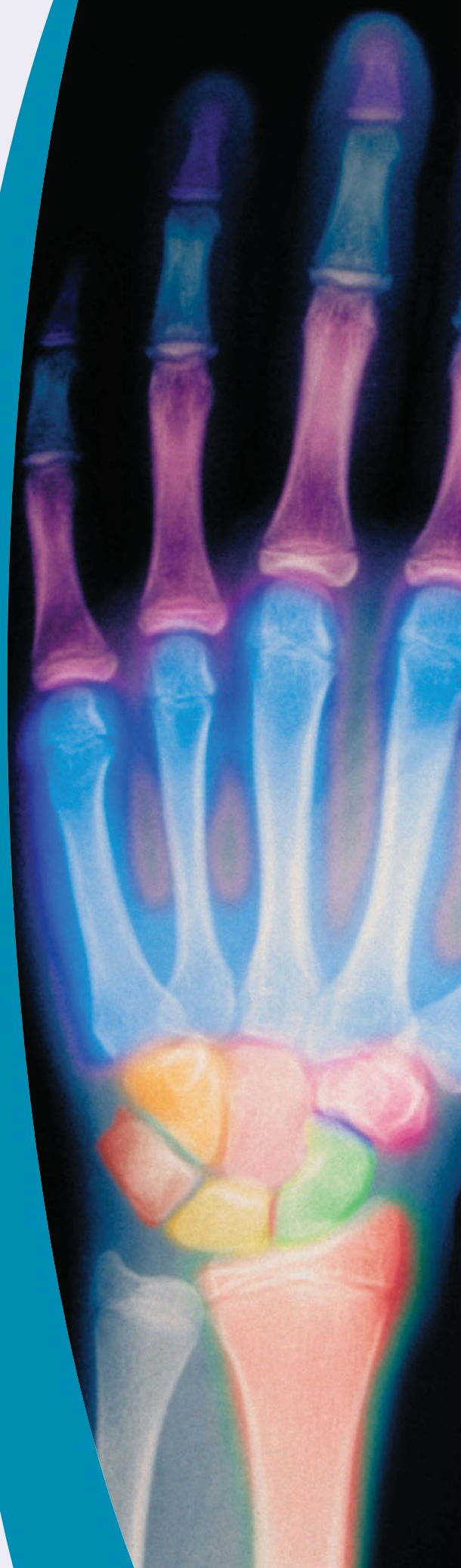
8 Bones, Part 2: The Appendicular Skeleton



Hand of a 12 year old (colored X ray).

Limb bones and their girdles are appended, or attached, to the axial skeleton. Thus, they are collectively called the **appendicular skeleton** (see Figure 7.1, p. 148). The pectoral girdles (pek′tor-al; "chest") attach the upper limbs to the trunk, whereas the pelvic girdle secures the lower limbs. Although the bones of the upper and lower limbs differ in their functions, they share the same basic structural plan. That is, each limb is composed of three basic segments: the hand, forearm, and arm in the upper limb; and the foot, leg, and thigh in the lower limb.

The appendicular skeleton enables people to carry out the wide variety of movements typical of their active, mobile, and object-manipulating lifestyle. Each time you take a step, throw a ball, write with a pencil, or even drive a car, you use your appendicular skeleton.

The bones of the appendicular skeleton are illustrated and described in detail in this chapter. We begin with the pectoral girdle and upper limb.

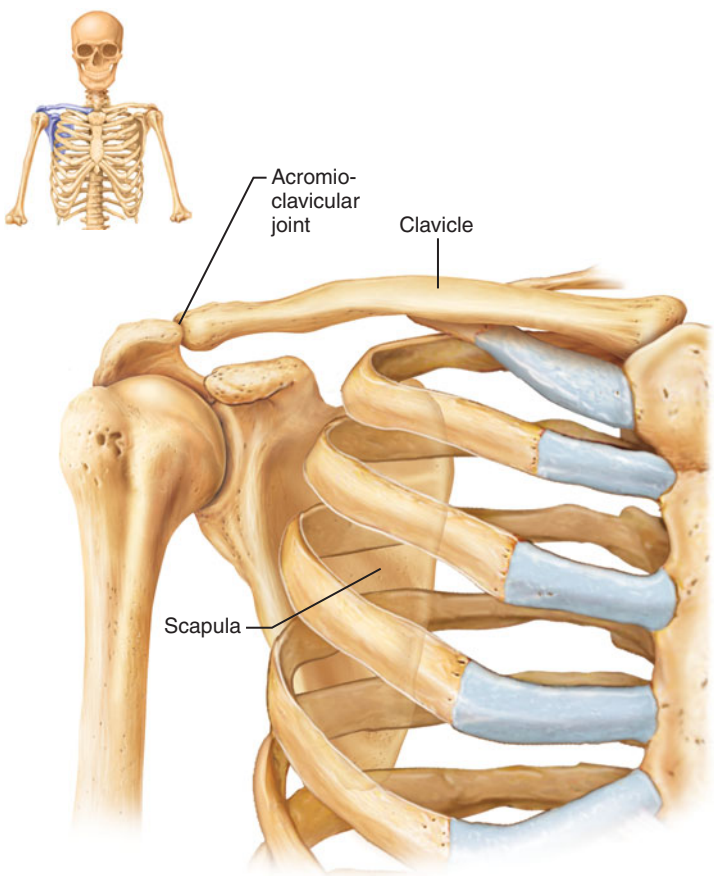
THE PECTORAL GIRDLE

- Identify the bones that form the pectoral girdle, and explain their functions.
- Identify the important bone features on the pectoral girdle.

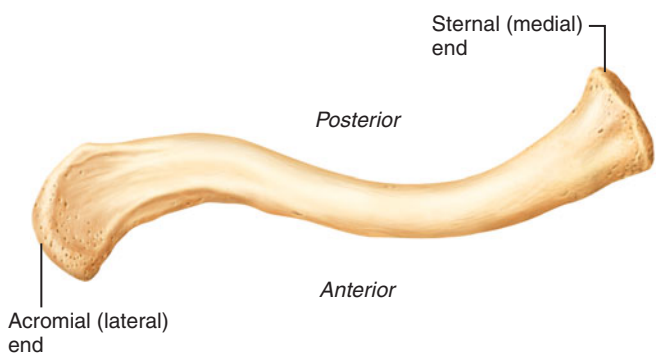
The **pectoral girdle,** or *shoulder girdle,* consists of a *clavicle* (klav′ĭ-kl) anteriorly and a *scapula* (skap′u-lah) posteriorly **(Figure 8.1)**. The paired pectoral girdles and their associated muscles form the shoulders. The term *girdle* implies a belt completely circling the body, but these girdles do not quite satisfy this description: Anteriorly, the medial end of each clavicle joins to the sternum and first rib, and the lateral ends of the clavicles join to the scapulae at the shoulder. However, the two scapulae fail to complete the ring posteriorly, because their medial borders do not join to each other or the axial skeleton.

Besides attaching the upper limb to the trunk, the pectoral girdle provides attachment for many muscles that move the limb. This girdle is light and allows the upper limbs to be quite mobile. This mobility springs from two factors:

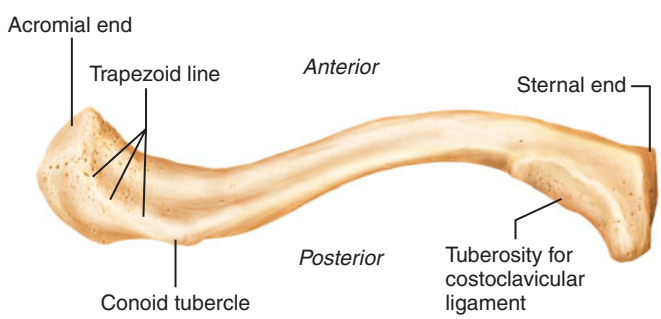
1. Because only the clavicle attaches to the axial skeleton, the scapula can move quite freely across the thorax, allowing the arm to move with it.



(a) Articulated pectoral girdle



(b) Right clavicle, superior view



(c) Right clavicle, inferior view

FIGURE 8.1 The pectoral girdle and clavicle. (See *A Brief Atlas of the Human Body,* Second Edition, Figure 24.)

2. The socket of the shoulder joint—the scapula's glenoid cavity—is shallow, so it does not restrict the movement of the humerus (arm bone). Although this arrangement is good for flexibility, it is bad for stability: Shoulder dislocations are fairly common.

Clavicles

The **clavicles** ("little keys"), or collarbones, are slender, S-shaped bones that extend horizontally across the superior thorax on the anterior surface (Figure 8.1a). The cone-shaped **sternal end** attaches to the manubrium medially, and the flattened **acromial** (ah-kro′me-al) **end** articulates with the scapula laterally (Figure 8.1b and c). The medial two-thirds of the clavicle is convex anteriorly; you can feel this anterior projection on yourself when you palpate the clavicle. The lateral third is concave anteriorly. The superior surface is almost smooth, but the inferior surface is ridged and grooved for the ligaments and muscles that attach to it, many of which act to bind the clavicle to the rib cage and scapula. For example, as shown in Figure 8.1c, the thick **trapezoid line** and the **conoid tubercle** near the acromial end provide attachment for a ligament that runs to the scapula's coracoid process (defined below), and a roughened tuberosity near the sternal end indicates the attachment of the costoclavicular ligament, a ligament that connects the clavicle to the first rib.

The clavicles perform several functions. Besides providing attachment for muscles, they act as braces; that is, they hold the scapulae and arms out laterally from the thorax. This function becomes obvious when a clavicle is fractured: The entire shoulder region collapses medially. The clavicles also transmit compression forces from the upper limbs to the axial skeleton, as when someone puts both arms forward and pushes a car to a gas station.

FRACTURES OF THE CLAVICLE The clavicles are not very strong, and they often fracture. This can occur when a person falls on the lateral border of a shoulder, is hit directly on the clavicle in a contact sport, or uses outstretched arms to break a fall. A fractured clavicle is also a common injury in automobile accidents in which the occupants are wearing seat belts. The curves in the clavicle ensure that it usually fractures anteriorly (outward) at its middle third. If it were to fracture posteriorly (inward), bone splinters would pierce the main blood vessels to the arm, the subclavian vessels, which lie just deep to the clavicle.

Scapulae

The **scapulae,** or shoulder blades, are thin, triangular flat bones **(Figure 8.2)** located on the dorsal surface of the rib cage, between rib 2 superiorly and rib 7 inferiorly. Each scapula has three borders. The **superior border** is the shortest and sharpest. The **medial border,** or *vertebral border,* parallels the vertebral column. The thick **lateral border,** or *axillary border,* abuts the axilla (armpit) and ends superiorly in a shallow fossa, the **glenoid cavity** (gle′noid; "pit-shaped") (Figure 8.2c). This cavity articulates with the humerus, forming the shoulder joint.

