek.

Vomer [6]—the thin, single, flat bone that forms the lower portion of the nasal septum.

Sinuses, or air cavities, are located in specific places within the cranial and facial bones to lighten the skull and warm and moisten air as it passes through. Figure 15-6 shows the sinuses of the skull.

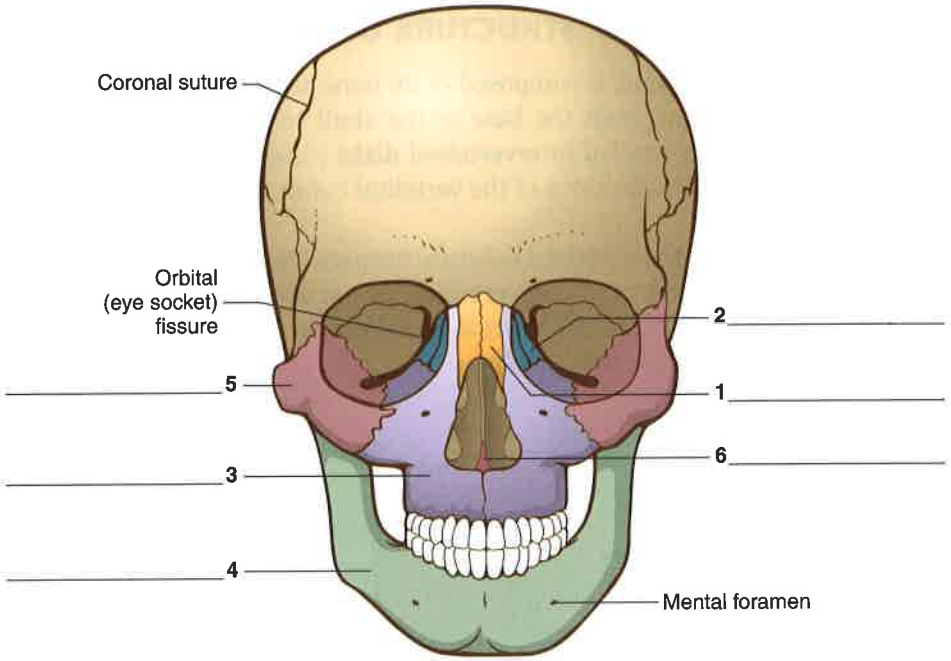

FIGURE 15–5 Facial bones.

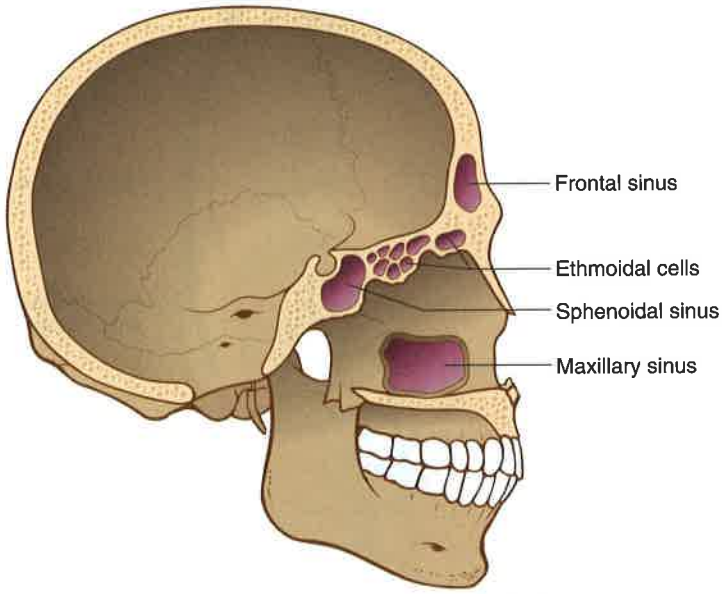

FIGURE 15–6 Sinuses of the skull.

VERTEBRAL COLUMN AND STRUCTURE OF VERTEBRAE

The **vertebral,** or **spinal, column** is composed of 26 bone segments, called vertebrae, that are arranged in five divisions from the base of the skull to the tailbone. The bones are separated by pads of cartilage called **intervertebral disks** (discs).

Figure 15-7 illustrates the divisions of the vertebral column: cervical, thoracic, lumbar, sacrum, and coccyx.

The first seven bones of the vertebral column, forming the bony aspect of the neck, are the **cervical (C1 to C7) vertebrae.** These vertebrae do not articulate (join) with the ribs.

The second set of 12 vertebrae is known as the **thoracic (T1 to T12) vertebrae.** These vertebrae articulate with the 12 pairs of ribs.

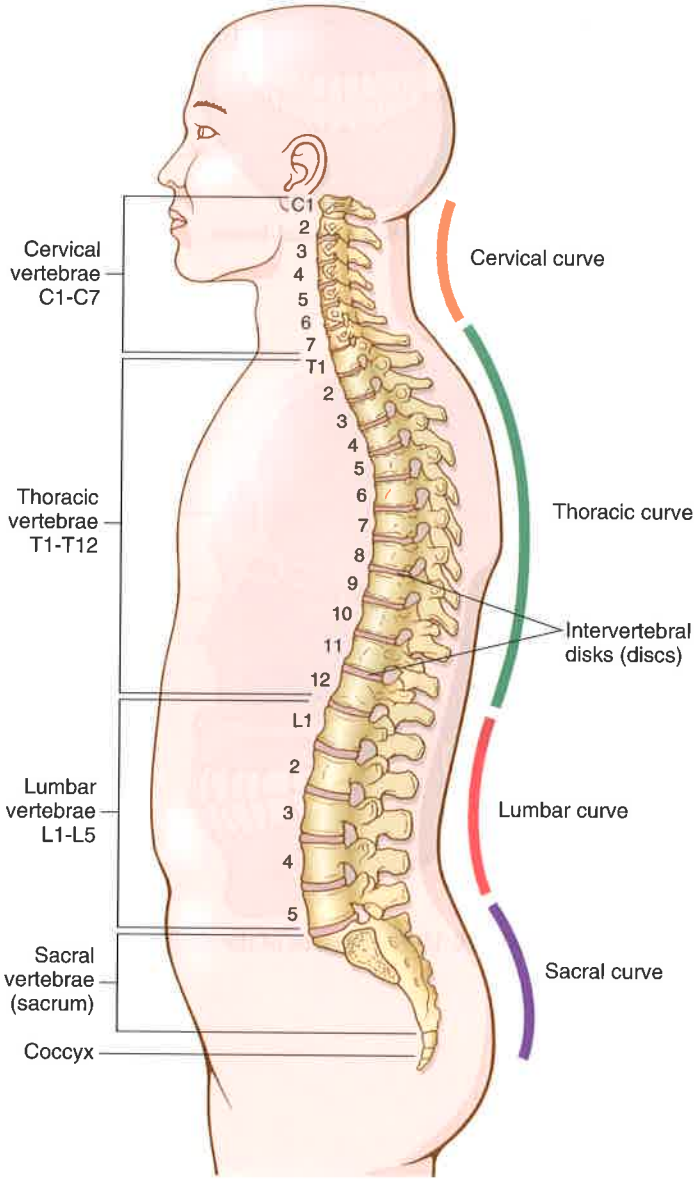

FIGURE 15–7 Vertebral column. Notice the four curves of the vertebral column. The sacral and thoracic curvatures are present at birth. The cervical curvature develops when the infant holds the head erect. The lumbar curvature develops as the infant begins to stand and walk.

The third set of five vertebral bones is the **lumbar (L1 to L5) vertebrae.** They are the strongest and largest of the backbones. Like the cervical vertebrae, these bones do not articulate with the ribs.

The **sacral vertebrae (sacrum)** are five separate bones that fuse in a young child. In an adult, the sacrum is a slightly curved, triangularly shaped bone.

The **coccyx** is the tailbone, and it, too, is a fused bone, having been formed from four small coccygeal bones.

Figure 15-8A illustrates the general structure of a vertebra. Although the individual vertebrae in the separate regions of the spinal column are all slightly different in structure, they do have several parts in common.

A vertebra is composed of an inner, thick, round anterior portion called the **vertebral body** [1]. Between the body of one vertebra and the body of the vertebra lying beneath or above is an **intervertebral disk (disc).** This is a pad of cartilage that provides flexibility and absorbs shocks to the vertebral column (see Figure 15-8B).

The posterior portion of a vertebra (vertebral arch) consists of a single **spinous process** [2], a **transverse process** [3] on each side of the spinous process, and a bar-like **lamina** [4] between each transverse process and the spinous process. The **neural canal** [5] is the space between the vertebral body and the vertebral arch through which the spinal cord passes. Figure 15-8B shows a lateral view of several vertebrae. Note the location of the spinal cord running through the neural canal.

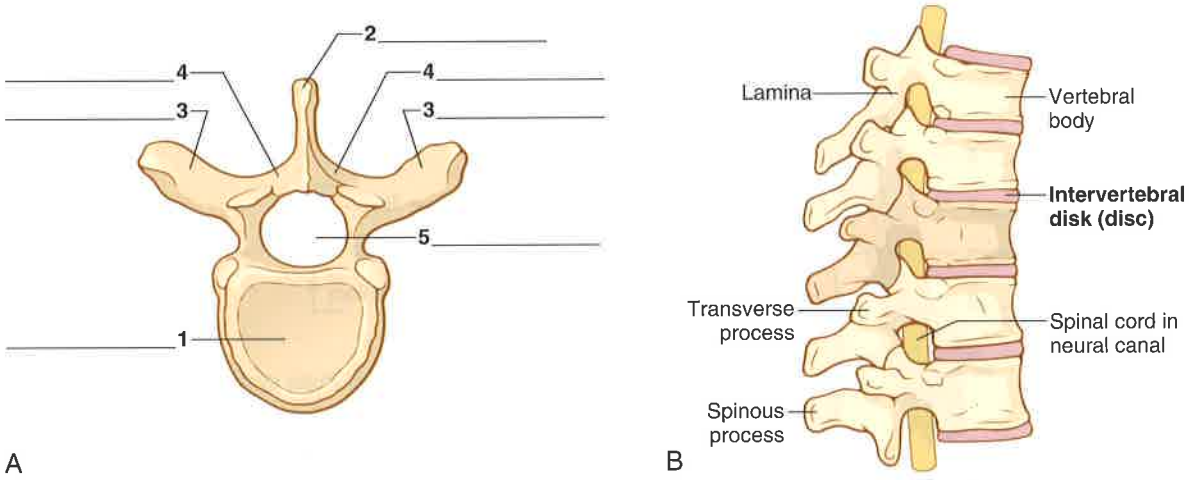

FIGURE 15–8 **(A) General structure of a vertebra,** viewed from above. **(B) Series of vertebrae,** lateral view, to show the position of the spinal cord behind the vertebral bodies and intervertebral disks.

BONES OF THE THORAX, PELVIS, AND EXTREMITIES

Label Figure 15-9 as you read the following descriptions of the bones of the thorax (chest cavity), pelvis (hip bone), and extremities (arms, hands, legs, and feet):

Bones of the Thorax

Clavicle [1]—collar bone; a slender bone, ventrally, one on each side, connecting the breastbone (sternum) to each shoulder blade (scapula).

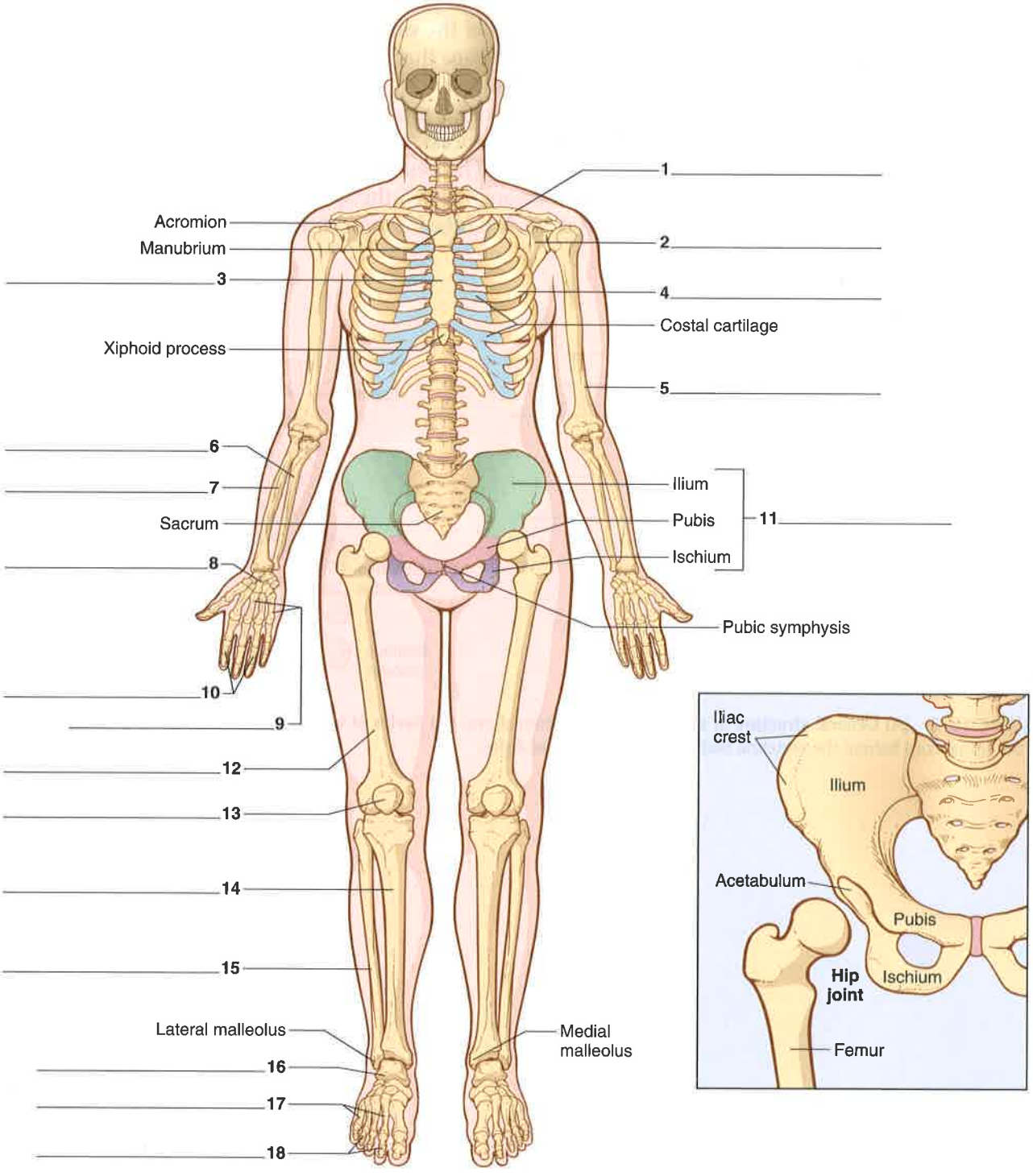

FIGURE 15–9 **Bones of the thorax, pelvis, and extremities.**

Scapula [2] (*plural*: **scapulae**)—shoulder blade; one of two flat, triangular bones on each dorsal side of the thorax. The extension of the scapula that joins with the clavicle to form a joint above the shoulder is called the **acromion** (**acr/o** means extremity, **om/o** means shoulder). The joint formed by these two bones is known as the acromioclavicular (AC) joint. Figure 15-10 shows a posterior view of the scapula.

Sternum [3]—breastbone; a flat bone extending ventrally down the midline of the chest. The upper part of the sternum articulates on the sides with the clavicle and ribs, and the lower, narrower portion is attached to the ribs, diaphragm, and abdominal muscles. The lowest portion of the sternum is the **xiphoid process** (**xiph/o** means sword). The uppermost portion is the **manubrium** (from a Latin term meaning handle).

Ribs [4]—There are 12 pairs of ribs. The first 7 pairs join the sternum anteriorly through cartilaginous attachments called **costal cartilages.** Ribs 1 to 7 are called **true ribs.** They join with the sternum anteriorly and with the vertebral column posteriorly. Ribs 8 to 10 are called **false ribs.** They join with the vertebral column posteriorly but join the 7th rib anteriorly instead of attaching to the sternum. Ribs 11 and 12 are the **floating ribs** because they are completely free at their anterior ends. Figure 15-10 shows a posterior view of the rib cage.

Bones of the Arm and Hand

These are described with the subject in the anatomic position—standing, with the arms held at the sides and the palms forward.

Humerus [5]—upper arm bone; the large head of the humerus is rounded and joins with the glenoid fossa of the scapula to form the shoulder or glenoid humeral joint (see Figure 15-10).

Ulna [6]—medial lower arm (forearm) bone; the proximal bony process of the ulna at the elbow is called the **olecranon** (elbow bone). The olecranon is the bony point of the elbow when the elbow is bent.

Radius [7]—lateral lower arm (forearm) bone (in line with the thumb).

Carpals [8]—wrist bones; there are two rows of four bones in the wrist.

Metacarpals [9]—the five bones of the palm of the hand.

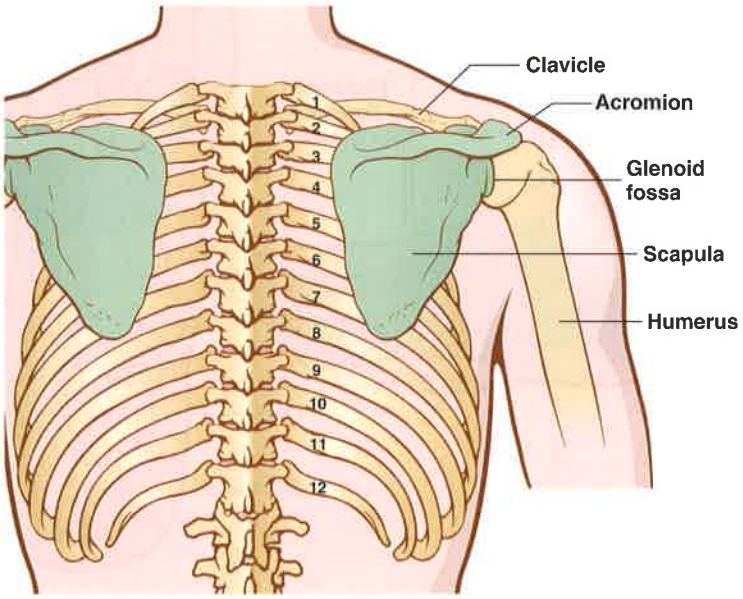

FIGURE 15–10 Scapulae and rib cage, posterior view. The **glenoid fossa** is the depression in the scapula into which the humerus fits.

Phalanges [10] (*singular*: **phalanx**)—finger bones. Each finger (except the thumb) has three phalanges: a proximal, a middle, and a distal phalanx. The thumb has only two phalanges: a proximal and a distal phalanx.

Bones of the Pelvis

Pelvic girdle [11]—pelvis. This collection of bones supports the trunk of the body and articulates with the femur to form the hip joint. The adult pelvis is composed of three pairs of fused bones: the ilium, ischium, and pubis.

Ilium—the uppermost and largest portion of the pelvis. Dorsally, the two parts of the ilium do not meet. Rather, they join the sacrum on either side to form the sacroiliac joints. The connection between the iliac bones and the sacrum is very firm, and very little motion occurs at these joints. The superior part of the ilium is the **iliac crest.** It is filled with red bone marrow and serves as an attachment for abdominal wall muscles.

Ischium—the posterior part of the pelvis. The ischium and the tendons and muscles attached to it are what you sit on.

Pubis—the anterior part of the pelvis. The two pubic bones join by way of a cartilaginous disk. This area is called the **pubic symphysis.** Like the sacroiliac joints, this area is quite rigid.

Pelvic cavity—the region within the ring of bone formed by the pelvic girdle. The rectum, sigmoid colon, bladder, and female reproductive organs lie within the pelvic cavity and are protected by the rigid architecture of the pelvic girdle. See Chapter 2, page 52, for comparison of the male pelvis and the female pelvis.

Bones of the Leg and Foot

Femur [12]—thigh bone; this is the longest bone in the body. At its proximal end it has a rounded head that fits into a depression, or socket, in the pelvis. This socket is

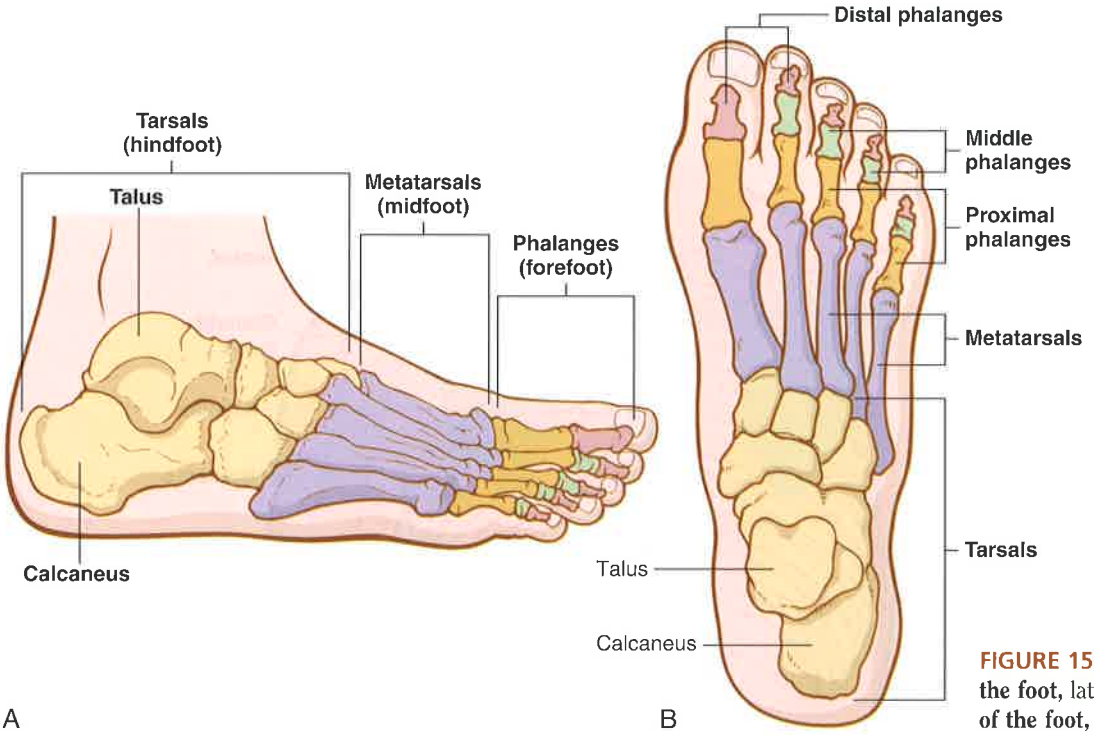

FIGURE 15–11 **(A) Bones of the foot,** lateral view. **(B) Bones of the foot,** as viewed from above.

called the **acetabulum.** The acetabulum was named because of its resemblance to a rounded cup the Romans used for vinegar *(acetum)*. The head of the femur and the acetabulum form a ball-and-socket joint otherwise known as the **hip joint.** See inset in Figure 15-9.

Patella [13]—kneecap; this is a small, flat bone that lies in front of the articulation between the femur and one of the lower leg bones called the tibia. It is a sesamoid bone surrounded by protective tendons and held in place by muscle attachments. Together with the femur and the tibia, it forms the knee joint.

Tibia [14]—larger of the two bones of the lower leg; the tibia runs under the skin in the front part of the leg. It joins with the femur and patella proximally, and at its distal end (ankle) forms a flare that is the bony prominence (medial **malleolus**) at the inside of the ankle. The tibia commonly is called the **shin bone.**

Fibula [15]—smaller of the two lower leg bones; this thin bone, well hidden under the leg muscles, runs parallel to the tibia. At its distal part, it forms a flare, which is the bony prominence (lateral **malleolus**) on the outside of the ankle. The tibia, fibula, and **talus** (the first of the tarsal bones) come together to form the **ankle joint.**

Tarsals [16]—bones of the hind part of the foot (hindfoot); these seven short bones resemble the carpal bones of the wrist but are larger. The **calcaneus** is the largest of these bones and also is called the **heel bone** (Figure 15-11). As noted, the **talus** is one of three bones that form the ankle joint.

Metatarsals [17]—bones of the midfoot; there are five metatarsal bones, which are similar to the metacarpals of the hand. Each articulates with the phalanges of the toes.

Phalanges of the toes [18]—bones of the forefoot; as in the digits of the hand, there are two phalanges in the big toe and three in each of the other toes.

Figure 15-11 illustrates the bones of the foot. Table 15-1 reviews bones and bone processes and their common names.

TABLE 15-1 Bones or Processes and Their Common Names

Bone or Process	Common Name	Bone or Process	Common Name
Acetabulum	Hip socket	Metacarpals	Hand bones
Calcaneus	Heel	Metatarsals	Midfoot bones
Carpals	Wrist bones	Olecranon	Elbow
Clavicle	Collar bone	Patella	Kneecap
Coccyx	Tailbone	Phalanges	Finger and toe bones
Cranium	Skull	Pubis	Anterior part of the pelvic bone
Femur	Thigh bone	Radius	Forearm bone—thumb side
Fibula	Smaller of the two lower leg bones	Scapula	Shoulder blade
Humerus	Upper arm bone	Sternum	Breastbone
Ilium	Upper part of pelvic bone	Tarsals	Hindfoot bones
Ischium	Posterior part of the pelvic bone	Tibia	Shin bone—larger of the two lower leg bones
Malleolus	Ankle	Ulna	Forearm bone—little finger side
Mandible	Lower jawbone	Vertebra	Backbone/spine
Maxilla	Upper jawbone		

VOCABULARY—BONES

This list reviews many of the new terms related to bones introduced in the text. Short definitions reinforce your understanding of the terms. Refer to the Pronunciation of Terms on page 639 for help with unfamiliar or difficult terms.

acetabulum	Rounded depression, or socket, in the pelvis that joins the femur (thigh bone), forming the hip joint.
acromion	Outward extension of the shoulder blade forming the point of the shoulder. It overlies the shoulder joint and articulates with the clavicle.
articular cartilage	Thin layer of cartilage covering the bone in the joint space.
bone	Dense, hard connective tissue composing the skeleton. Examples are long bones (femur), short bones (carpals), flat bones (scapula), and sesamoid bones (patella).
calcium	One of the mineral constituents of bone. **Calcium phosphate** is the major calcium salt in bones.
cancellous bone	Spongy, porous, bone tissue in the inner part of a bone.
cartilage	Flexible, rubbery connective tissue. It is found in the immature skeleton, at the epiphyseal growth plate, and on joint surfaces.
collagen	Dense, connective tissue protein strands found in bone and other tissues.
compact bone	Hard, dense bone tissue, usually found around the outer portion of bones.
condyle	Knuckle-like process at the end of a bone near the joint.
cranial bones	Skull bones: ethmoid, frontal, occipital, parietal, sphenoid, and temporal.
diaphysis	Shaft, or mid-portion, of a long bone.
disk (disc)	Flat, round, plate-like structure. An intervertebral disk is a fibrocartilaginous substance between two vertebrae.
epiphyseal plate	Cartilaginous area at the ends of long bones where lengthwise growth takes place in the immature skeleton.
epiphysis	Each end of a long bone; the area beyond the epiphyseal plate.
facial bones	Bones of the face: lacrimal, mandibular, maxillary, nasal, vomer, and zygomatic.
fissure	Narrow, slit-like opening in or between bones.
fontanelle	Soft spot (incomplete bone formation) between the skull bones of an infant.
foramen	Opening or passage in bones where blood vessels and nerves enter and leave. The **foramen magnum** is the opening of the occipital bone through which the spinal cord passes.
fossa	Shallow cavity in a bone.
haversian canals	Minute spaces filled with blood vessels; found in compact bone.