Like all triangles, the scapula has three corners, or *angles.* The glenoid cavity lies at the scapula's **lateral angle.** The **superior angle** is where the superior and medial borders meet, and the **inferior angle** is at the junction of the medial and lateral borders. The inferior angle moves as the arm is raised and lowered, and it is an important landmark for studying scapular movements.

The anterior, or costal, surface of the scapula is slightly concave and relatively featureless. The **coracoid** (kor′ah-coid) **process** projects anteriorly from the lateral part of the superior scapular border. The root *corac* means "like a crow's beak," but this process looks more like a bent finger. It is an attachment point for the biceps muscle of the arm. Strong ligaments also bind the coracoid process to the clavicle. Just medial to the coracoid process lies the **suprascapular notch** (passageway for the suprascapular nerve), and just lateral to it lies the glenoid cavity.

The posterior surface bears a prominent **spine** that is easily felt through the skin. The spine ends laterally in a flat projection, the **acromion** (ah-kro′me-on; "apex of shoulder"), which articulates with the acromial end of the clavicle.

Several large fossae occur on both surfaces of the scapula and are named according to location. The **infraspinous** ("below the spine") and **supraspinous** ("above the spine") **fossae** lie inferior and superior to the scapular spine, respectively (Figure 8.2b). The **subscapular** ("under the scapula") **fossa** is the shallow concavity formed by the entire anterior surface of the scapula (Figure 8.2a). Lying within these fossae are muscles with similar names, *infraspinatus, supraspinatus,* and *subscapularis.*

check your understanding

1. Which part of the scapula articulates with the clavicle?
2. How is the pectoral girdle attached to the axial skeleton?
3. Name the three fossae of the scapula, and describe their location.

For answers, see Appendix B.

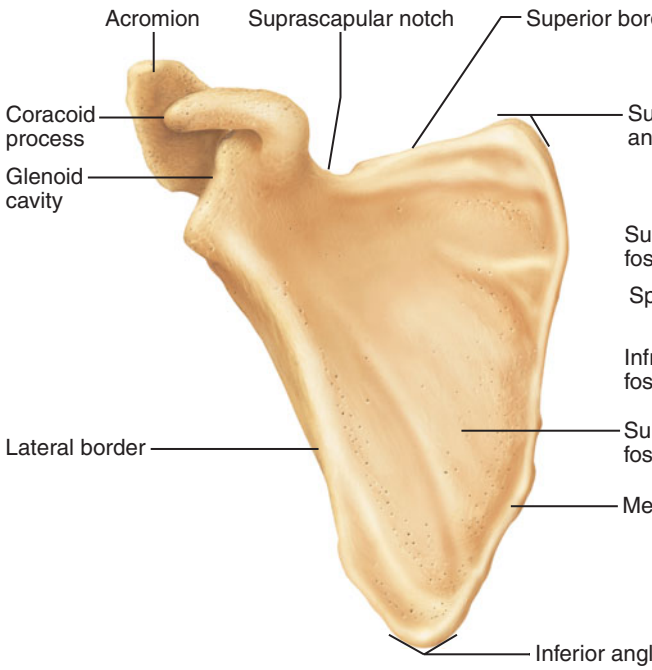
THE UPPER LIMB

➤ Identify the bones of the upper limb and their important features, and describe how they articulate with each other.

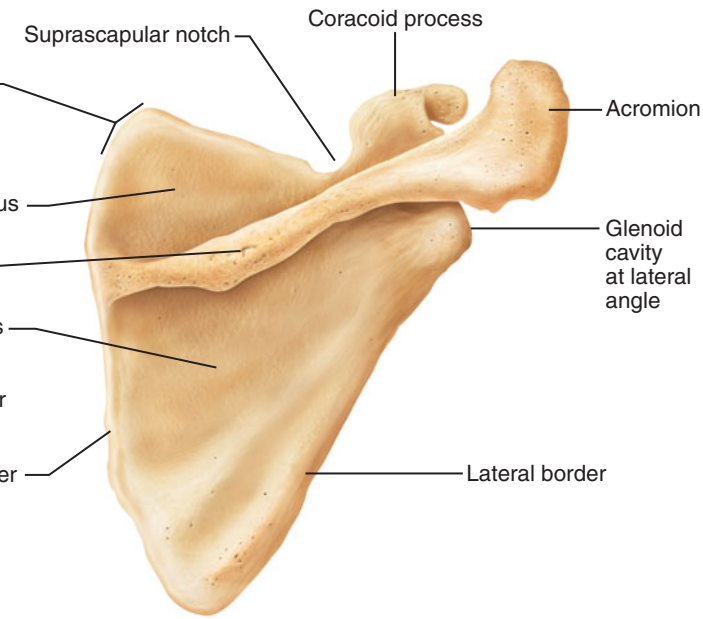
Thirty bones form the skeleton of the upper limb (see Figures 8.3 to 8.6). They are grouped into bones of the arm, forearm, and hand (**Table 8.1**, p. 186).

Arm

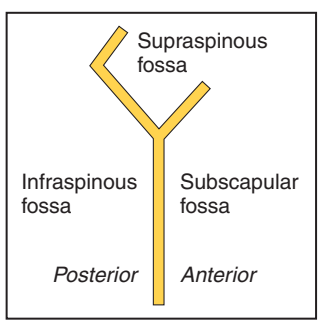
Anatomists use the term *arm* or *brachium* (bra′ke-um) to designate the part of the upper limb between the shoulder and

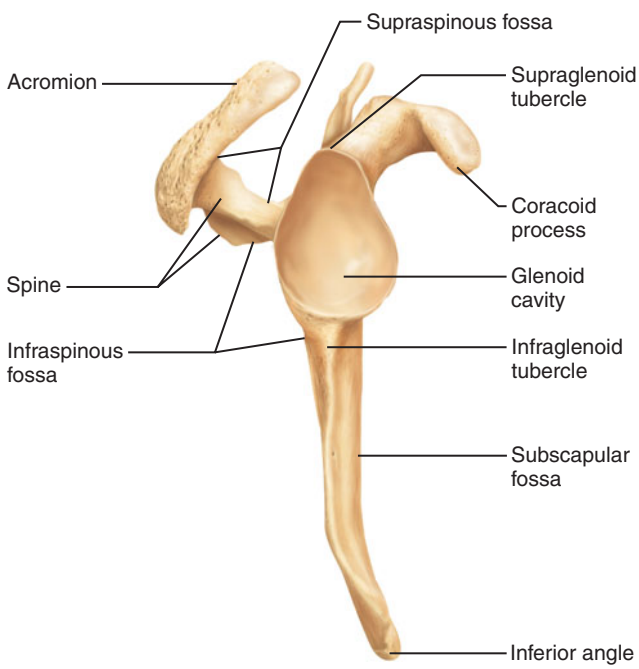


(a) Right scapula, anterior aspect



(b) Right scapula, posterior aspect





(c) Right scapula, lateral aspect

FIGURE 8.2 The scapula. (See *A Brief Atlas of the Human Body,* Second Edition, Figure 24.)

TABLE 8.1 Bones of the Upper Limb

Body Region	Bones*	Illustration	Location	Markings
PECTORAL GIRDLE (Figures 8.1, 8.2)	**Clavicle** (2)		Clavicle is in superoanterior thorax; articulates medially with sternum and laterally with scapula	Acromial end; sternal end; conoid tubercle
	Scapula (2)		Scapula is in posterior thorax; forms part of the shoulder; articulates with humerus and clavicle	Glenoid cavity; spine; acromion; coracoid process; infraspinous, supraspinous, and subscapular fossae
UPPER LIMB Arm (Figure 8.3)	**Humerus** (2)		Humerus is sole bone of arm; between scapula and elbow	Head; greater and lesser tubercles; intertubercular sulcus; radial groove; deltoid tuberosity; trochlea; capitulum; coronoid and olecranon fossae; medial and lateral epicondyles
Forearm (Figure 8.4)	**Ulna** (2)		Ulna is medial bone of forearm between elbow and wrist; forms elbow joint	Coronoid process; olecranon process; radial notch; trochlear notch; styloid process; head
	Radius (2)		Radius is lateral bone of forearm; articulates with proximal carpals to form part of the wrist joint	Head; radial tuberosity; styloid process; ulnar notch
Hand (Figure 8.6)	8 **Carpals** (16) Scaphoid Lunate Triquetrum Pisiform Trapezium Trapezoid Capitate Hamate		Carpals form a bony crescent at the wrist; arranged in two rows of four bones each	
	5 **Metacarpals** (10)		Metacarpals form the palm; one in line with each digit	
	14 **Phalanges** (28) Proximal Middle Distal		Phalanges form the fingers; three in digits 2–5; two in digit 1 (the thumb)	

Anterior view of pectoral girdle and upper limb

*The number in parentheses ( ) following the bone name denotes the total number of such bones in the body.

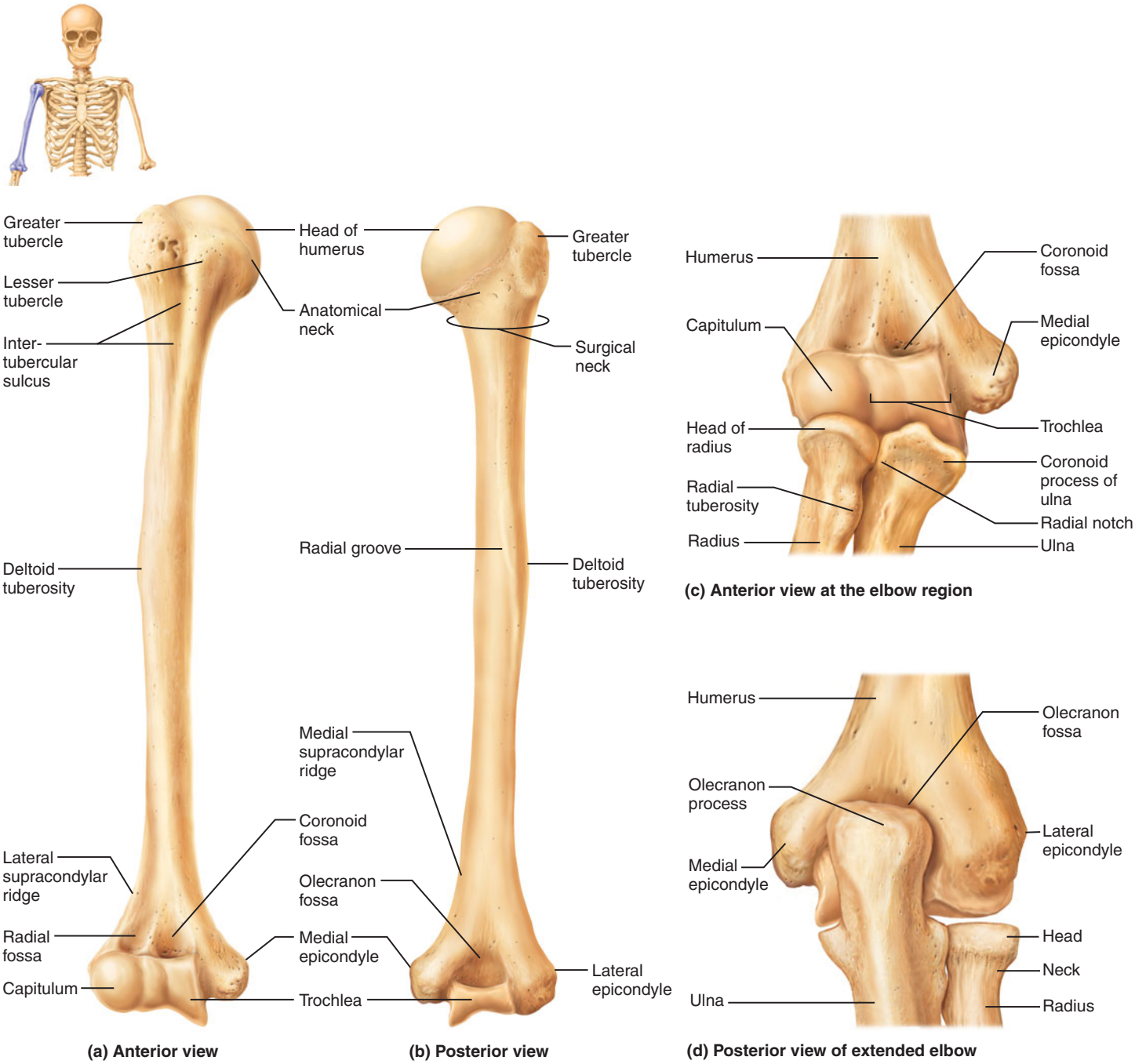


FIGURE 8.3 The humerus of the right arm and detailed views of articulation at the elbow. (See *A Brief Atlas of the Human Body,* Second Edition, Figure 25.)

elbow only. The **humerus** (hu′mer-us) is the only bone of the arm **(Figure 8.3)**. The largest and longest bone in the upper limb, it articulates with the scapula at the shoulder and with the radius and ulna (forearm bones) at the elbow.

At the proximal end of the humerus is the hemispherical **head,** which fits into the glenoid cavity of the scapula. Just inferior to the head is a slight constriction, the **anatomical neck.** Inferior to this, the lateral **greater tubercle** and the more medial **lesser tubercle** are separated by the **intertubercular** ("between the tubercles") **sulcus,** or *bicipital* (bi-sip′ĭ-tal) *groove.* The tubercles are sites of attachment for the rotator cuff muscles (Chapter 11, p. 302). The intertubercular sulcus guides a tendon of the biceps muscle to its attachment point at the rim of the glenoid cavity (the supraglenoid tubercle, Figure 8.2c). The **surgical neck** of the humerus, so named because it is the most frequently fractured part of the humerus, is inferior to the tubercles. About midway down the shaft, on the lateral side, is the **deltoid tuberosity.** This V-shaped, roughened area is an attachment site for the deltoid muscle of the shoulder. Near the deltoid tuberosity along the posterior surface of the shaft, the **radial groove** descends obliquely. It marks the course of the radial nerve, an important nerve of the upper limb.

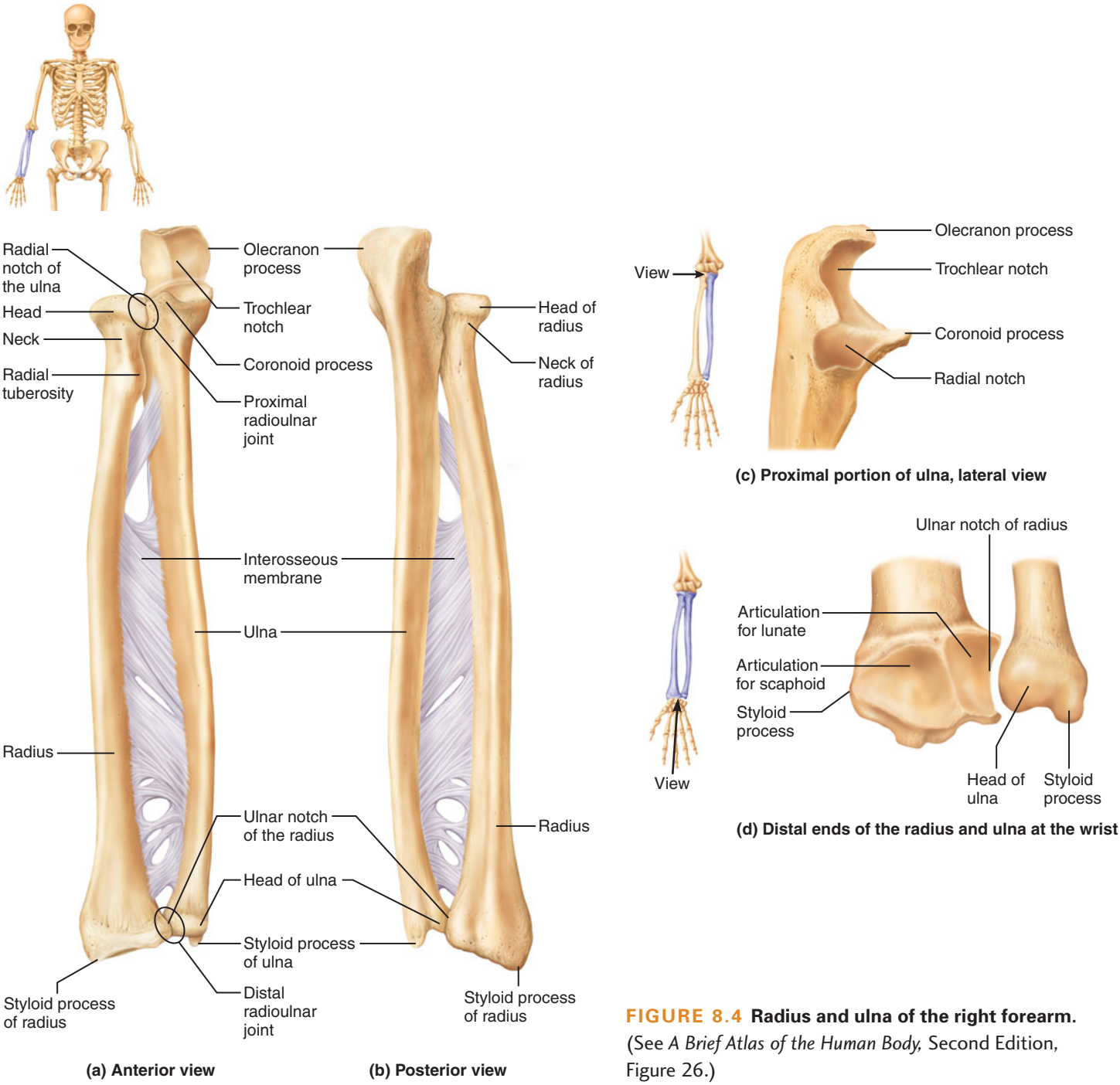


FIGURE 8.4 Radius and ulna of the right forearm. (See *A Brief Atlas of the Human Body,* Second Edition, Figure 26.)

At the distal end of the humerus are two condyles, a medial **trochlea** (trok′le-ah; "pulley") that articulates with the ulna, and a lateral **capitulum** (kah-pit′u-lum; "small head") that articulates with the radius (Figure 8.3c). The trochlea looks like an hourglass turned on its side, and the capitulum is shaped like half a ball. They are flanked by the **medial** and **lateral epicondyles** ("beside the condyles"), which are attachment sites for muscles of the forearm. Directly above these epicondyles are the **medial** and **lateral supracondylar ridges** (Figure 8.3a).

On the posterior surface of the humerus directly proximal to the trochlea is the deep **olecranon** (o-lek′rah-non) **fossa.** In the corresponding position on the anterior surface is a shallower **coronoid** (kor′o-noid) **fossa** medially and **radial fossa** laterally. These fossae receive similarly named projections of the forearm bones during forearm movement, as shown in Figure 8.3c and d.

Forearm

Forming the skeleton of the *forearm* or *antebrachium* (an′te-bra′ke-um) are two parallel long bones, the radius and ulna **(Figure 8.4)**, that articulate with the humerus proximally and

the bones of the wrist distally. The radius and ulna also articulate with each other both proximally and distally at the small *radioulnar* (ra″de-o-ul′nar) *joints.* Furthermore, they are interconnected along their entire length by a flat ligament called the **interosseous membrane** (in″ter-os′e-us; "between the bones"). In the anatomical position, the radius lies laterally (on the thumb side), and the ulna medially. However, when the palm faces posteriorly, the distal end of the radius crosses over the ulna, and the two bones form an X.

Ulna

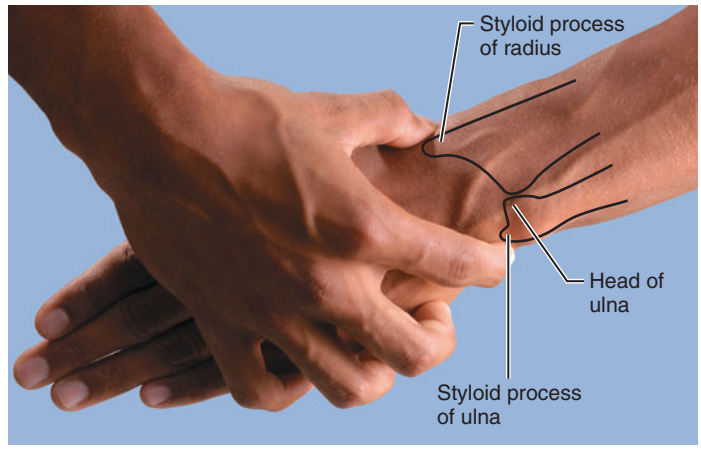
The **ulna** (ul′nah; "elbow"), which is slightly longer than the radius, is the main bone forming the elbow joint with the humerus. It looks much like a monkey wrench. At its proximal end are two prominent projections, the **olecranon** ("elbow") **process** and **coronoid** ("crown-shaped") **process,** separated by a deep concavity, the **trochlear notch** (Figure 8.4c). Together, these two processes grip the trochlea of the humerus (Figure 8.3c), forming a hinge joint that allows the forearm to bend upon the arm (flex), then straighten again (extend). When the forearm is fully extended, the olecranon process "locks" into the olecranon fossa of the humerus (Figure 8.3d). When the forearm is flexed, the coronoid process of the ulna fits into the coronoid fossa of the humerus. On the lateral side of the coronoid process is a smooth depression, the **radial notch** (Figure 8.4c), where the head of the radius articulates with the ulna.