malleolus	Round process on both sides of the ankle joint. The lateral malleolus is part of the fibula, and the medial malleolus is part of the tibia.
manubrium	Upper portion of the sternum; articulates with the medial aspect of the clavicle.
mastoid process	Round projection on the temporal bone behind the ear.
medullary cavity	Central, hollowed-out area in the shaft of a long bone.
metaphysis	Flared portion of a long bone, between the diaphysis (shaft) and the epiphyseal plate (in this term, meta- means between).
olecranon	Large process on the proximal end of the ulna; the point of the flexed elbow.
osseous tissue	Bone tissue.
ossification	Process of bone formation.
osteoblast	Bone cell that helps form bony tissue.
osteoclast	Bone cell that absorbs and removes unwanted bony tissue.
periosteum	Membrane surrounding bones; rich in blood vessels and nerve tissue.
phosphorus	Mineral substance found in bones in combination with calcium.
pubic symphysis	Area of confluence (coming together) of the two pubic bones in the pelvis. They are joined (sym- = together, -physis = to grow) by a fibrocartilaginous disk.
red bone marrow	Found in cancellous bone; site of hematopoiesis.
ribs	Twelve pairs of curved bones that form the chest wall. True ribs are the first 7 pairs; false ribs are pairs 8 to 10; floating ribs are pairs 11 and 12.
sella turcica	Depression in the sphenoid bone where the pituitary gland is located.
sinus	Hollow air cavity within a bone.
styloid process	Pole-like process extending downward from the temporal bone on each side of the skull.
suture	Immovable joint between bones, such as the skull (cranium).
temporomandibular joint	Connection on either side of the head between the temporal bone of the skull and mandibular bone of the jaw.
trabeculae	Supporting bundles of bony fibers in cancellous (spongy) bone.
trochanter	Large process at the neck of the femur; attachment site for tendons of the hip musculature.
tubercle	Rounded, small process on bone; attachment site for muscles and tendons.
tuberosity	Rounded process on bone; attachment site for muscles and tendons.
vertebra	Individual segment of the spine composed of the vertebral body, vertebral arch, spinous process, transverse process, and lamina, enclosing the neural canal.
xiphoid process	Lower, narrow portion of the sternum.
yellow bone marrow	Fatty tissue found in the medullary cavity of most adult long bones.

TERMINOLOGY—BONES

The following word parts pertaining to bones are divided into two groups: general terms and terms related to specific bones. Write the meanings of the medical terms in the spaces provided.

15

General Terms

COMBINING FORMS

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
calc/o, calci/o	calcium	hypercalcemia _____	
		decalcification _____	
		de- means less or lack of; -fication is the process of making.	
kyph/o	humpback, hunchback (posterior curvature in the thoracic region)	kyphosis _____	
		This term (from Greek meaning hill or mountain) indicates a hump on the back. The affected person's height is reduced, and kyphosis may lead to pressure on the spinal cord or peripheral nerves (Figure 15-12).	
lamin/o	lamina (part of the vertebral arch)	laminectomy _____	
		An operation often performed to relieve the symptoms of compression of the spinal cord or spinal nerve roots. It involves removal of the lamina and spinous process.	
lord/o	curve, swayback (anterior curvature in the lumbar region)	lordosis _____	
		The normal anterior curvature of the lumbar spine becomes exaggerated (see Figure 15-12). The word lordosis is derived from Greek, describing a person leaning backward in a lordly fashion.	

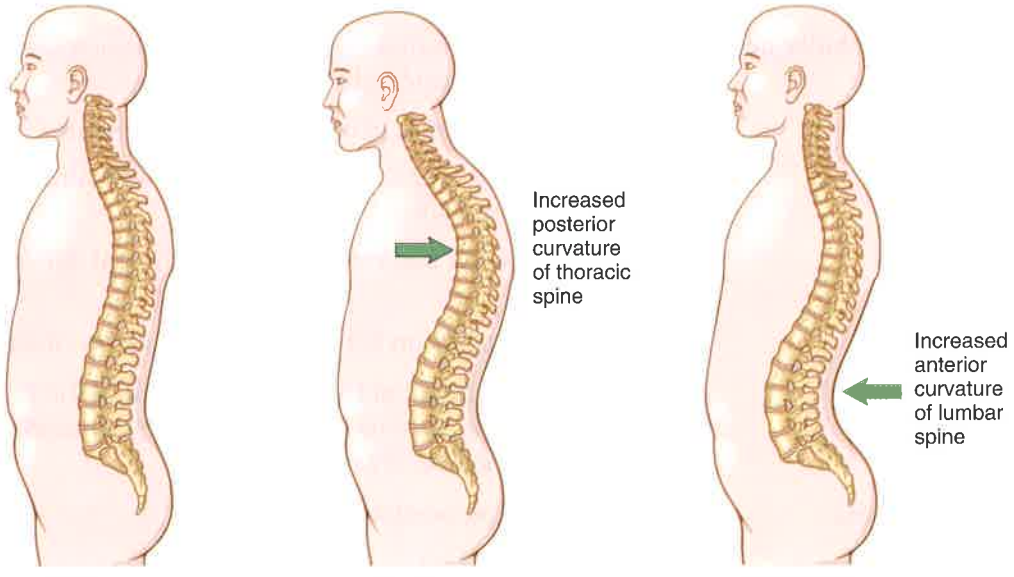

FIGURE 15–12 **Kyphosis** and **lordosis.**

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
lumb/o	loins, lower back	lumbar	
		lumbosacral	
myel/o	bone marrow	myelopoiesis	
orth/o	straight	orthopedics	
		Ped/o means child.	
oste/o	bone	osteitis	
		***Osteitis deformans** is better known as **Paget disease.** Bones become weak and painful, especially in the spine, skull, pelvis, and legs.*	
		osteodystrophy	
		osteogenesis	
		***Osteogenesis imperfecta** is a genetic disorder involving defective development of bones that are brittle and fragile; fractures occur with the slightest trauma.*	
scoli/o	crooked, bent (lateral curvature)	scoliosis	
		The spinal column is bent abnormally to the side. Scoliosis is the most common spinal deformity in adolescent girls (Figure 15-13).	

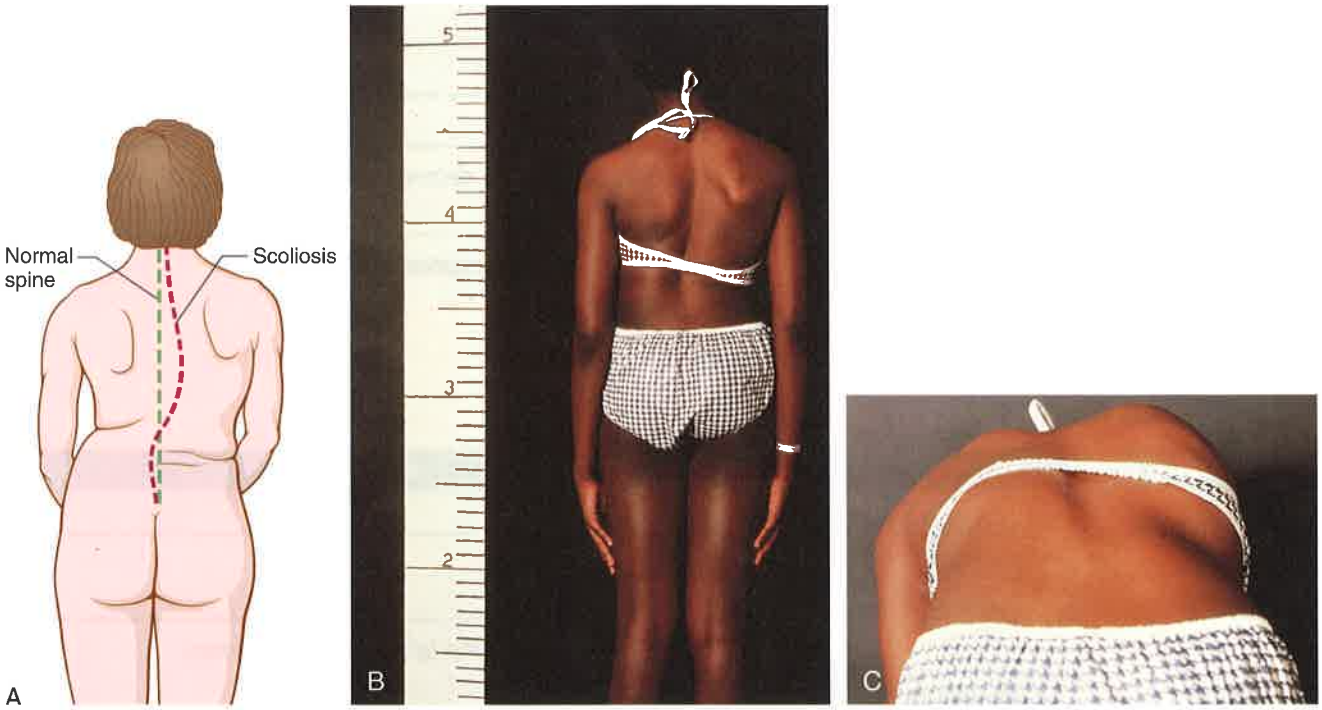

FIGURE 15–13 **Moderate thoracic idiopathic adolescent scoliosis. (A) Normal spine** and **scoliosis. (B)** Notice the **scapular asymmetry** in the upright position. This results from rotation of the spine and attached rib cage. **(C)** Bending forward reveals a mild rib hump deformity. (**B** and **C,** From Zitelli BJ, Davis HW: Atlas of Pediatric Physical Diagnosis, 4th ed., St. Louis, Mosby, 2002, p. 756.)

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
spondyl/o (used to make words about conditions of the structure)	vertebra	spondylosis *Degeneration of the intervertebral disks in the cervical, thoracic, and lumbar regions. Signs and symptoms include pain and restriction of movement.*	
vertebr/o (used to describe the structure itself)	vertebra	vertebroplasty *Percutaneous vertebroplasty relieves pain caused by compression fractures of the vertebrae. Medical cement is used to fill in the cracks and strengthen bone.*	

SUFFIXES

SUFFIX	MEANING	TERMINOLOGY	MEANING
-blast	embryonic or immature cell	osteoblast *This cell synthesizes collagen and protein to form bone tissue.*	
-clast	to break	osteoclast *This cell breaks down bone to remove bone tissue.*	
-listhesis	slipping	spondylolisthesis *(Pronounced spŏn-dĭ-lō-lĭs-THĒ-sĭs.) The forward slipping (subluxation) of a vertebra over a lower vertebra.*	
-malacia	softening	osteomalacia *A condition in which vitamin D deficiency leads to decalcification of bones; known as rickets in children.*	
-physis	to grow	epiphysis pubic symphysis	
-porosis	pore, passage	osteoporosis *Loss of bony tissue with decreased mass of bone.* *See page 600.*	
-tome	instrument to cut	osteotome *This surgical chisel is designed to cut bone.*	

Terms Related to Specific Bones

COMBINING FORMS

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
acetabul/o	acetabulum (hip socket)	acetabular	
calcane/o	calcaneus (heel)	calcaneal *The calcaneus is one of the tarsal (hindfoot) bones.*	
carp/o	carpals (wrist bones)	carpal	
clavicul/o	clavicle (collar bone)	supraclavicular *Supra- means above.*	

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
cost/o	ribs (true ribs, false ribs, and floating ribs)	subcostal	
		chondrocostal	*Cartilage that is attached to the ribs.*
crani/o	cranium (skull)	craniotomy	
		craniotome	
femor/o	femur (thigh bone)	femoral	
fibul/o	fibula (smaller lower leg bone)	fibular	*See perone/o.*
humer/o	humerus (upper arm bone)	humeral	
ili/o	ilium (upper part of pelvic bone)	iliac	
ischi/o	ischium (posterior part of pelvic bone)	ischial	
malleol/o	malleolus (process on each side of the ankle)	malleolar	*The medial malleolus is at the distal end of the tibia, and the lateral malleolus is at the distal end of the fibula.*
mandibul/o	mandible (lower jawbone)	mandibular	
maxill/o	maxilla (upper jawbone)	maxillary	
metacarp/o	metacarpals (hand bones)	metacarpectomy	
metatars/o	metatarsals (foot bones)	metatarsalgia	
olecran/o	olecranon (elbow)	olecranal	
patell/o	patella (kneecap)	patellar	
pelv/i	pelvis (hipbone)	pelvimetry	
perone/o	fibula	peroneal	
phalang/o	phalanges (finger and/or toe bones)	phalangeal	
pub/o	pubis (anterior part of the pelvic bone)	pubic	

Peroneal/Peritoneal

Peroneal means pertaining to the fibula (smaller of two lower leg bones). Don't confuse this term with *peritoneal,* meaning pertaining to the peritoneum (membrane surrounding the abdominal organs).

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
radi/o	radius (forearm bone—thumb side)	radial	
scapul/o	scapula (shoulder blade)	scapular	
stern/o	sternum (breastbone)	sternal	
tars/o	tarsals (bones of the hindfoot)	tarsectomy	
tibi/o	tibia (shin bone)	tibial	
uln/o	ulna (forearm bone—little finger side)	ulnar	

PATHOLOGY—BONES

Ewing sarcoma

Rare malignant tumor arising in bone; most often occurring in children.

Pain and swelling are common, especially if the tumor involves the shaft (medullary cavity) of a long bone. This tumor usually occurs at an early age (5 to 15 years old), and combined treatment with surgery, radiotherapy, and chemotherapy represents the best chance for cure (60% to 70% of patients are cured if metastasis has not occurred).

exostosis

Bony growth (benign) arising from the surface of bone (ex- means out, -ostosis means condition of bone).

Osteochondromas (composed of cartilage and bone) are **exostoses** usually found on the metaphyses of long bones near the epiphyseal plates

A **bunion** is a swelling of the metatarsophalangeal joint near the base of the big toe and is accompanied by the buildup of soft tissue and underlying bone at the distal/medial aspect of the first metatarsal.

fracture

Traumatic breaking of a bone.