Distally, the shaft of the ulna narrows and ends in a knoblike **head** that articulates with the radius (Figure 8.4d). Medial to this is the **styloid** ("stake-shaped") **process,** from which a ligament runs to the wrist. The head of the ulna is separated from the bones of the wrist by a disc of fibrocartilage and plays little or no role in hand movements.

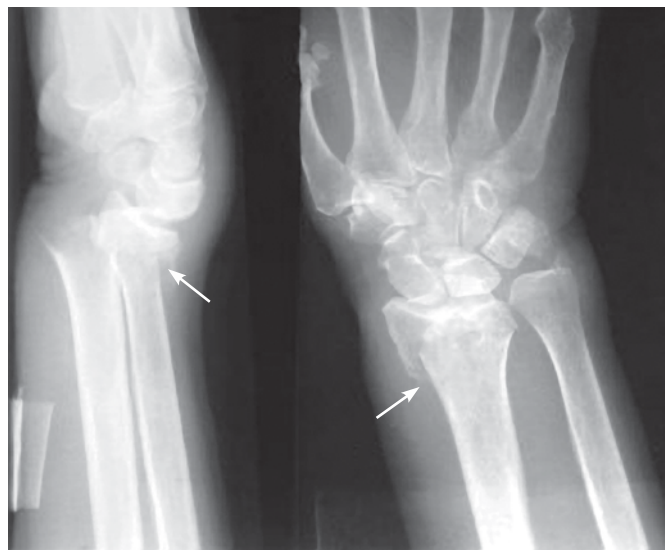
Radius

The **radius** ("spoke" or "ray") is thin at its proximal end and widened at its distal end—the opposite of the ulna (Figure 8.4). The proximal **head** of the radius is shaped like the end of a spool of thread (Figure 8.3c and d). Its superior surface is concave, and it articulates with the capitulum of the humerus. Medially, the head of the radius articulates with the radial notch of the ulna, forming the *proximal radioulnar joint.* Just distal to the head, on the anterior surface in anatomical position, is a rough bump, the **radial tuberosity,** a site of attachment of the biceps muscle. On the distal end of the radius (Figure 8.4d), the medial **ulnar notch** articulates with the head of the ulna, forming the *distal radioulnar joint,* and the lateral **styloid process** anchors a ligament that runs to the wrist. The distal articular surface is concave and articulates with carpal bones of the wrist. Whereas the ulna contributes heavily to the elbow joint, the radius is the primary forearm bone contributing to the wrist joint. When the radius rotates, the hand moves with it.

Figure 8.5a shows a way to locate the distal, knoblike styloid processes of the radius and ulna. The styloid process of the radius lies about 1 cm (0.4 inch) distal to that of the ulna.



(a) Normal position



(b) Radiograph of fractured radius, Colles' fracture

FIGURE 8.5 Location of styloid processes of radius and ulna. (a) Palpation of normal positioning. **(b)** Radiograph of fractured radius. Note the "dinner fork" bending in lateral view.

PALPATION OF COLLES' FRACTURE When presented with a patient who has fallen on an outstretched hand and whose wrist has curves that resemble those on a fork, a clinician uses the method depicted in Figure 8.5a. If palpation reveals that the styloid process of the radius has moved proximally from its normal position, the diagnosis is **Colles' fracture,** an impacted fracture in which the distal end of the radius is forced proximally into the shaft of the radius (Figure 8.5b).

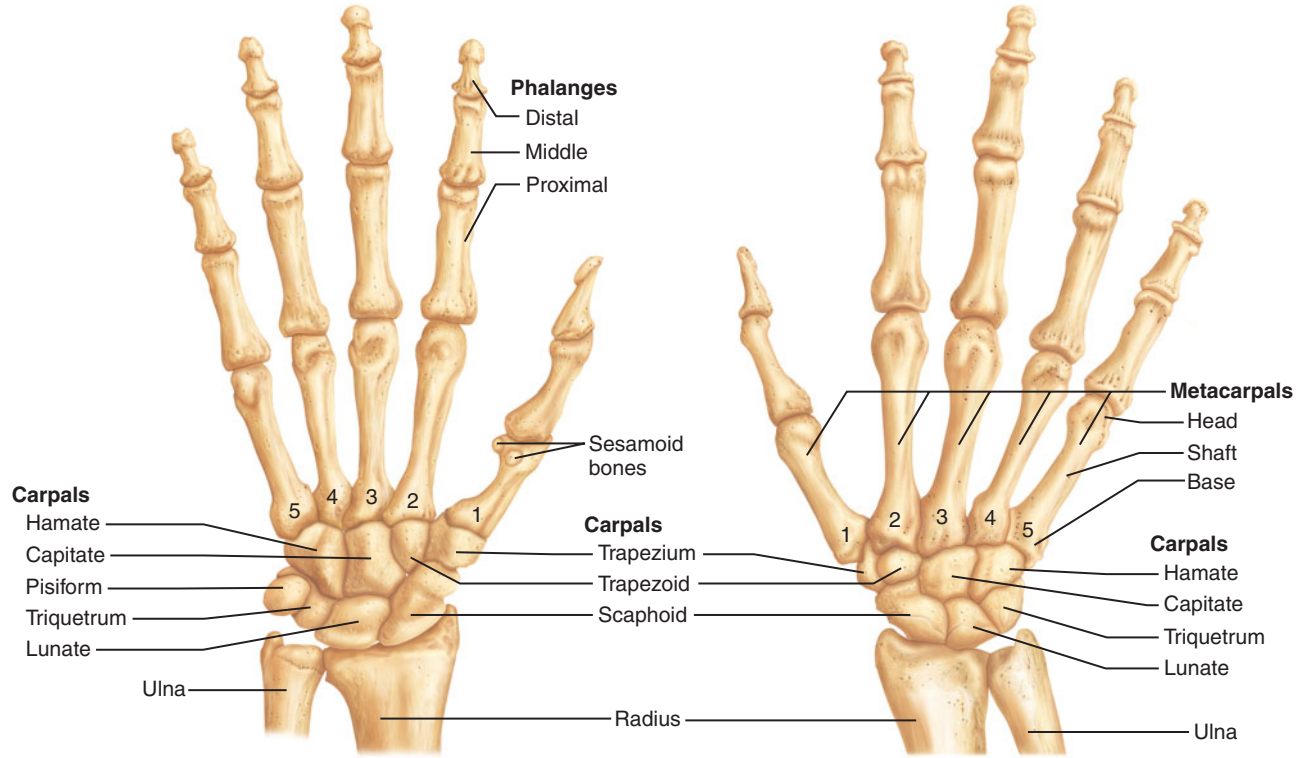


FIGURE 8.6 Bones of the hand. (a) Anterior (palm) view of the right hand, illustrating the carpals, metacarpals, and phalanges. **(b)** Posterior view. (See *A Brief Atlas of the Human Body,* Second Edition, Figure 27.)

Hand

The skeleton of the hand includes the bones of the *carpus,* or wrist; the bones of the *metacarpus,* or palm; and the *phalanges,* or bones of the fingers **(Figure 8.6)**.

Carpus

A wristwatch is actually worn on the distal forearm, not on the wrist at all. The true wrist, or **carpus** (kar′pus), is the proximal region of the hand, just distal to the wrist joint. The carpus contains eight marble-sized short bones, or **carpals** (kar′palz), closely united by ligaments. Gliding movements occur between the carpals, making the wrist rather flexible. The carpals are arranged in two irregular rows of four bones each (Figure 8.6). In the proximal row, from lateral (thumb side) to medial, are the **scaphoid** (skaf′oid; "boat-shaped"), **lunate** (lu′nāt; "moonlike"), **triquetrum** (tri-kwet′rum; "triangular"), and **pisiform** (pis′i-form; "pea-shaped") bones. Only the scaphoid and lunate bones articulate with the radius to form the wrist joint. The carpals of the distal row, again from lateral to medial, are the **trapezium** (trah-pe′ze-um; "little table"), **trapezoid** ("four-sided"), **capitate** (kap′i-tāt; "head-shaped"), and **hamate** (ham′āt; "hooked") bones. A simple mnemonic may help you remember the names and positions of the carpal bones, starting with the proximal row from lateral to medial, and continuing with the distal row from lateral to medial: **S**ally **L**eft **T**he **P**arty **T**o **T**ake **C**armen **H**ome.

The scaphoid is the most frequently fractured carpal bone, which often results from falling on an outstretched hand. The impact bends the scaphoid, which then breaks at its narrow midregion.

CARPAL TUNNEL SYNDROME The arrangement of carpal bones makes the carpus concave anteriorly. A ligamentous band covers this concavity superficially, forming the *carpal tunnel* **(Figure 8.7)**. Many long muscle tendons that run from the forearm to the fingers pass through this narrow tunnel. Also crowded in the tunnel is the median nerve, which (roughly speaking) innervates the lateral half of the hand, including the muscles that move the thumb. Inflammation of any element in the carpal tunnel, such as tendons swollen from overuse, can compress the median nerve. This nerve impairment is called **carpal tunnel syndrome,** and it affects many workers who repeatedly flex their wrists and fingers. At high risk are workers who use vibrating hand-held tools for extended periods, assembly workers, and workers in food processing and packaging. Because the median nerve is impaired, the skin of the lateral part of the hand tingles or becomes numb, and movements of the thumb weaken. Pain is

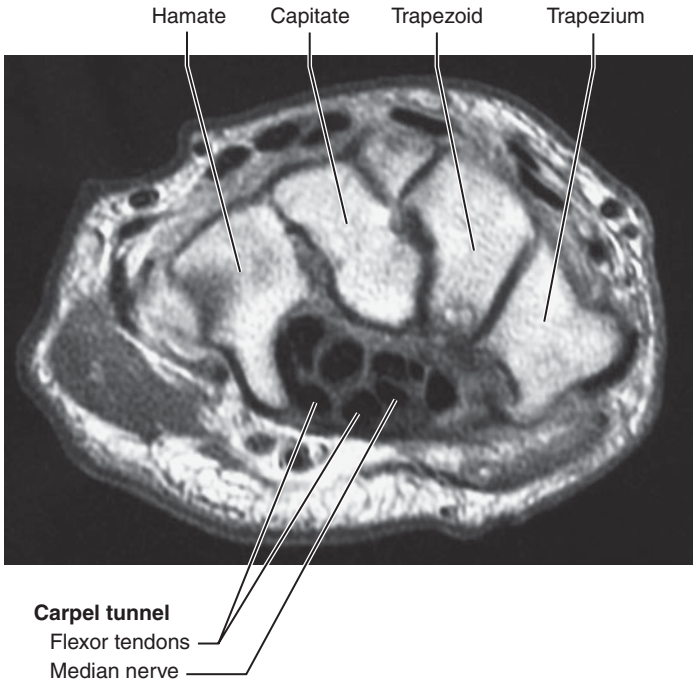


FIGURE 8.7 Carpal tunnel. Transverse section through the distal row of the carpals of the right hand. Only two flexor tendons are labeled, others are visible.

greatest at night. This condition can be treated by resting the hand in a splint during sleep, by anti-inflammatory drugs, or by surgery.