In a **closed fracture,** the bone is broken but there is no open wound in the skin, whereas in an **open (compound) fracture,** the bone is broken and a fragment of bone protrudes through an open wound in the skin. A **pathologic fracture** is caused by disease of the bone such as tumor or infection, making it weak. **Crepitus** is the crackling sound produced when ends of bones rub each other or rub against roughened cartilage.

Examples of fractures (Figure 15-14) are the following:

Colles fracture—occurs near the wrist joint at the distal end of the radius.

comminuted fracture—bone is splintered or crushed into several pieces. A simple fracture means that a bone breaks in only one place and is therefore not comminuted.

compression fracture—bone collapses or is compressed, as may happen to vertebrae in osteoporosis or with traumatic injury.

greenstick fracture—bone is partially broken; it breaks on one surface and only bends on the other, as when a small tree branch breaks; occurs in children.

impacted fracture—one fragment is driven firmly into the other.

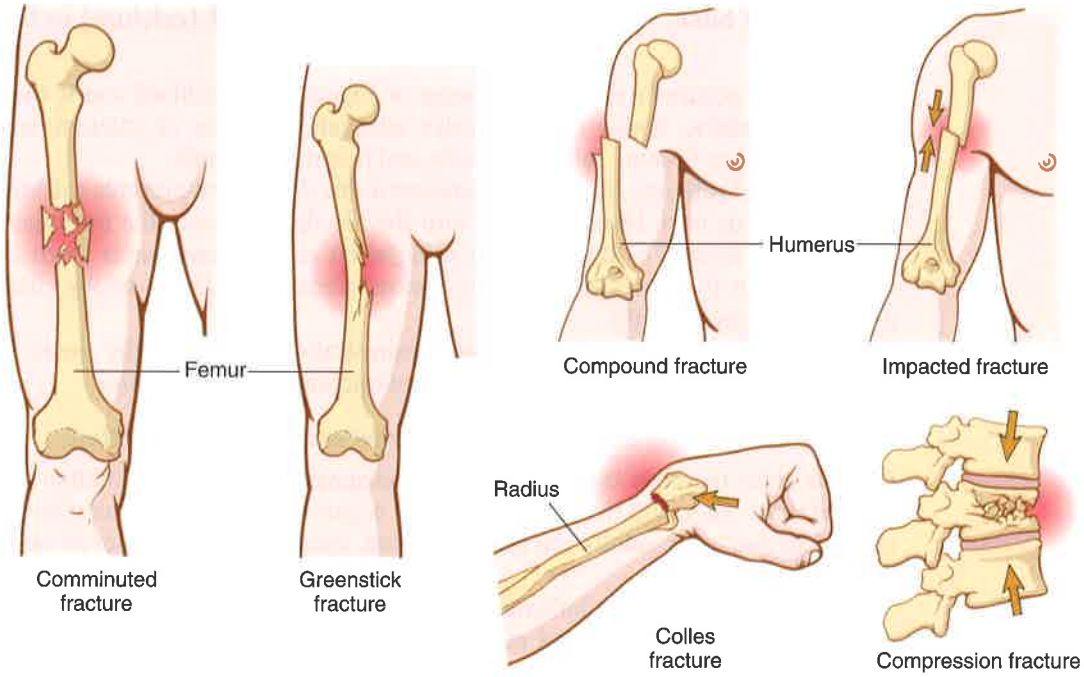

FIGURE 15–14 **Types of fractures.**

Treatment of fractures involves **reduction,** which is restoration of the bone to its normal position. A **closed reduction** is manipulative reduction without a surgical incision; in an **open reduction,** an incision is made for access to the fracture site. A **cast** (solid mold of the body part) is applied to fractures to immobilize the injured bone after a closed reduction. The abbreviation **ORIF** means open reduction/internal fixation. Often this involves insertion of metal plates, screws, rods, or pins to stabilize the bone.

osteogenic sarcoma (osteosarcoma)

Common malignant tumor arising from osteoblasts.

Osteoblasts multiply, forming large, bony tumors, especially at the ends of long bones (half of the lesions are located just below or just above the knee) (Figure 15-15). Metastasis (spread of tumor) takes place through the bloodstream, often affecting the lungs. Surgical resection followed by chemotherapy improves the survival rate.

Malignant tumors from other parts of the body (breast, prostate, lung, thyroid gland, and kidney) that metastasize to bones are **metastatic bone lesions.**

FIGURE 15–15 **Osteosarcoma.** The tumor has grown through the cortex of the bone and elevated the periosteum. (Courtesy Dr. Francis Hornicek, Massachusetts General Hospital Department of Orthopedics, Boston.)

osteomalacia

Softening of bone, with inadequate amounts of mineral (calcium) in the bone.

Osteomalacia occurs primarily as a disease of infancy and childhood and is then known as **rickets.** Bones fail to receive adequate amounts of calcium and phosphorus; they become soft, bend easily, and become deformed.

In affected patients, vitamin D is deficient in the diet, which prevents calcium and phosphorus from being absorbed into the bloodstream from the intestines. Vitamin D is formed by the action of sunlight on certain compounds (such as cholesterol) in the skin; thus, rickets is more common in large, smoky cities during the winter months.

Treatment most often consists of administration of large daily doses of vitamin D and an increase in dietary intake of calcium and phosphorus.

osteomyelitis

Inflammation of the bone and bone marrow secondary to infection.

Bacteria enter the body through a wound and spread to the bone. Children are affected most often, and the infection usually occurs near the ends of long bones of the legs and arms. Adults can be affected too, usually as the result of an open fracture.

The lesion begins as an inflammation with pus collection. Pus tends to spread down the medullary cavity and outward to the periosteum. Antibiotic therapy corrects the condition if the infection is treated quickly. If treatment is delayed, an **abscess** can form. An abscess is a walled-off area of infection that can be difficult or impossible to penetrate with antibiotics. Surgical drainage of an abscess usually is necessary.

osteoporosis

Decrease in bone density (mass); thinning and weakening of bone.

Osteopenia is a condition in which bone mineral density is lower than normal. In some cases, it is a precursor to osteoporosis. In osteoporosis, the interior of bones is diminished in structure, as if the steel skeleton of a building had rusted and deteriorated (Figure 15-16). The condition commonly occurs in older women as a consequence of estrogen deficiency with menopause. Lack of estrogen promotes

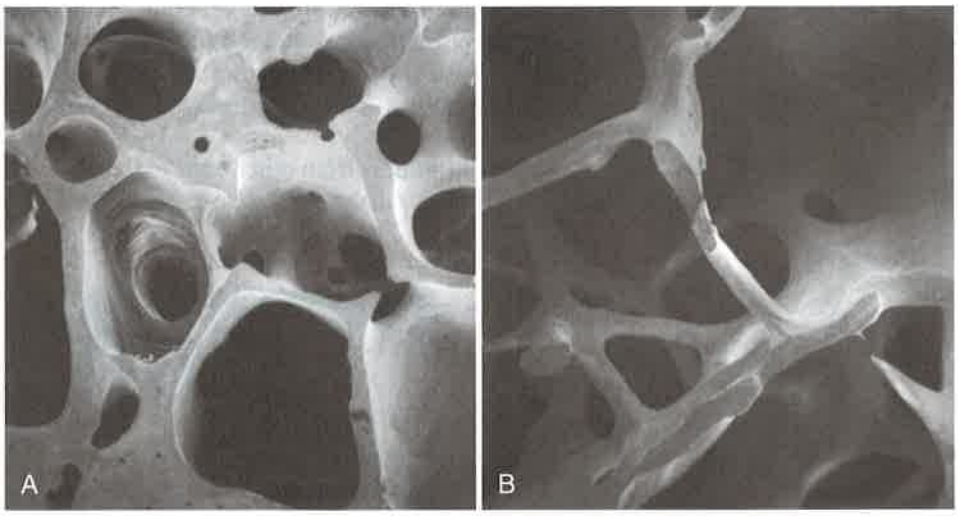

FIGURE 15–16 Scanning electron micrograph of normal bone (A) and bone with osteoporosis (B). Notice the thinning and wide separation of the trabeculae in the osteoporotic bone. (From Dempster DW, Shane E, Horbert W, et al: A simple method for correlative light and scanning electron microscopy of human iliac crest bone biopsies: qualitative observations in normal and osteoporotic subjects, J Bone Miner Res 1986;1:15.)

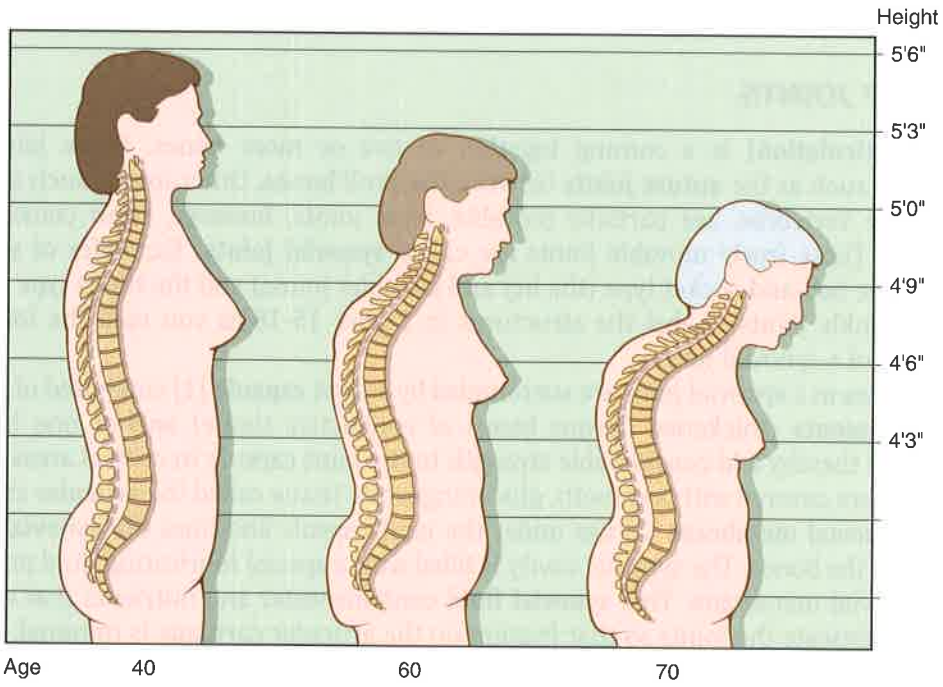

FIGURE 15–17 **Kyphosis.** Loss of bone mass due to osteoporosis produces posterior curvature of the spine in the thoracic region. A normal spine is shown at the age of 40 years, and osteoporotic changes are illustrated at the ages of 60 and 70 years. The changes in the spine can cause a loss of as much as 6 to 9 inches in height.

excessive bone resorption (osteoclast activity) and less bone deposition. Weakened bones are subject to fracture (as in the hip); loss of height and kyphosis occur as vertebrae collapse (Figure 15-17).

Osteoporosis can occur with atrophy caused by disuse, as in a limb that is in a cast, in the legs of a person with paraplegia, or in a bedridden patient. It also may occur in men as part of the aging process and in patients who have received corticosteroids (hormones made by the adrenal gland and used to treat inflammatory conditions).

Treatment and prevention of osteoporosis are critical to maintaining strong bones and avoiding fractures of the spine, hip, or wrist.

talipes

Congenital abnormality of the hindfoot (involving the talus).

Talipes (Latin *talus* = ankle, *pes* = foot) is a congenital anomaly. The most common form is **talipes equinovarus** (**equin/o** = horse), or **clubfoot.** The infant cannot stand with the sole of the foot flat on the ground. The defect can be corrected by applying orthopedic casts in the early months of infancy or, if that fails, by surgery.

Preventing Osteoporosis

Prevention of osteoporosis includes the following:

- Balanced diet rich in calcium and vitamin D
- Weight-bearing and resistance exercise
- Reduction of smoking and alcohol intake
- Checking bone mineral density (BMD) with a DEXA test (see page 618)
- Medications when appropriate—such as bisphosphonates (Fosamax, Boniva) and selective estrogen receptor modulators (SERMs—Raloxifene, Evista) and hormone replacement therapy (HRT)

JOINTS

TYPES OF JOINTS

A **joint (articulation)** is a coming together of two or more bones. Some joints are immovable, such as the **suture joints** between the skull bones. Other joints, such as those between the vertebrae, are partially movable. Most joints, however, allow considerable movement. These freely movable joints are called **synovial joints.** Examples of synovial joints are the ball-and-socket type (the hip and shoulder joints) and the hinge type (elbow, knee, and ankle joints). Label the structures in Figure 15-18 as you read the following description of a synovial joint.

The bones in a synovial joint are surrounded by a **joint capsule** [1] composed of fibrous tissue. **Ligaments** (thickened fibrous bands of connective tissue) anchor one bone to another and thereby add considerable strength to the joint capsule in critical areas. Bones at the joint are covered with a smooth, glistening white tissue called the **articular cartilage** [2]. The **synovial membrane** [3] lies under the joint capsule and lines the **synovial cavity** [4] between the bones. The synovial cavity is filled with a special lubricating fluid produced by the synovial membrane. This **synovial fluid** contains water and nutrients that nourish as well as lubricate the joints so that friction on the articular cartilage is minimal.

Bursae

Bursae (*singular*: **bursa**) are closed sacs of synovial fluid lined with a synovial membrane and are located near but not within a joint. Bursae are present wherever two types of tissue are closely opposed and need to slide past one another with as little friction as possible. Bursae serve as layers of lubrication between the tissues. Common sites of bursae are between **tendons** (connective tissue that connects a muscle to bone) and bones, between **ligaments** (connective tissue binding bone to bone) and bones, and between skin and bones in areas where bony anatomy is prominent.

Some common locations of bursae are at the elbow joint (olecranon bursa), knee joint (prepatellar bursa), and shoulder joint (subacromial bursa). Figure 15-19A shows a lateral view of the knee joint with bursae. Figure 15-19B is a frontal view of the knee showing ligaments that provide stability for the joint.