Carpal tunnel syndrome is just one of a series of overuse disorders that can affect the tendons, muscles, and joints of the upper limbs and back. Collectively, these conditions are called **repetitive stress injuries.**

Metacarpus

Five **metacarpals** radiate distally from the wrist to form the **metacarpus,** or palm of the hand (*meta* = beyond). These small long bones are not named individually but instead are numbered 1 to 5, from thumb to little finger (Figure 8.6). The *bases* of the metacarpals articulate with the carpals proximally and with each other on their lateral and medial sides. Distally, the bulbous *heads* of the metacarpals articulate with the proximal phalanges of the fingers to form knuckles. Metacarpal 1, associated with the thumb, is the shortest and most mobile.

Phalanges of the Fingers

The digits, or fingers, are numbered 1 to 5 beginning with the thumb, or *pollex* (pol′eks). The fingers contain miniature long bones called **phalanges** (fah-lan′jēz). The singular of this term is *phalanx* (fa′langks; "a closely knit row of soldiers"). In most people, the third finger is the longest. With the exception of the thumb, each finger has three phalanges: *proximal, middle,* and *distal* (Figure 8.6). The thumb has no middle phalanx.

check your understanding

4. In anatomical position, which forearm bone is located laterally?
5. For each of the features listed, identify (a) the bone each is located on and (b) the bone that each articulates with: capitulum, trochlear notch, head of the ulna, radial notch.
6. What is the difference between the anatomical neck and the surgical neck of the humerus?
7. Name the bones that are located in the palm of the hand.

For answers, see Appendix B.

THE PELVIC GIRDLE

- Name the bones contributing to the hip bone, and relate the structure of the pelvic girdle to its function.
- Compare and contrast the male and female pelves.

The **pelvic girdle,** or *hip girdle,* attaches the lower limbs to the spine and supports the visceral organs of the pelvis. The full weight of the upper body passes through this girdle to the lower limbs. Whereas the pectoral girdle barely attaches to the thoracic cage, the pelvic girdle attaches to the axial skeleton by some of the strongest ligaments in the body. Furthermore, whereas the glenoid cavity of the scapula is shallow, the corresponding socket in the pelvic girdle is a deep cup that firmly secures the head of the femur (thigh bone). Consequently, the lower limbs have less freedom of movement than the upper limbs but are much more stable.

The pelvic girdle consists of the paired **hip bones (Figure 8.8)**. A hip bone is also called a **coxal** (kok′sal) **bone,** or an **os coxae** (*os* = bone; *coxa* = hip). Each hip bone unites with its partner anteriorly and with the sacrum posteriorly. The deep, basinlike structure formed by the hip bones, sacrum, and coccyx is the *pelvis* (Figure 8.8a).

The hip bone is large and irregularly shaped (Figure 8.8b and c). During childhood, it consists of three separate bones: the *ilium, ischium,* and *pubis.* In adults, these bones are fused, and their boundaries are indistinguishable. Their names are retained, however, to refer to different regions of the composite hip bone. At the Y-shaped junction of the ilium, ischium, and pubis is a deep hemispherical socket, the **acetabulum** (as″ĕ-tab′u-lum), on the lateral pelvic surface (Figure 8.8b). The acetabulum ("vinegar cup") receives the ball-shaped head of the femur at the hip joint.

Ilium

The **ilium** (il′e-um; "flank") is a large, flaring bone that forms the superior region of the hip bone. It consists of an inferior **body** and a superior winglike **ala** ("wing"). The thickened superior margin of the ala is the **iliac crest.** Many muscles

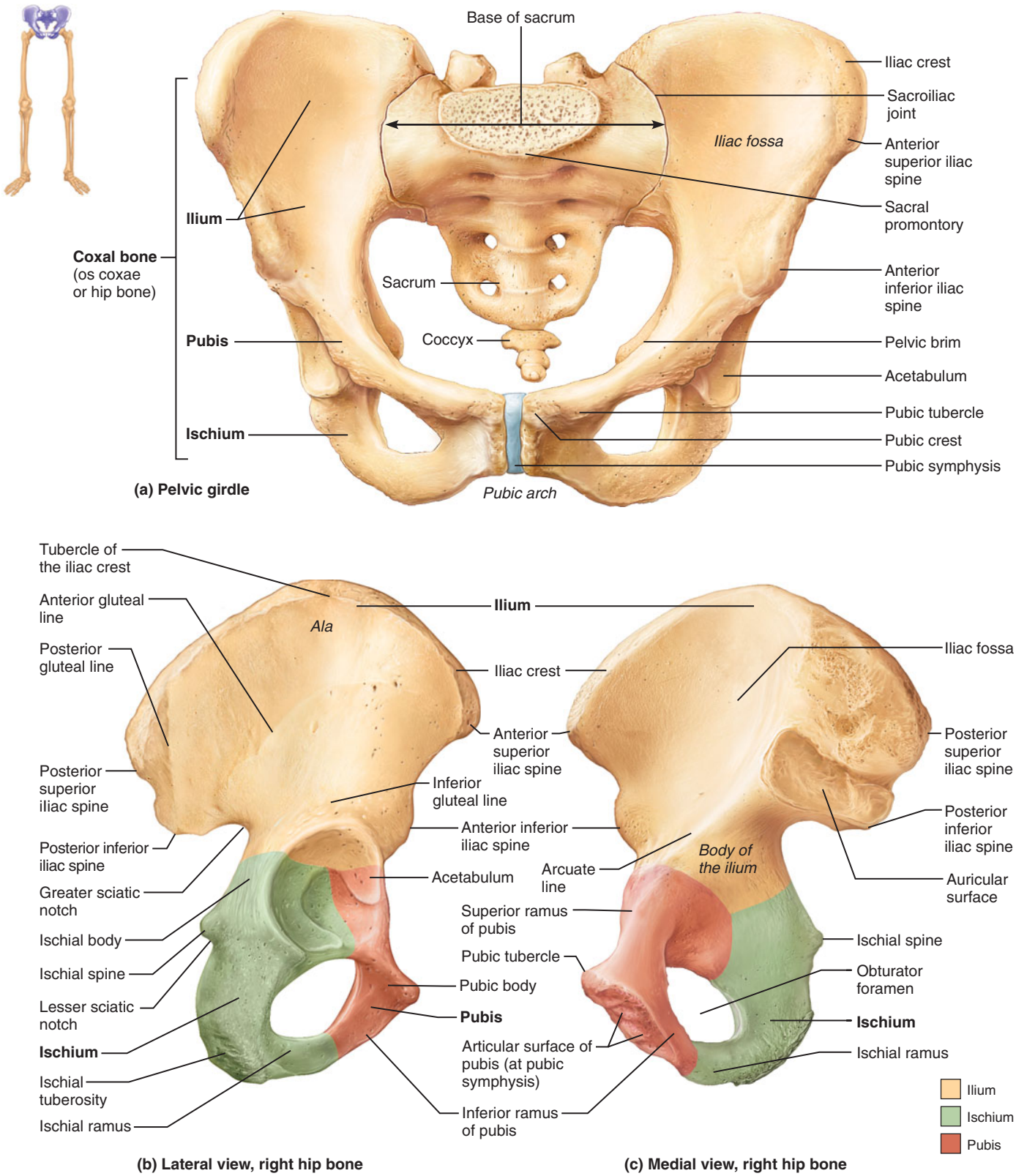
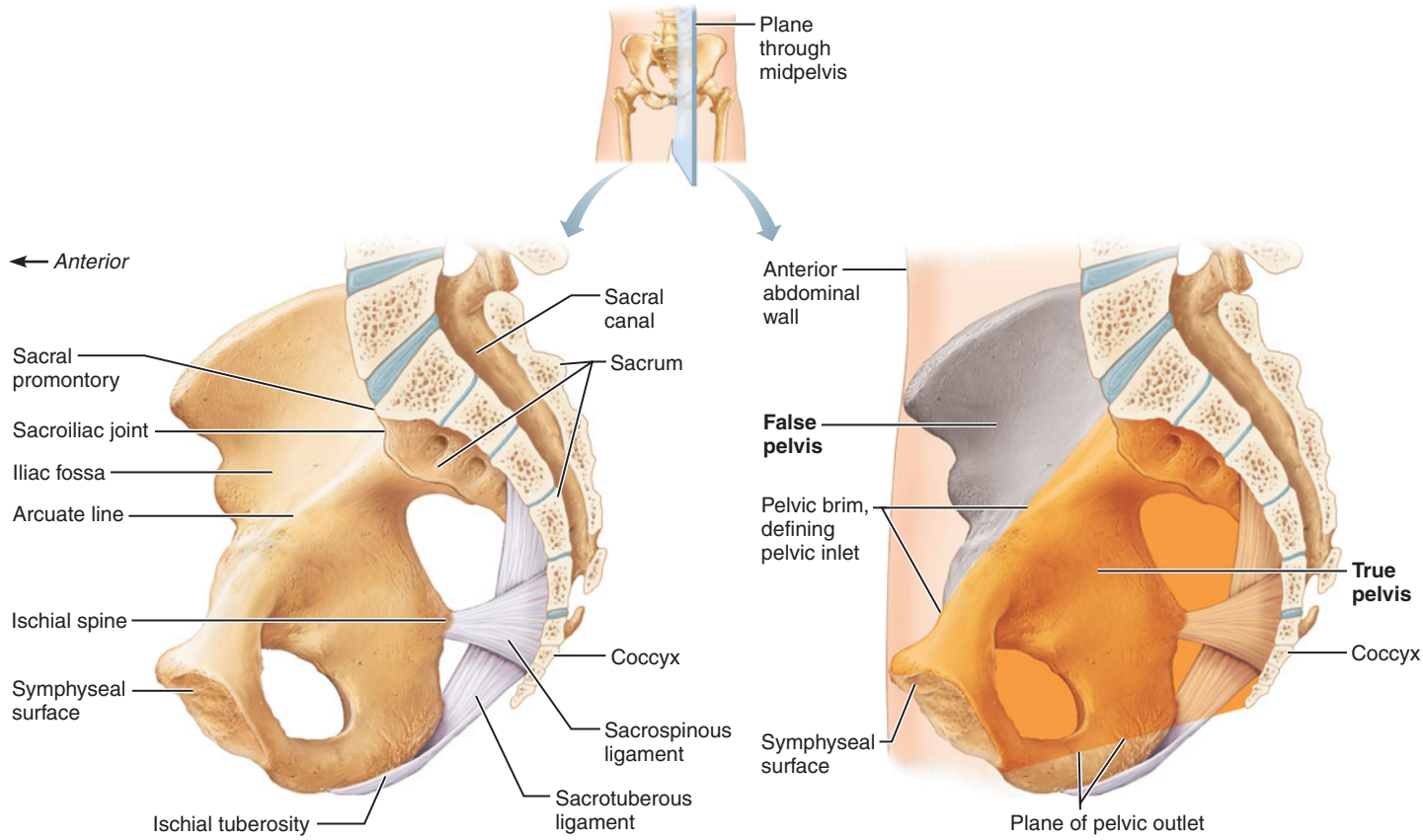


FIGURE 8.8 Bones of the pelvic girdle. (a) Articulated pelvis showing the two hip bones, the sacrum, and the coccyx. **(b)** Lateral view of the right hip bone (anterior is to the right). **(c)** Medial view of the right hip bone (anterior is to the left). (See *A Brief Atlas of the Human Body,* Second Edition, Figure 28.)