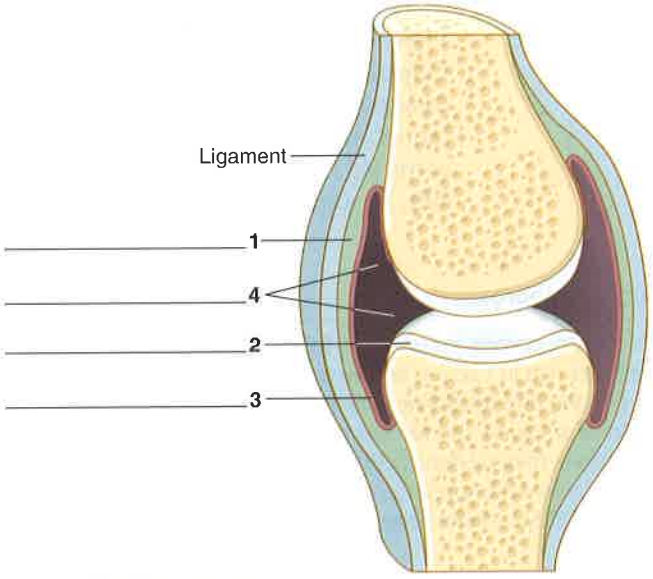

FIGURE 15–18 **Structure of a synovial joint.**

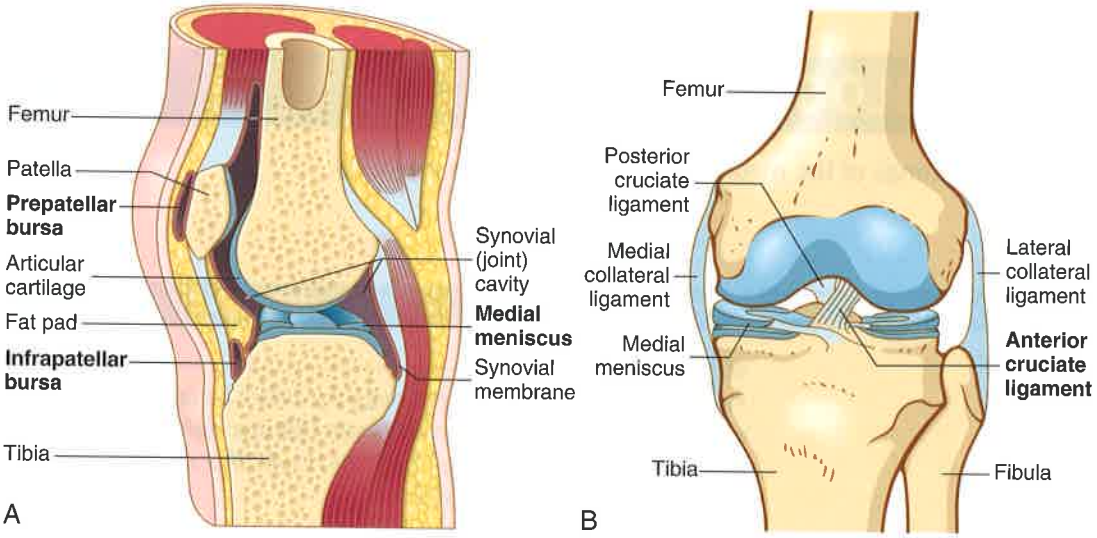

FIGURE 15–19 **(A) Sagittal (lateral) section of the knee showing bursae and other structures.** A **meniscus** (*plural*: menisci) is a crescent-shaped piece of cartilage that acts as a protective cushion in a synovial joint such as the knee. A "torn cartilage" in the knee is a damaged meniscus and is frequently repaired with arthroscopic surgery. **(B) Frontal section of the knee.** Notice the **anterior cruciate ligament (ACL),** which may be damaged ("torn ligament") with knee injury. Reconstruction of the ACL can require extensive surgery and months of physical therapy may be required before return of normal function. See case study, page 622.

VOCABULARY—JOINTS

This list reviews many new terms related to joints introduced in the text. Short definitions reinforce your understanding of the terms. Refer to the Pronunciation of Terms on page 643 for help with unfamiliar or difficult terms.

articular cartilage	Smooth, glistening white tissue that covers the surface of a joint.
articulation	Any type of joint.
bursa (*plural*: bursae)	Sac of fluid near a joint; promotes smooth sliding of one tissue against another.
ligament	Connective tissue binding bones to other bones; supports, strengthens, and stabilizes the joint.
suture joint	Immovable joint, such as between the bones of the skull.
synovial cavity	Space between bones at a synovial joint; contains synovial fluid produced by the synovial membrane.
synovial fluid	Viscous (sticky) fluid within the synovial cavity. Synovial fluid is similar in viscosity to egg white; this accounts for the origin of the term (syn- = like, ov/o = egg).
synovial joint	A freely movable joint.
synovial membrane	Tissue lining the synovial cavity; it produces synovial fluid.
tendon	Connective tissue that binds muscles to bones.

TERMINOLOGY—JOINTS

Write the meanings of the medical terms in the spaces provided.

COMBINING FORMS

15

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
ankyl/o	stiff	ankylosis	
		*Fusion of bones across a joint space by either bone tissue **(bony ankylosis)** or growth of fibrous tissue **(fibrous ankylosis).** Immobility and stiffening of the joint result; this most often occurs in rheumatoid arthritis.*	
arthr/o	joint	arthroplasty	
		Replacement arthroplasty is replacement of one or both bone ends by a prosthesis (artificial part) of metal or plastic. See page 617. Carpometacarpal arthroplasty is a treatment for arthritis in the thumb (at the basal joint).	
		arthrotomy	
		hemarthrosis	
		hydrarthrosis	
		Synovial fluid collects abnormally in the joint.	
		polyarthritis	
articul/o	joint	articular cartilage	
burs/o	bursa	bursitis	
		Causes of this periarticular condition may be related to stress placed on the bursa or to diseases such as gout or rheumatoid arthritis. The bursa becomes inflamed and movement is limited and painful. Intrabursal injection of corticosteroids and also rest and splinting of the limb are helpful in treatment.	
chondr/o	cartilage	achondroplasia	
		This is an inherited condition in which the bones of the arms and legs fail to grow to normal size because of a defect in cartilage and bone formation. Dwarfism results, with short limbs and a normal-sized head and trunk. See page 85.	
		chondroma	
		chondromalacia	
		***Chondromalacia patellae** is a softening and roughening of the articular cartilaginous surface of the kneecap, resulting in pain, a grating sensation, and mechanical "catching" behind the patella with joint movement.*	

Ankylosis/Alkalosis

Ankylosis is a condition of joint stiffening or immobilization. Don't confuse this term with *alkalosis,* meaning increased alkalinity (pH) of blood and tissues.

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
ligament/o	ligament	ligamentous	
rheumat/o	watery flow	rheumatologist	
		Various forms of arthritis are marked by collection of fluid in joint spaces.	
synov/o	synovial membrane	synovitis	
ten/o	tendon	tenorrhaphy	
		tenosynovitis	
		Synov/o here refers to the sheath (covering) around the tendon.	
tendin/o	tendon	tendinitis	
		Also spelled tendonitis.	

SUFFIXES

SUFFIX	MEANING	TERMINOLOGY	MEANING
-desis	to bind, tie together	arthrodesis	
		Bones are fused across the joint space by surgery (artificial ankylosis). This operation is performed when a joint is very painful, unstable, or chronically infected.	
-stenosis	narrowing	spinal stenosis	
		Narrowing of the neural (spinal) canal in the lumbar spine. Symptoms (pain, paresthesias, urinary retention, bowel incontinence) come from compression of the cauda equina (nerves that spread out from the lower end of the spinal cord like a horse's tail). See Figure 15-20.	

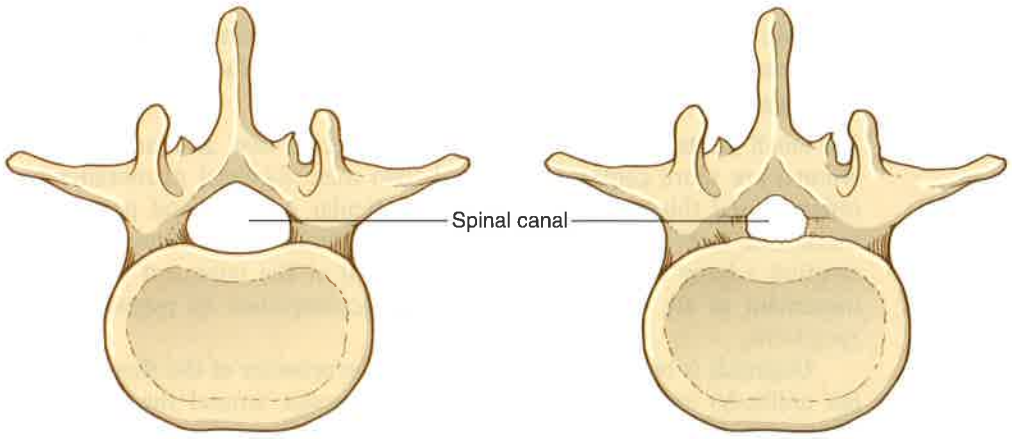

FIGURE 15–20 **Spinal stenosis.** Wear-and-tear effects of aging can lead to narrowing of the spinal canal.

PATHOLOGY—JOINTS

arthritis — **Inflammation of joints.**

Some of the more common forms are:

1. **ankylosing spondylitis** — **Chronic, progressive arthritis with stiffening of joints, primarily of the spine.**

   Bilateral sclerosis (hardening) of the sacroiliac joints is a diagnostic sign. Joint changes are similar to those seen in rheumatoid arthritis, and the condition can respond to corticosteroids and anti-inflammatory drugs.

2. **gouty arthritis (gout)** — **Inflammation and painful swelling of joints caused by excessive uric acid in the body.**

   A congenital defect in the metabolism of uric acid causes too much of it to accumulate in blood **(hyperuricemia),** joints, and soft tissues near joints. The "pointy" uric acid crystals (salts) destroy the articular cartilage and damage the synovial membrane, often resulting in excruciating pain. The joint chiefly affected is the big toe; hence, the condition often is called **podagra** (pod/o = foot, -agra = excessive pain). Treatment consists of drugs to lower uric acid production (allopurinol) and to prevent inflammation (colchicine and indomethacin) and a special diet that avoids foods that are rich in uric acid, such as red meats, red wines, and fermented cheeses.

3. **osteoarthritis (OA)** — **Progressive, degenerative joint disease with loss of articular cartilage and hypertrophy of bone (formation of osteophytes, or bone spurs) at articular surfaces.**

   This condition, also known as **degenerative joint disease,** occurs mainly in the hips and knees of older people and is marked by a narrowing of the joint space (due to loss of cartilage). Treatment consists of aspirin and nonsteroidal anti-inflammatory drugs (NSAIDs) to reduce inflammation and pain and physical therapy to loosen impaired joints. Figure 15-21 compares a normal joint and those with changes characteristic of osteoarthritis and rheumatoid arthritis.

   End-stage osteoarthritis is the most common reason for joint replacement surgery (total joint arthroplasty).

4. **rheumatoid arthritis (RA)** — **Chronic joint condition with inflammation and pain; caused by an autoimmune reaction against joint tissue, particularly the synovial membrane.**

   The small joints of the hands and feet are affected first, and larger joints later. Women are more commonly afflicted than men. Synovial membranes become inflamed and thickened, damaging the articular cartilage and preventing easy movement (see Figure 15-21). Sometimes fibrous tissue forms and calcifies, creating a **bony ankylosis** (pathologic union) at the joint and preventing any movement at all. Swollen, painful joints accompanied by **pyrexia** (fever) are symptoms.

   Diagnosis is by a blood test that shows the presence of the rheumatoid factor (an antibody) and x-ray images revealing changes around the affected joints. Treatment consists of heat applications and drugs such as aspirin and other NSAIDs and corticosteroids to reduce inflammation and pain. Disease-modifying antirheumatic drugs (DMARDs) such as methotrexate and gold salts also are used.

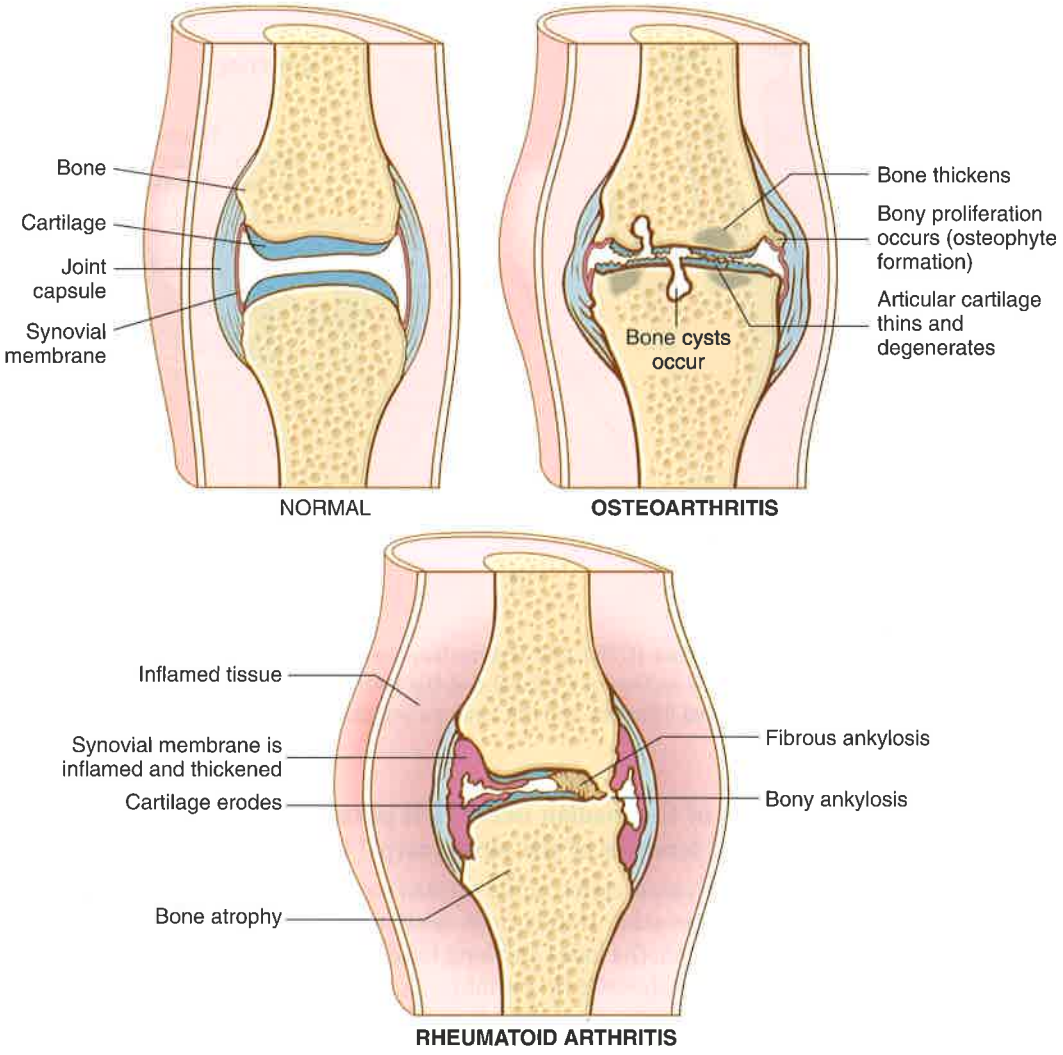

FIGURE 15–21 Changes in a joint with **osteoarthritis (OA)** and **rheumatoid arthritis (RA).**

bunion

Enlargement of bone or tissue around the joint at the base of the big toe (metatarsophalangeal joint).