(a) Some of the ligaments of the pelvis **(b) True and false pelves**

FIGURE 8.9 Midsagittal section through the pelvis.

attach to this crest, which is thickest at the **tubercle of the iliac crest** (Figure 8.8b). Each iliac crest ends anteriorly in a blunt **anterior superior iliac spine** and posteriorly in a sharp **posterior superior iliac spine.** The anterior superior iliac spine is an especially prominent anatomical landmark and is easily felt through the skin. The position of the posterior superior iliac spines is indicated by dimples in the skin that lie approximately 5 cm lateral to the midline of the back at the junction of the lumbar and gluteal regions (see Figure 11.37, p. 338). Located inferior to these superior iliac spines are the **anterior** and **posterior inferior iliac spines.**

Posteriorly, just inferior to the posterior inferior iliac spine, the ilium is deeply indented to form the **greater sciatic notch** (si-at′ik; "of the hip"). The sciatic nerve, the largest nerve in the body, passes through this notch to enter the posterior thigh. The broad posterolateral surface of the ilium, the *gluteal surface* (glu′te-al; "buttocks"), is crossed by three ridges: the **posterior, anterior,** and **inferior gluteal lines.** These lines define the attachment sites of the gluteal (buttocks) muscles.

The internal surface of the iliac ala is concave. This broad concavity is called the **iliac fossa** (Figure 8.8c). Posterior to this fossa lies a roughened **auricular surface** (aw-rik′u-lar; "ear-shaped"), which articulates with the sacrum, forming the *sacroiliac joint.* The weight of the body is transmitted from the vertebral column to the pelvis through this joint. Running anteriorly and inferiorly from the auricular surface is a robust ridge called the **arcuate line** (ar′ku-āt; "bowed"), which helps define the superior boundary of the true pelvis (described below). The inferior part of the ilium joins with the ischium posteriorly, shown in purple, and the pubis anteriorly, illustrated in red.

Ischium

The **ischium** (is′ke-um; "hip") forms the posteroinferior region of the hip bone (Figure 8.8b). Shaped roughly like an L or an arc, it has a thicker, superior **body** and a thinner, inferior **ramus** (*ramus* = branch). Anteriorly, the ischial ramus joins the pubis. The triangular **ischial spine** lies posterior to the acetabulum and projects medially. It is an attachment point for a ligament from the sacrum and coccyx, the *sacrospinous ligament* **(Figure 8.9a)**. Just inferior to the ischial spine is the **lesser sciatic notch,** through which pass nerves and vessels that serve the perineum (area around the anus and external genitals). The inferior surface of the ischial body is the rough and thickened **ischial tuberosity.** When you sit, your weight is borne entirely by the ischial tuberosities, which are the strongest parts of the hip bones. A massive *sacrotuberous ligament* (Figure 8.9a) runs from the sacrum to each ischial tuberosity and helps hold the pelvis together. The ischial tuberosity is also an area of attachment of the hamstring muscles.

Pubis

The **pubis** (pu′bis; "sexually mature"), or *pubic bone,* forms the anterior region of the hip bone. In the anatomical position, it lies nearly horizontally, and the bladder rests upon it. Essentially, the pubis is V-shaped, with **superior** and **inferior rami** extending from a flat **body** (Figure 8.8b and c). The body of the pubis lies medially, and its anterior border is thickened to form a **pubic crest.** At the lateral end of the pubic crest is the knoblike **pubic tubercle,** an attachment point for the *inguinal ligament* (shown in Figure 11.31 on p. 333). The two rami of the pubic bone extend laterally: The inferior ramus joins to the ischial ramus, and the superior ramus joins with the bodies of the ischium and ilium. A thin ridge called the *pectineal line* lies along the superior pubic ramus, forming the anterior portion of the pelvic brim.

A large hole, the **obturator** (ob′tu-ra″tor) **foramen,** occurs between the pubis and ischium (Figure 8.8b and c). Students ask the function of this foramen, reasonably assuming something big goes through it. However, that is not the case: Although a few vessels and nerves do pass through it, the obturator foramen is almost completely closed by a fibrous membrane, the obturator membrane. In fact, the word *obturator* literally means "closed up."

In the midline, the bodies of the two pubic bones are joined by a disc of fibrocartilage. This joint is the *pubic symphysis* (Figure 8.8a). Inferior to this joint, the inferior pubic rami and the ischial rami form an arch shaped like an inverted V, the **pubic arch** or **subpubic angle.** The angle of this arch helps to distinguish the male pelvis from the female pelvis.

True and False Pelves

The bony pelvis is divided into two parts, the *false (greater) pelvis* and the *true (lesser) pelvis* (Figure 8.9). These parts are separated by the **pelvic brim,** a continuous oval ridge that runs from the pubic crest through the arcuate line, the rounded inferior edges of the sacral ala, and the sacral promontory (Figure 8.8a). The **false pelvis,** superior to the pelvic brim, is bounded by the alae of the iliac bones. It is actually part of the abdomen and contains abdominal organs. The **true pelvis** lies inferior to the pelvic brim. It forms a deep bowl containing the pelvic organs.

Pelvic Structure and Childbearing

The major differences between typical male and female pelves are summarized in **Table 8.2**. So consistent are these differences that an anatomist can determine the sex of a skeleton with 90% certainty merely by examining the pelvis. The female pelvis is adapted for childbearing: It tends to be wider, shallower, and lighter than that of a male. These features provide more room in the true pelvis, which must be wide enough for an infant's head to pass during birth.

The *pelvic inlet* is delineated by the pelvic brim (Figure 8.9b). Its largest diameter is from side to side (see Table 8.2). As labor begins, the infant's head enters this inlet, its forehead facing one ilium and its occiput facing the other. If the mother's sacral promontory is too large, it can block the entry of the infant into the true pelvis. The *pelvic outlet* is the inferior margin of the true pelvis, as shown in the photos at the bottom of Table 8.2. The outlet's anterior boundary is the pubic arch; its lateral boundaries are the ischial tuberosities, and its posterior boundary is the sacrum and coccyx. Both the coccyx and the ischial spines protrude into the outlet, so a sharply angled coccyx or unusually large ischial spine can interfere with delivery. The largest dimension of the pelvic outlet is the anteroposterior diameter. Generally, after the infant's head passes through the inlet, it rotates so that the forehead faces posteriorly and the occiput anteriorly. This is the usual position of the head as it leaves the mother's body (see Figure 25.27, p. 760). Thus, during birth, the infant's head makes a quarter turn to follow the widest dimensions of the true pelvis.

check your understanding

8. What is the most anterior bone of the pelvic girdle?
9. Name the specific part of the hip bone that bears your weight when you sit.
10. When you place your hands on your "hips," what structure are you resting your hands upon?
11. How does the structure of the pubic arch, the greater sciatic notch, and the sacrum differ between males and females?

For answers, see Appendix B.

THE LOWER LIMB

- Identify the bones of the lower limb and their important features, and describe how they articulate with each other.
- Name the three supporting arches of the foot, and explain their importance.

The lower limbs carry the entire weight of the erect body and experience strong forces when we jump or run. Thus, the bones of the lower limbs are thicker and stronger than the comparable bones of the upper limbs. The three segments of the lower limb are the thigh, the leg, and the foot (**Table 8.3** on p. 196).

Thigh

The **femur** (fe′mur; "thigh") is the single bone of the thigh **(Figure 8.10b)**. It is the largest, longest, strongest bone in the body. Its durable structure reflects the fact that the stress on this bone can reach 280 kg per cm^2, or 2 tons per square inch! The femur courses medially as it descends toward the knee. Such a medial course places the knee joints closer to the body's center of gravity in the midline and thus provides for better balance. The medial course of the femur is more pronounced in women because of their wider pelvis. Thus, there is a greater angle between the femur and the tibia (shinbone),

TABLE 8.2 Comparison of the Male and Female Pelves

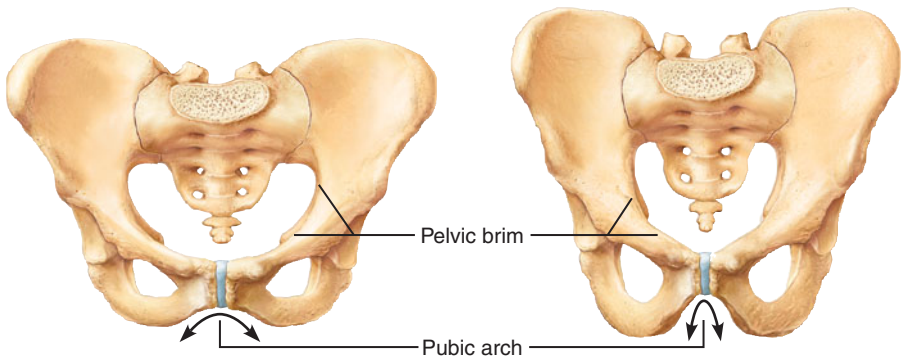
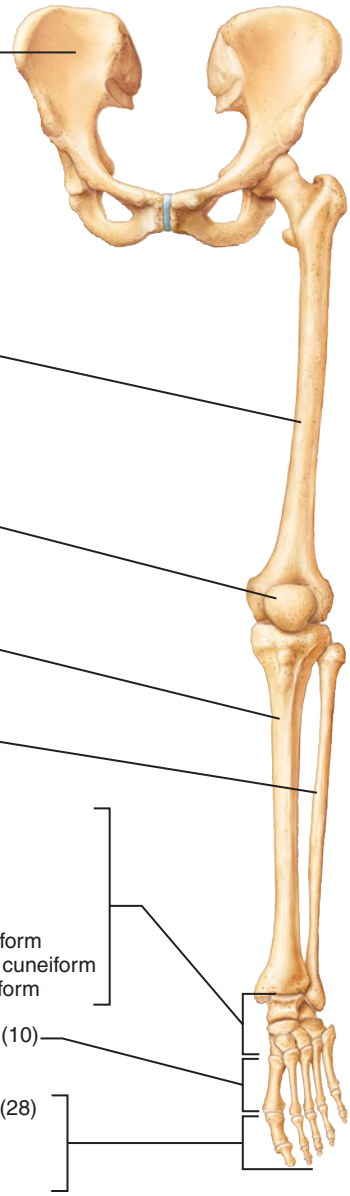
Characteristic	Female	Male
General structure and functional modifications	Tilted forward; adapted for childbearing; true pelvis defines the birth canal; cavity of the true pelvis is broad, shallow, and has a greater capacity	Tilted less far forward; adapted for support of a male's heavier build and stronger muscles; cavity of the true pelvis is narrow and deep
Bone thickness	Less; bones lighter, thinner, and smoother	Greater; bones heavier and thicker, and markings are more prominent
Acetabula	Smaller; farther apart	Larger; closer
Pubic angle/arch	Broader (80° to 90°); more rounded	Angle is more acute (50° to 60°)
Anterior view		
Sacrum	Wider; shorter; sacral curvature is accentuated	Narrow; longer; sacral promontory more ventral
Coccyx	More movable; straighter	Less movable; curves ventrally
Greater sciatic notch	Wide and shallow	Narrow and deep
Left lateral view		
Pelvic inlet (brim)	Wider; oval from side to side	Narrow; basically heart-shaped
Pelvic outlet	Wider; ischial tuberosities shorter, farther apart, and everted	Narrower; ischial tuberosities longer, sharper, and point more medially
Posteroinferior view		