Chronic irritation from ill-fitting shoes can cause a buildup of soft tissue and underlying bone. Bunionectomy (removal of a bony exostosis and associated soft tissue) is indicated if other measures (changing shoes and use of anti-inflammatory agents) fail. Another name for a bunion is **hallux** (great toe) **valgus** (abnormal angulation of the toe).

The photograph shows a **bunion** of the left foot. The first x-ray is before **bunionectomy,** and the second is after surgery to remove tissue and realign the bones. (Courtesy Dr. Sidra Ezrahi and Dr. Richard DeAsia, Massachusetts General Hospital, Boston.)

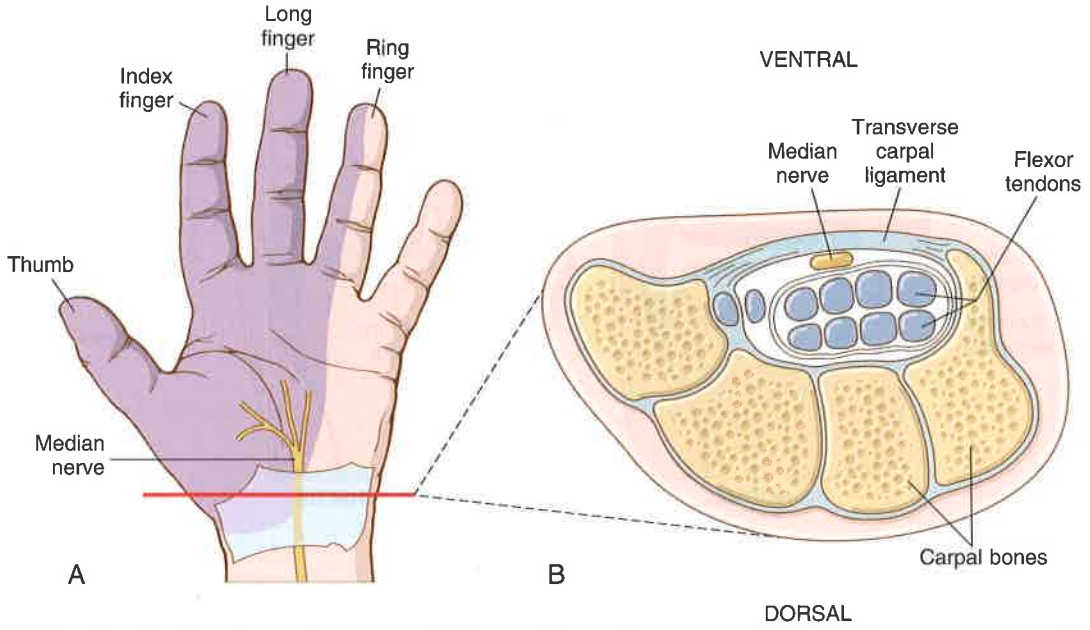

FIGURE 15–22 **Carpal tunnel syndrome (CTS). (A)** The median nerve's sensory distribution in the thumb, first three fingers, and palm. **(B)** Cross section of a left hand at the level indicated in **(A)**. Note the position of the median nerve between the carpal ligament and the tendons and carpal bones.

carpal tunnel syndrome (CTS)

Compression of the median nerve as it passes between the ligament and the bones and tendons of the wrist (carpal tunnel). See Figure 15-22.

CTS is caused by compression of the median nerve (see Figure 15-22) in the carpal tunnel. The compression results from swelling and/or inflammation of the flexor tendons. The thumb, the index and long (middle) fingers, and the radial half of the ring finger become dysesthetic (numb).

Treatment consists of splinting the wrist during sleep to immobilize it, use of anti-inflammatory medications, and injection of cortisone into the carpal tunnel. If these measures fail, surgical release of the transverse carpal ligament is usually curative.

dislocation

Displacement of a bone from its joint.

Dislocated bones do not articulate with each other. The most common cause of dislocations is trauma. **Shoulder dislocation** (disruption of articulation between the head of the humerus and the glenoid fossa of the scapula) and **hip dislocation** (disruption of articulation between the head of the femur and the acetabulum of the pelvis) are examples.

Treatment of dislocations involves **reduction,** which is restoration of the bones to their normal positions. A **subluxation** is a partial or incomplete dislocation.

ganglion

Fluid-filled cyst arising from joint capsules or tendons, typically in the hand.

Most common in the wrist, but can occur in the shoulder, knee, hip, or ankle.

herniation of an intervertebral disk (disc)

Abnormal protrusion of an intervertebral disk into the spinal canal or spinal nerves.

This condition is commonly referred to as a **slipped disk** (disc). Pain is experienced as the protruded disk or nucleus pulposus (Figure 15-23) presses on spinal nerves or on the spinal cord. Low back pain and **sciatica** (pain radiating down the leg) are symptoms when the disk protrudes in the lumbar spine. Neck pain and burning pain radiating down an arm are characteristic of a herniated disk in the cervical spine. Physical therapy and drugs for pain help in initial treatment. In patients with chronic or recurrent disk herniation, **laminectomy** (surgical removal of a portion of the vertebral arch) and open **diskectomy** (removal of all or part of the protruding disk) may be advised. **Spinal fusion** of the two vertebrae may be necessary as well. In endoscopic diskectomy the disk is removed by inserting a tube through the skin and aspirating the disk through the tube. **Chemonucleolysis** is injection of a disk-dissolving enzyme (such as chymopapain) into the center of a herniated disk in an effort to relieve pressure on the compressed nerve or spinal cord.

Lyme disease (Lyme arthritis)

Disorder marked by arthritis, myalgia, and malaise; cause is a bacterium carried by a tick.

It was first reported in Old Lyme, Connecticut, and is now found throughout the eastern coastal region of the United States. It is treated with antibiotics.

sprain

Trauma to a joint without rupture.

A **strain** is an injury involving the overstretching of muscle. Application of ice, elevation of the joint, and application of a gentle compressive wrap are immediate measures to relieve pain and minimize swelling caused by sprains.

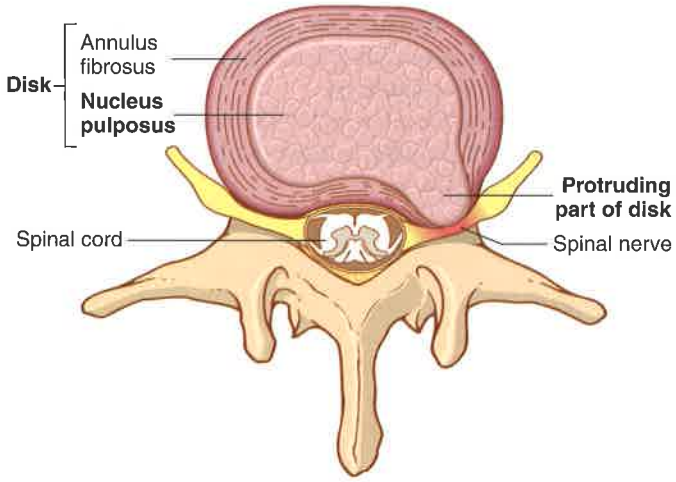

FIGURE 15–23 **Protrusion (herniation) of an intervertebral disk** (view from above the vertebra). The inner portion (nucleus pulposus) of the disk can be seen pressing on the spinal nerve. The condition is also known as **herniated nucleus pulposus (HNP).**

FIGURE 15–24 **Butterfly rash** that may accompany systemic lupus erythematosus. (From Lewis SM et al: Medical-Surgical Nursing: Assessment and Management of Clinical Problems, 7th ed., St. Louis, Mosby, 2007, p. 1718.)

systemic lupus erythematosus (SLE)

Chronic inflammatory autoimmune disease involving joints, skin, kidneys, nervous system (CNS), heart, and lungs.

This condition affects connective tissue (specifically a protein component called **collagen**) in tendons, ligaments, bones, and cartilage all over the body. Typically, there is a red, scaly rash over the nose and cheeks ("butterfly" rash) (Figure 15-24). Patients, usually women, experience joint pain in several joints (polyarthralgia), pyrexia (fever), kidney inflammation, and malaise. SLE is an autoimmune disease that is diagnosed by the presence of abnormal antibodies in the bloodstream and characteristic white blood cells called LE cells. Treatment involves giving corticosteroids, hormones made by the adrenal gland that are used to treat inflammatory conditions.

The name **lupus,** meaning wolf, has been used since the 13th century, because affected people were thought to have the look of a wolf due to the facial changes in long-standing disease.

MUSCLES

TYPES OF MUSCLES

There are three types of muscles in the body. Label Figure 15-25 as you read the following descriptions of the various types of muscles.

Striated muscle [1] makes up the **voluntary** or **skeletal muscles** that move all bones, as well as controlling facial expression and eye movements. Through the central and peripheral nervous systems, we have conscious control over these muscles. Striated muscle fibers (cells) have a pattern of dark and light bands, or fibrils, in their cytoplasm. Fibrous tissue that envelops and separates muscles is called **fascia,** which contains the muscle's blood, lymph, and nerve supply.

Smooth muscle [2] makes up the **involuntary** or **visceral muscles** that move internal organs such as the digestive tract, blood vessels, and secretory ducts leading from glands. These muscles are controlled by the autonomic nervous system. They are called smooth because they have no dark and light fibrils in their cytoplasm. Skeletal muscle fibers are arranged in bundles, whereas smooth muscle forms sheets of fibers as it wraps around tubes and vessels.

Cardiac muscle [3] is striated in appearance but is like smooth muscle in its action. Its movement cannot be consciously controlled. The fibers of cardiac muscle are branching fibers and are found in the heart.

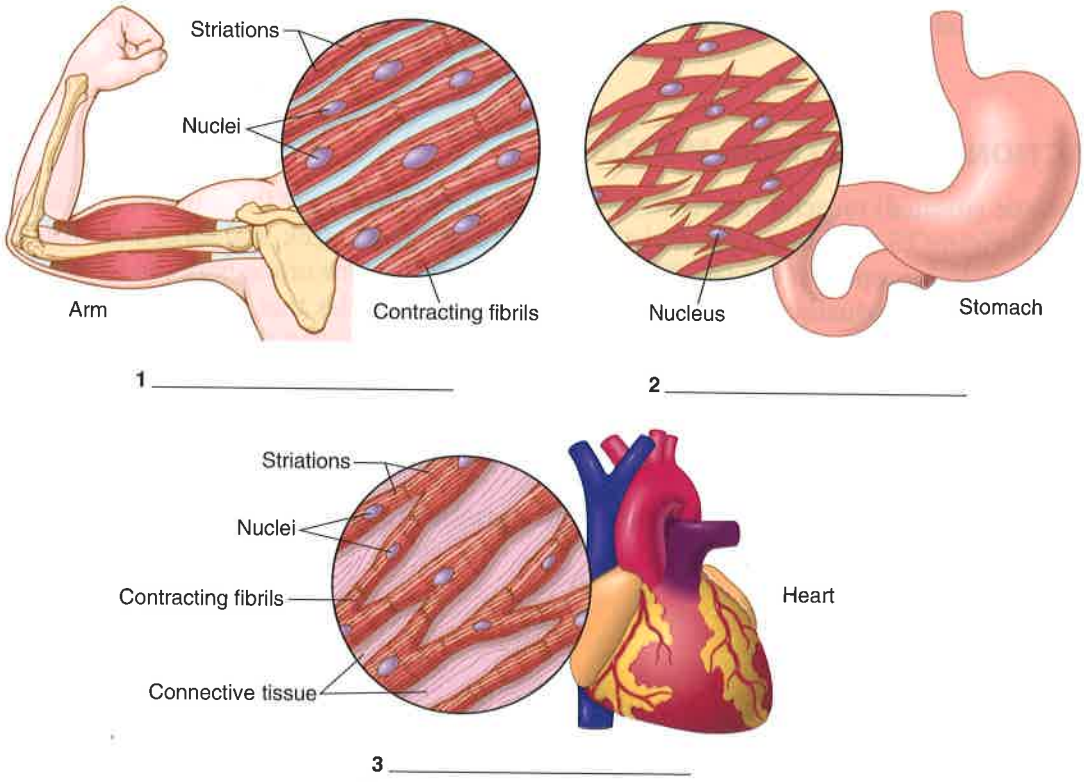

FIGURE 15–25 **Types of muscles.**

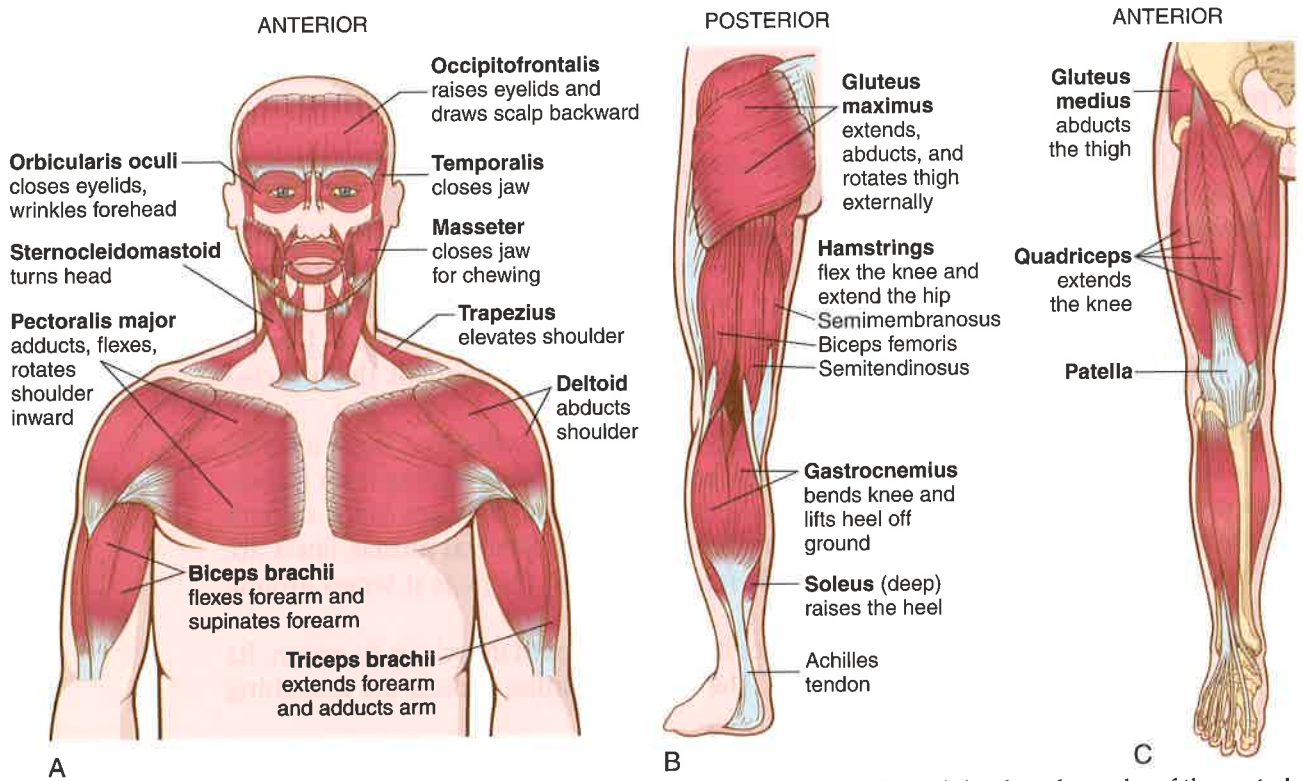

FIGURE 15–26 **(A)** Selected muscles of the **head, neck, torso, and arm** and their functions. **(B)** Selected muscles of the **posterior and anterior aspect of the left leg** and their functions. The accompanying CD contains additional anterior and posterior images of major muscles and their functions.

ACTIONS OF SKELETAL MUSCLES

Skeletal (striated) muscles (more than 600 in the human body) are the muscles that move bones. Figure 15-26 shows some skeletal muscles of the head, neck, and torso and muscles of the posterior aspect of the leg. When a muscle contracts, one of the bones to which it is joined remains virtually stationary as a result of other muscles that hold it in place. The point of attachment of the muscle to the stationary bone is called the **origin (beginning)** of that muscle. When the muscle contracts, however, another bone to which it is attached does move. The point of junction of the muscle to the bone that moves is called the **insertion** of the muscle. Most often, the origin of a muscle lies proximal in the skeleton, whereas its insertion lies distal.

Figure 15-27 shows the biceps and triceps muscles in the upper arm. One origin of the

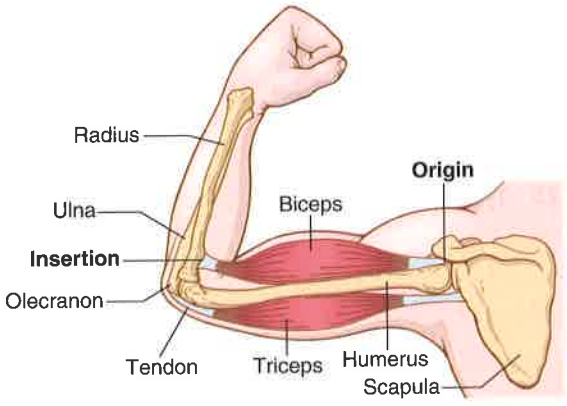

FIGURE 15–27 **Origin and insertion of the biceps in the arm.** Note also the origin of the triceps at the scapula and the insertion at the olecranon of the ulna.

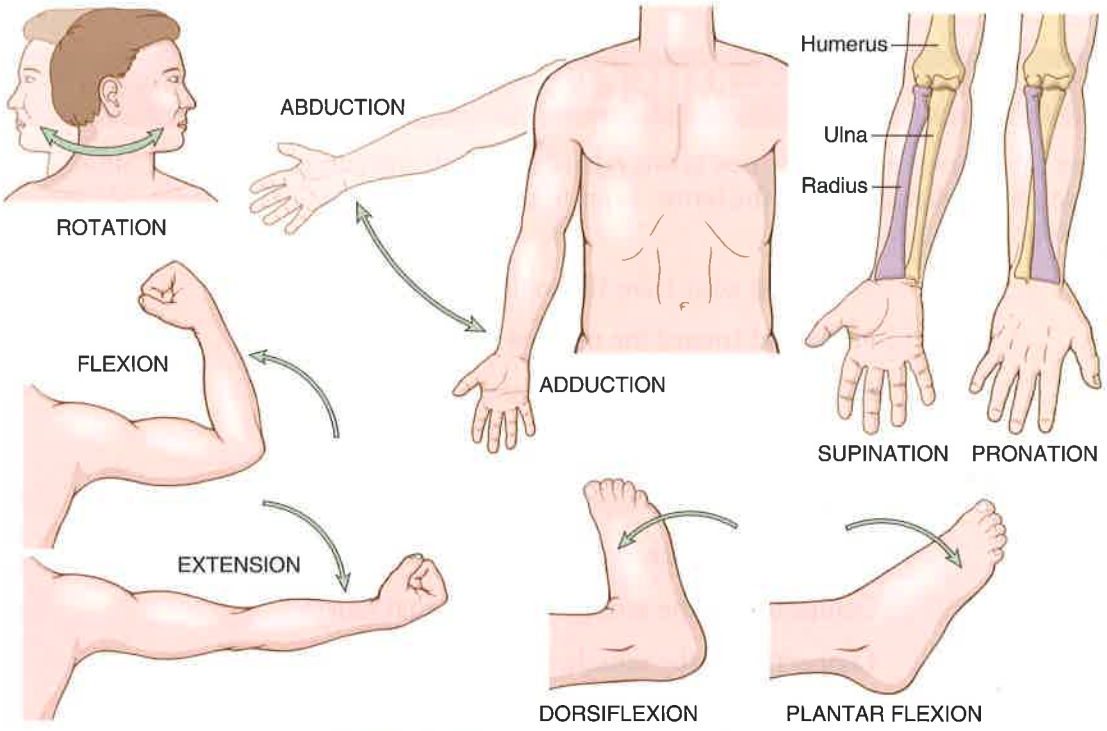

FIGURE 15–28 **Types of muscular actions.**

biceps is at the scapula, and its insertion is at the radius. Tendons are the connective tissue bands that connect muscles to the bones.

Muscles can perform a variety of actions. Some of the terms used to describe those actions are listed here, with a short description of the specific type of movement performed (Figure 15-28).

ACTION	MEANING
flexion	Decreasing the angle between two bones; bending a limb.
extension	Increasing the angle between two bones; straightening out a limb.
abduction	Movement away from the midline of the body.
adduction	Movement toward the midline of the body.
rotation	Circular movement around an axis (central point). Internal rotation is toward the midline and external rotation is away from the midline.
dorsiflexion	Decreasing the angle of the ankle joint so that the foot bends backward (upward). This is the opposite movement of stepping on the gas pedal when driving a car.
plantar flexion	Motion that extends the foot downward toward the ground as when pointing the toes or stepping on the gas pedal. Plant/o means sole of the foot.
supination	As applied to the hand and forearm, the act of turning the palm up. As applied to the foot, it is outward roll of the foot during normal motion.
pronation	As applied to the hand and forearm, the act of turning the palm down. As applied to the foot, it is inward roll of the foot during normal motion.

VOCABULARY—MUSCLES

This list reviews many of the new terms related to muscle introduced in the text. Short definitions reinforce your understanding of the terms. Refer to the Pronunciation of Terms on p. 643 for help with unfamiliar or difficult terms.

abduction	Movement away from the midline of the body.
adduction	Movement toward the midline of the body.
dorsiflexion	Backward (upward) bending of the foot.
extension	Straightening of a flexed limb.
fascia	Fibrous membrane separating and enveloping muscles.
flexion	Bending a limb; decreasing the angle between bones.
insertion of a muscle	Connection of the muscle to a bone that moves.
origin of a muscle	Connection of the muscle to a stationary bone.
plantar flexion	Bending the sole of the foot downward toward the ground.
pronation	Turning the palm downward.
rotation	Circular movement around a central point.
skeletal muscle	Muscle connected to bones; voluntary or striated muscle.
smooth muscle	Visceral muscle.
striated muscle	Skeletal muscle.
supination	Turning the palm upward.
visceral muscle	Muscle connected to internal organs; involuntary or smooth muscle.

TERMINOLOGY—MUSCLES

Write the meanings of the medical terms in the spaces provided.

COMBINING FORMS

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
fasci/o	fascia (forms sheaths enveloping muscles)	fasciectomy _____	
fibr/o	fibrous connective tissue	fibromyalgia _____	*Chronic pain and stiffness in muscles, joints, and fibrous tissue, especially of the back, shoulders, neck, hips, and knees. Fatigue is a common complaint.*

COMBINING FORM	MEANING	TERMINOLOGY	MEANING
leiomy/o	smooth (visceral) muscle that lines the walls of internal organs	leiomyoma	
		leiomyosarcoma	
my/o	muscle	myalgia	
		electromyography	
		myopathy	
myocardi/o	heart muscle	myocardial	
myos/o	muscle	myositis	
plant/o	sole of the foot	plantar flexion	
rhabdomy/o	skeletal (striated) muscle connected to bones	rhabdomyoma	
		rhabdomyosarcoma	
sarc/o	muscle and flesh	sarcopenia	
		Loss of muscle mass and strength associated with aging. Exercise and strength training can help preserve and enhance muscle mass at any age.	

SUFFIXES

SUFFIX	MEANING	TERMINOLOGY	MEANING
-asthenia	lack of strength	myasthenia gravis	
		Muscles lose strength because of a failure in transmission of the nervous impulse from the nerve to the muscle cell.	
-trophy	development, nourishment	atrophy	
		Decrease in size of an organ or tissue.	
		hypertrophy	
		Increase in size of an organ or tissue.	
		amyotrophic	
		*In **amyotrophic lateral sclerosis** (Lou Gehrig disease), muscles are affected (paralysis occurs) by degeneration of nerves in the spinal cord and lower region of the brain.*	

PREFIXES

PREFIX	MEANING	TERMINOLOGY	MEANING
ab-	away from	abduction	
		Duct/o means to lead.	
ad-	toward	adduction	
dorsi-	back	dorsiflexion	
poly-	many, much	polymyalgia	
		***Polymyalgia rheumatica** is a syndrome marked by aching and morning stiffness in the shoulder, hip, or neck for longer than 1 month.*	

PATHOLOGY—MUSCLES

muscular dystrophy

Group of inherited diseases characterized by progressive weakness and degeneration of muscle fibers without involvement of the nervous system.

Duchenne muscular dystrophy is the most common form. Muscles appear to enlarge **(pseudohypertrophy)** as fat replaces functional muscle cells that have degenerated and atrophied. Onset of muscle weakness occurs soon after birth, and diagnosis can be made by muscle biopsy and electromyography. The disease predominantly affects males; muscle weakness produces stumbling, falling, lordosis, winged (prominent) scapulae, and cardiac problems.

polymyositis

Chronic inflammatory myopathy.

This condition is marked by symmetrical muscle weakness and pain, often accompanied by a rash around the eyes and on the face and limbs. Evidence that polymyositis is an autoimmune disorder is growing stronger, and some patients recover completely with immunosuppressive therapy.

LABORATORY TESTS AND CLINICAL PROCEDURES

LABORATORY TESTS

antinuclear antibody test (ANA)

Detects an antibody present in serum of patients with systemic lupus erythematosus (SLE).

erythrocyte sedimentation rate (ESR)

Measures time it takes for erythrocytes to settle to the bottom of a test tube.

Elevated ESR is associated with inflammatory disorders such as rheumatoid arthritis, tumors, and infections, and with chronic infections of bone and soft tissue.

rheumatoid factor test (RF)

Serum is tested for the presence of an antibody found in patients with rheumatoid arthritis.

serum calcium (Ca)

Measurement of calcium level in serum.

Hypercalcemia may be caused by disorders of the parathyroid gland and malignancy that affects bone metabolism. Hypocalcemia is seen in critically ill patients with burns, sepsis, and acute renal failure.

serum creatine kinase (CK)

Measurement of the enzyme creatine kinase in serum.

This enzyme normally is present in skeletal and cardiac muscle. Increased levels occur in muscular dystrophy, polymyositis, and traumatic injuries.

uric acid test

Measurement of uric acid in serum.