TABLE 8.3 Bones of the Lower Limbs

Body Region	Bones*	Illustration	Location	Markings
PELVIC GIRDLE (Figure 8.8)	**Coxal** (2) (hip)		Each coxal (hip) bone is formed by the fusion of an ilium, ischium, and pubic bone; the coxal bones fuse anteriorly at the pubic symphysis and form sacroiliac joints with the sacrum posteriorly; girdle consisting of both coxal bones is basinlike	Iliac crest; anterior and posterior iliac spines; auricular surface; greater and lesser sciatic notches; obturator foramen; ischial tuberosity and spine; acetabulum; pubic arch; pubic crest; pubic tubercle
LOWER LIMB Thigh (Figure 8.10)	**Femur** (2)		Femur is the sole bone of thigh; between hip joint and knee; largest bone of the body	Head; greater and lesser trochanters; neck; lateral and medial condyles and epicondyles; gluteal tuberosity; linea aspera
Kneecap (Figure 8.10)	**Patella** (2)		Patella is a sesamoid bone formed within the tendon of the quadriceps (anterior thigh) muscles	
Leg (Figure 8.11)	**Tibia** (2)		Tibia is the larger and more medial bone of leg; between knee and foot	Medial and lateral condyles; tibial tuberosity; anterior border; medial malleolus
	Fibula (2)		Fibula is the lateral bone of leg; sticklike	Head; lateral malleolus
Foot (Figure 8.12)	7 **Tarsals** (14) Talus Calcaneus Navicular Cuboid Lateral cuneiform Intermediate cuneiform Medial cuneiform		Tarsals are seven bones forming the proximal part of the foot; the talus articulates with the leg bones at the ankle joint; the calcaneus, the largest tarsal, forms the heel	
	5 **Metatarsals** (10)		Metatarsals are five bones numbered 1–5	
	14 **Phalanges** (28) Proximal Middle Distal		Phalanges form the toes; three in digits 2–5, two in digit 1 (the great toe)	

Anterior view of pelvic girdle and left lower limb

*The number in parentheses ( ) following the bone name denotes the total number of such bones in the body.

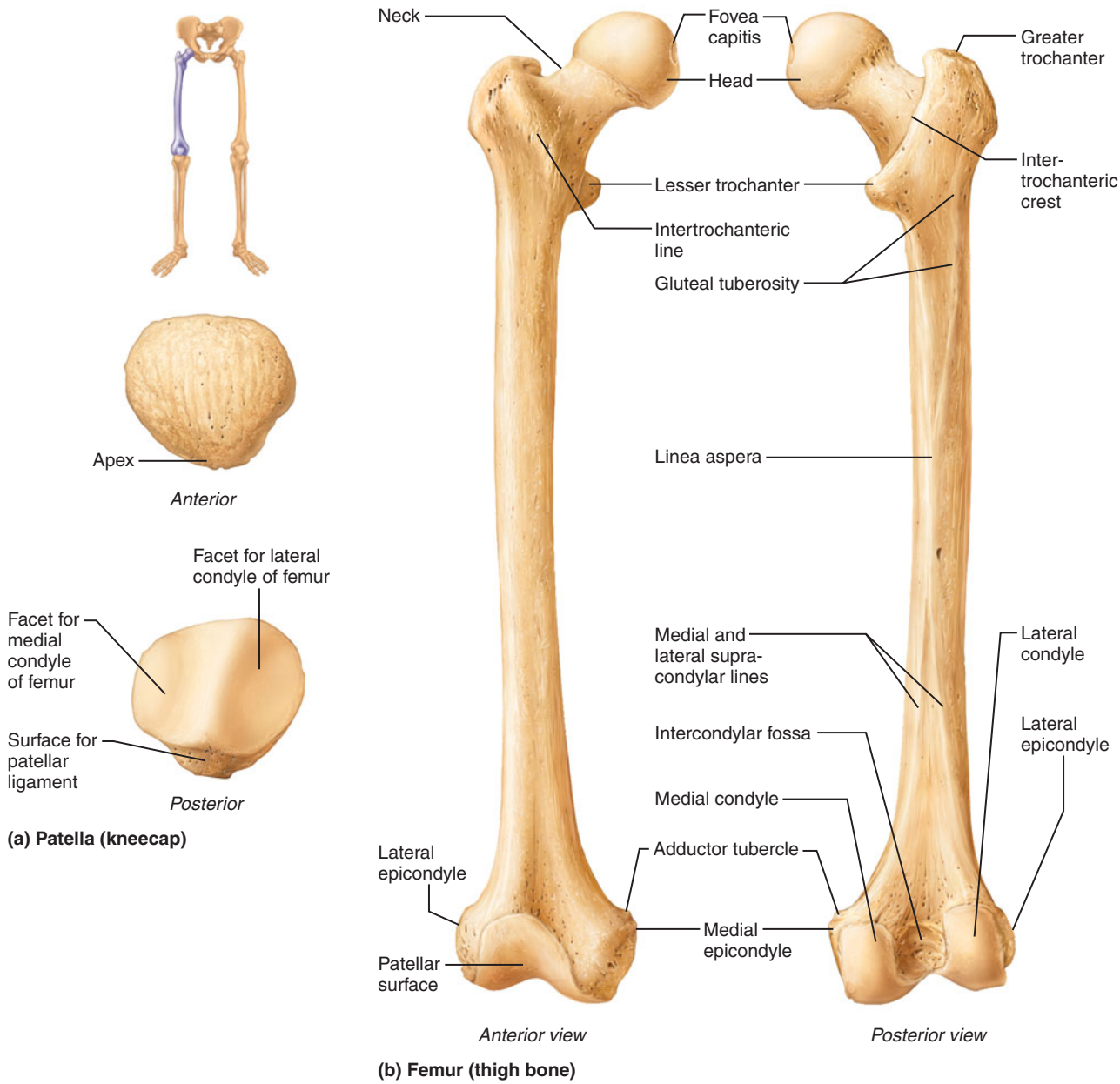


FIGURE 8.10 The right patella (a) and femur (b). (See *A Brief Atlas of the Human Body,* Second Edition, Figure 29.)

which is vertical. This may contribute to the greater incidence of knee problems in female athletes.

The ball-like **head** of the femur has a small central pit called the **fovea capitis** (fo′ve-ah cap′ĭ-tis; "pit of the head"). A short ligament, the *ligament of the head of the femur,* runs from this pit to the acetabulum of the hip bone. The head of the femur is carried on a **neck,** which does not descend straight vertically but angles laterally to join the shaft. This angled course reflects the fact that the femur articulates with the lateral aspect, rather than the inferior region, of the pelvis. The neck is the weakest part of the femur and is often fractured in a "broken hip."

HIP FRACTURE AS RESULT OF OSTEOPOROSIS

When elderly people describe falling and "breaking a hip," the order of events is in many cases actually the reverse. Bone loss due to osteoporosis causes the neck of the femur to weaken and fracture from stresses that a normal, healthy bone would withstand. The fracture causes the person to fall.

At the junction of the shaft and neck are the lateral **greater trochanter** and posteromedial **lesser trochanter,** sites of muscle attachment. The two trochanters are interconnected by the **intertrochanteric line** anteriorly and by the prominent **intertrochanteric crest** posteriorly. Inferior to the intertrochanteric crest on the posterior surface of the shaft is the **gluteal tuberosity.** The inferior part of this tuberosity blends into a long vertical ridge, the **linea aspera** (lin′e-ah as′per-ah; "rough line"). These areas are also sites of muscle attachment.

Distally, the femur broadens to end in **lateral** and **medial condyles** shaped like wide wheels. These are the joint surfaces that articulate with the tibia. The most raised points on the sides of these condyles are the **lateral** and **medial epicondyles,** to which muscles and ligaments attach. The **adductor tubercle** is a bump on the upper part of the medial epicondyle. Anteriorly, the two condyles are separated by a smooth **patellar surface,** which articulates with the kneecap, or patella. Posteriorly, they are separated by a deep **intercondylar fossa.** Extending superiorly from the respective condyles to the linea aspera are the **lateral** and **medial supracondylar lines.**

The **patella** (pah-tel′ah; "small pan") is a triangular sesamoid bone enclosed in the tendon that secures the quadriceps muscles of the anterior thigh to the tibia (Figure 8.10a). It protects the knee joint anteriorly and improves the leverage of the thigh muscles acting across the knee.

Leg

Anatomists use the term *leg* to refer to the part of the lower limb between the knee and the ankle. Two parallel bones, the *tibia* and *fibula,* form the skeleton of the leg **(Figure 8.11)**. The tibia is more massive than the sticklike fibula and lies medial to it. These two bones articulate with each other both proximally and distally. However, unlike the joints between the radius and ulna of the forearm, the *tibiofibular* (tib″e-o-fib′u-lar) *joints* allow almost no movement. Thus, the two leg bones do not cross one another when the leg rotates. An **interosseous membrane** connects the tibia and fibula along their entire length. The tibia articulates with the femur to form the knee joint, and with the talus bone of the foot at the ankle joint. The fibula, by contrast, does not contribute to the knee joint and merely helps stabilize the ankle joint.