High levels are associated with gouty arthritis.

CLINICAL PROCEDURES

arthrocentesis

Surgical puncture to remove fluid from the joint space.

Synovial fluid is removed for analysis.

arthrography

Taking x-ray images after injection of contrast material into a joint.

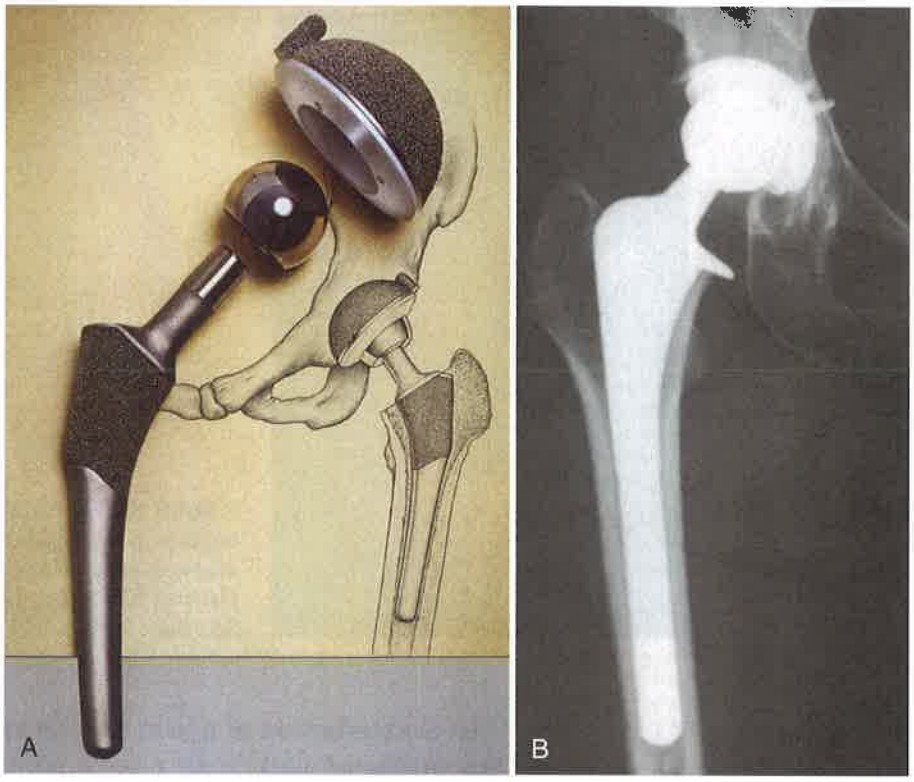

FIGURE 15–29 **(A) Acetabular and femoral components of a total hip arthroplasty. (B)** Radiograph showing a hip after a **Charnley total hip arthroplasty.** (**A,** From Jebson LR, Coons DD: Total hip arthroplasty, Surg Technol October 1998; **B,** from Mercier LR: Practical Orthopedics, 5th ed., St. Louis, Mosby, 2000, p. 237.)

arthroplasty

Surgical repair or replacement of a joint.

Total hip arthroplasty or **total hip replacement (THR)** is replacement of the femoral head and acetabulum with prostheses that are fastened into the bone (Figure 15-29).

In a **total knee replacement (TKR)** a metal prosthesis covers the end of the femur, and a tibial component made of metal and plastic covers the tip end of the tibia (Figure 15-30).

Other examples of arthroplasties are **resection arthroplasty** (small portion of a bone is removed to repair the joint; acromioclavicular joint is a common location), **interposition arthroplasty** (new tissue taken from another place is placed between damaged surface of elbow joint), and **revision arthroplasty** (second operation to replace a failing joint, such as the hip).

FIGURE 15–30 **Knee replacement prosthesis.** (From Black JM, Hawks JH: Medical-Surgical Nursing, 7th ed., Philadelphia, Saunders, 2005.)

FIGURE 15–31 Knee arthroscopy in progress. Notice the monitor in the background. An arthroscope is used in the diagnosis of pathologic changes. (From Miller MD, Howard RF, Plancher KD: Surgical Atlas of Sports Medicine, Philadelphia, Saunders, 2003, p. 53.)

arthroscopy

Visual examination of a joint with an arthroscope and television camera.

An orthopedist passes small surgical instruments into a joint (knee, shoulder, ankle, wrist, hip) to evaluate and/or remove and repair damaged tissue (Figure 15-31).

bone density test (bone densitometry)

Low-energy x-ray absorption in bones of the spinal column, pelvis, and wrist is used to measure bone mass.

An x-ray detector measures how well x-rays penetrate through bones (Figure 15-32). Areas of decreased density indicate osteopenia and osteoporosis. Also called **dual-energy x-ray absorptiometry (DEXA *or* DXA).**

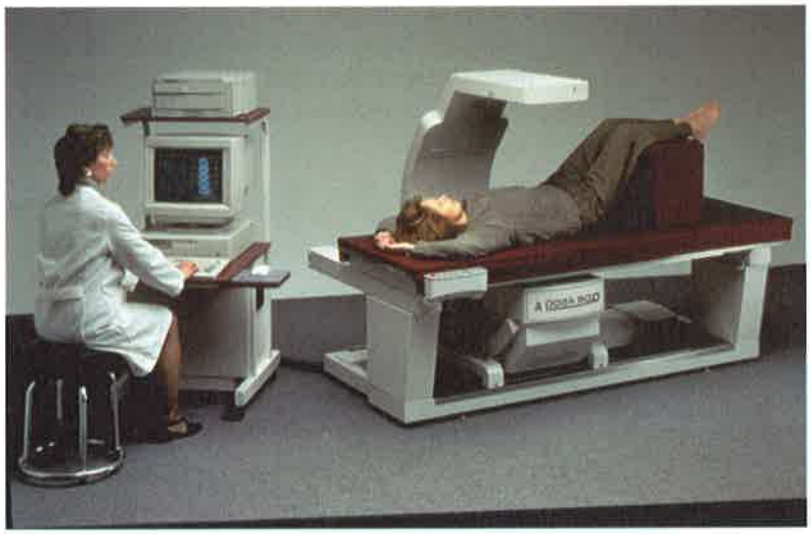

FIGURE 15–32 Patient undergoing **bone density test** or **dual energy x-ray absorptiometry** (DEXA or DXA). (From Greer I et al: Mosby's Color Atlas and Text of Obstetrics and Gynecology, London, Mosby, 2001.)

bone scan

Uptake of a radioactive substance is measured in bone.

A nuclear medicine physician uses a special scanning device to detect areas of increased uptake (tumors, infection, inflammation, stress fractures) (Figure 15-33).

computed tomography (CT)

X-ray beam and computer provide cross-sectional and other images.

CT scans identify soft tissue abnormalities, bone abnormalities, and musculoskeletal trauma.

diskography

X-ray examination of cervical or lumbar intervertebral disk after injection of contrast into nucleus pulposus (interior of the disk).

electromyography (EMG)

Recording the strength of muscle contraction as a result of electrical stimulation.

magnetic resonance imaging (MRI)

A magnetic field creates images of soft tissue.

muscle biopsy

Removal of muscle tissue for microscopic examination.

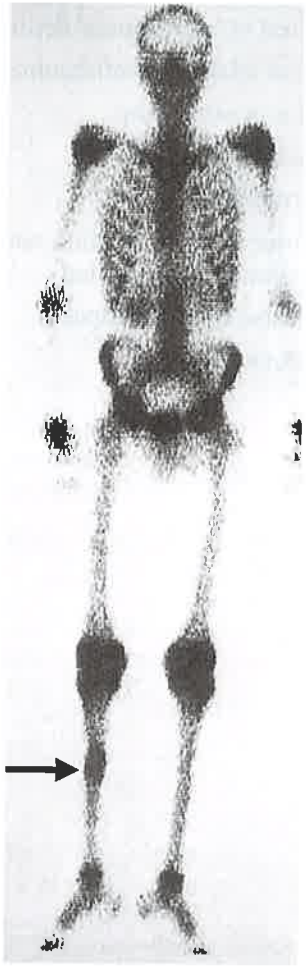

FIGURE 15–33 A technetium-99m bone scan of a skeleton showing an area of increased radioactive uptake on the right tibia *(arrow)* that indicates a bone tumor. (From Walter JB: An Introduction to the Principles of Disease, 3rd ed., Philadelphia, Saunders, 1992.)

ABBREVIATIONS

AC	acromioclavicular (joint)
ACL	anterior cruciate ligament of the knee
ANA	antinuclear antibody—indicator of systemic lupus erythematosus
BKA	below-knee amputation
BMD	bone mineral density
C1 to C7	cervical vertebrae
Ca	calcium
CK	creatine kinase—enzyme elevated in muscle disease
CMC	carpometacarpal (joint)
CTS	carpal tunnel syndrome
DEXA *or* DXA	dual-energy x-ray absorptiometry—a test of bone mineral density
DMARD	disease-modifying antirheumatic drug
DO	doctor of osteopathy
DTRs	deep tendon reflexes
EMG	electromyography
ESR (sed rate)	erythrocyte sedimentation rate—indicates inflammation
HNP	herniated nucleus pulposus
IM	intramuscular
L1 to L5	lumbar vertebrae
NSAID	nonsteroidal anti-inflammatory drug—often prescribed to treat musculoskeletal disorders
OA	osteoarthritis
ORIF	open reduction (of fracture)/internal fixation
ortho	orthopedics (*or* orthopaedics)
OT	occupational therapy—helps patients perform activities of daily living and function in work-related situations
P	phosphorus
PT	physical therapy—helps patients regain use of muscles and joints after injury or surgery
RA	rheumatoid arthritis
RF	rheumatoid factor
ROM	range of motion
SLE	systemic lupus erythematosus
T1 to T12	thoracic vertebrae
TKR	total knee replacement/arthroplasty
THR	total hip replacement/arthroplasty
TMJ	temporomandibular joint

PRACTICAL APPLICATIONS

This section contains an x-ray report, an orthopedic operating room schedule, a case report with findings presented in SOAP format, and a short clinical case. Explanations of more difficult or unfamiliar terms are given in brackets.

Answers to the matching questions are found on page 638.

MEDICAL REPORT: RESULTS OF CHEST X-RAY EXAMINATION

PA [posteroanterior] and lateral chest: The heart is enlarged in its transverse diameter. The lungs are fully expanded and free of active disease.

Thoracic spine shows a scoliosis of the upper thoracic spine convex to the left. There is 50% wedge compression fracture of T6 and slight wedge compression fracture of T5. There is also anterior wedge compression fracture of T12.

Lumbar spine shows 90% compression fractures of L1 and L3 with 30% compression fractures of L2 and L5. All bones are markedly osteoporotic. There is calcification within the aortic arch. There are gallstones in the right upper quadrant. The findings in the spine are most compatible with osteoporotic compression fractures. During the procedure, the patient had a sickable [syncopal—this word was incorrectly transcribed!] episode and fell, striking her head. A skull series, done at no cost to the patient, shows no evidence of bony fracture. The pineal gland is calcified and has a midline location. The sella turcica is normal.

OPERATING ROOM SCHEDULE

Match the operation in Column I with an accompanying diagnosis or indication for surgery from Column II.

COLUMN I

1. Excision, osteochondroma, R calcaneus ____
2. TMJ arthroscopy with probable arthrotomy ____
3. L4–5 laminectomy and diskectomy ____
4. Arthroscopy, left knee ____
5. Open reduction, malleolar fracture ____
6. R occipital craniotomy with tumor resection ____
7. Excision, distal end right clavicle, with prob. acromioplasty ____
8. Acetabuloplasty with open reduction hip ____

COLUMN II

A. Fracture of the ankle
B. ACL rupture
C. Neoplastic lesion in brain
D. Exostosis on heel bone
E. Pelvic fracture
F. Pain and malocclusion of jawbones
G. Lower back pain radiating down one leg
H. Pain in shoulder joint with bone spur (exostosis) evident on x-ray

CASE REPORT—SOAP FORMAT: ACL INJURY

(Note: **SOAP** stands for **S**ubjective, **O**bjective, **A**ssessment, and **P**lan.)
S: Patient reports that she fell and twisted her right knee while skiing last month. She notes that she felt a "pop" and experienced immediate pain and swelling of the knee. X-ray was negative for fracture, but an MRI revealed a torn ACL [anterior cruciate ligament]. Patient underwent an ACL reconstruction using a patellar tendon autograft 1 week ago. Pain is 3/10 at rest and 6/10 during weight-bearing. Her goals are to decrease pain, walk normally, and return to prior level of functioning, including skiing and soccer.

O: *Gait:* Ambulates with Bledsoe [hinged] brace and bilateral axillary crutches.

	Left	Right
Range of Motion:		
Extension	0°	0°
Flexion	140°	90°
Strength:		
Quadriceps	5/5	3+/5
Hamstrings	5/5	4−/5
Gluteus medius	5/5	4−/5
Gluteus maximus	5/5	4−/5
Gastroc/soleus	5/5	4−/5
Girth (mid-patella):	15″	16″

A: Patient is a 20-year-old female presenting with signs and symptoms consistent with status post-ACL reconstruction. Impairments include gait disturbance, decreased range of motion, decreased strength, edema, pain, and decreased functional activities.

P: Treatment will include manual therapy, therapeutic exercise modalities, patient education, and gait training.

SHORT CLINICAL CASE: OA OF THE KNEE

A 65-year-old woman has been suffering from right knee joint stiffness, aching pain, and limited movement that is worse when she rises in the morning or after inactivity. She has been taking acetaminophen (Tylenol) and other NSAIDs (Motrin or Advil) to cope with the pain.

An x-ray of her knees (see Figure 15-34A) shows deterioration of articular cartilage in the right knee with narrowing of the joint space. See left knee for comparison. Surgery is recommended for TKR and performed (see Figure 15-34B and C). Follow-up x-ray (Figure 15-34D) shows the prosthesis in place. After a successful healing of the incision and removal of surgical clips, the patient had several months of PT and is walking normally without pain.