Tibia

The **tibia** (tib′e-ah; "shinbone") receives the weight of the body from the femur and transmits it to the foot. It is second only to the femur in size and strength. At its proximal end the broad **medial** and **lateral condyles,** which resemble two thick checkers lying side by side on the top of the shaft, articulate with the corresponding condyles of the femur. The tibial condyles are separated by an irregular projection, the **intercondylar eminence.** On the inferior part of the lateral tibial condyle is a facet that articulates with the fibula to form the *proximal tibiofibular joint* (Figure 8.11a and d). Just inferior to the condyles, on the tibia's anterior surface, is the **tibial tuberosity** (Figure 8.11c), attachment site of the patellar ligament.

The shaft of the tibia is triangular in cross section. The sharp **anterior border** lies just below the skin and is easily palpated. Distally, the end of the tibia is flat where it articulates with the talus of the foot. Medial to this joint surface, the tibia has an inferior projection called the **medial malleolus** (mah-le′o-lus; "little hammer"), which forms the medial bulge of the ankle. The **fibular notch,** on the lateral side of the distal tibia, articulates with the fibula, forming the *distal tibiofibular joint.*

Fibula

The **fibula** (fib′u-la; "pin") is a thin long bone with two expanded ends. Its superior end is its **head,** and its inferior end is the **lateral malleolus.** This malleolus forms the lateral bulge of the ankle and articulates with the talus bone of the foot. The shaft of the fibula is heavily ridged and appears to have been twisted a quarter turn. The fibula does not bear weight, but several muscles originate from it.

ANKLE FRACTURES The medial and lateral malleoli are commonly fractured (Figure 8.11e) when the foot is forcefully inverted or everted at the ankle—that is, when one lands either on the lateral side of the foot and twists the sole medially (inversion) or on the medial side and turns the sole laterally (eversion). This type of injury occurs frequently in the general population and in people participating in contact sports.

Foot

The skeleton of the foot includes the bones of the *tarsus,* the bones of the *metatarsus,* and the *phalanges,* or toe bones **(Figure 8.12)**. The foot has two important functions: It supports the weight of the body, and it acts as a lever to propel the body forward during walking or running. A single bone could serve both these purposes but would function poorly on uneven ground. Its multicomponent structure makes the foot pliable, avoiding this problem.

Tarsus

The **tarsus** (tar′sus) makes up the posterior half of the foot and contains seven bones called **tarsals.** It is comparable to the carpus of the hand. The weight of the body is carried primarily by the two largest, most posterior tarsal bones: the **talus** (ta′lus; "ankle"), which articulates with the tibia and fibula superiorly, and the strong **calcaneus** (kal-ka′ne-us; "heel bone"), which forms the heel of the foot. The tibia articulates with the talus at the **trochlea of the talus** (Figure 8.12a). Inferiorly, the talus articulates with the calcaneus. The thick tendon of the calf muscles attaches to the posterior surface of the calcaneus. The part of the calcaneus that touches the ground is the **calcaneal tuberosity,** and the medial, shelflike projection is the **sustentaculum tali** (sus″ten-tak′u-lum ta′le; "supporter of the talus") or **talar shelf** (Figure

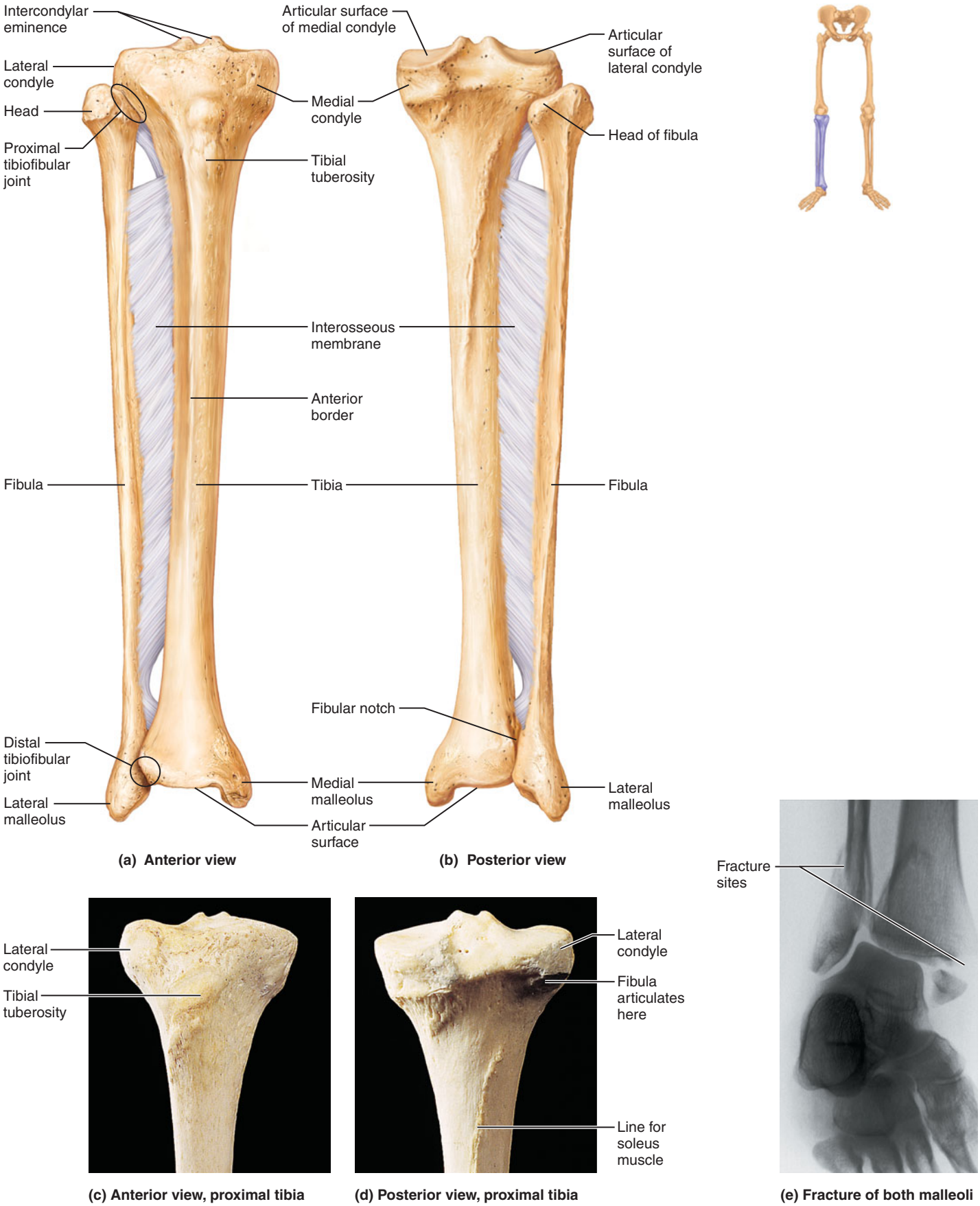


FIGURE 8.11 The tibia and fibula of the right leg. (See *A Brief Atlas of the Human Body,* Second Edition, Figure 30.)

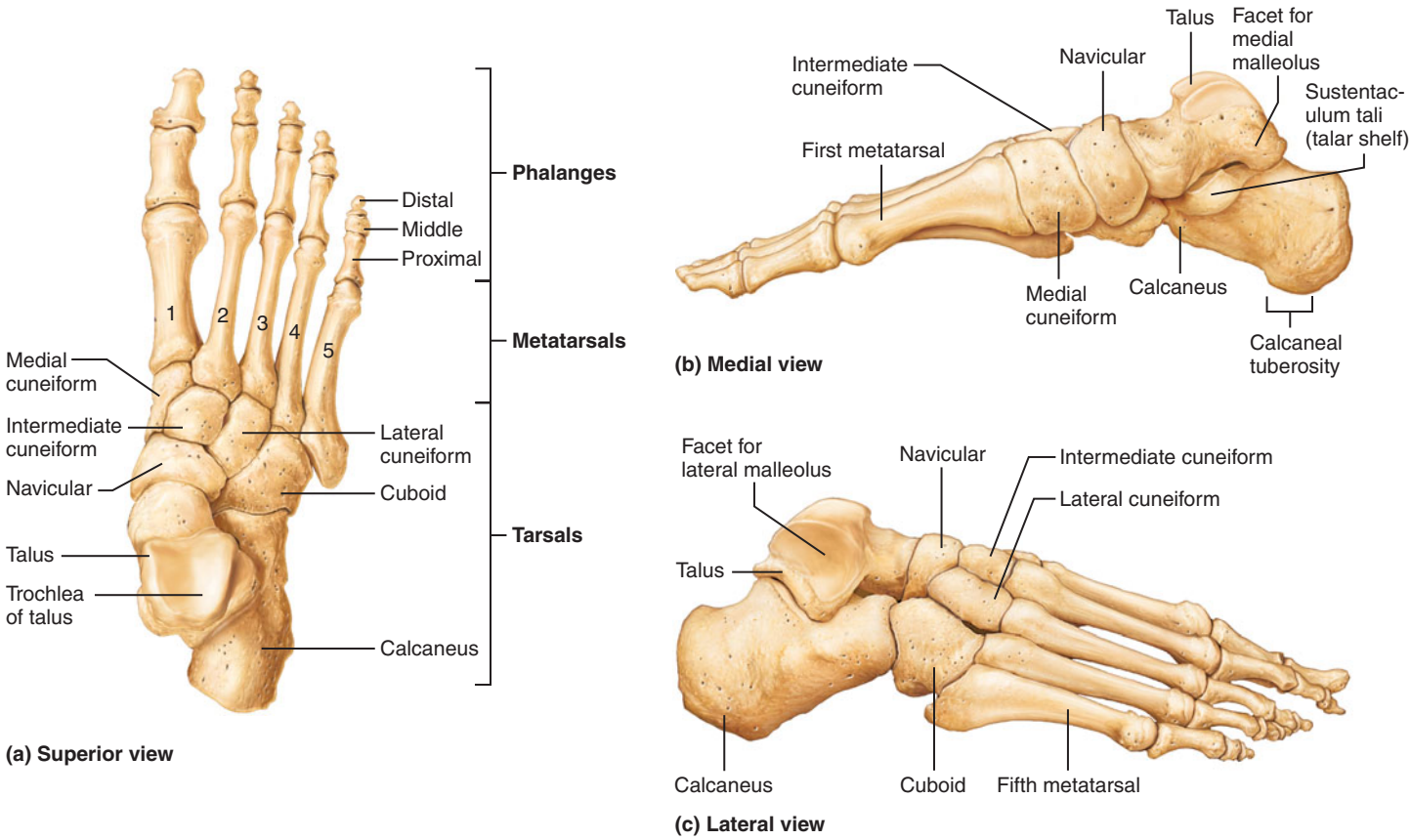


FIGURE 8.12 Bones of the right foot. (See *A Brief Atlas of the Human Body,* Second Edition, Figure 31a, c, and d.)

8.12b). The remaining tarsal bones are the lateral **cuboid** (ku′-boid; "cube-shaped"), the medial **navicular** (nah-vik′u-lar; "boatlike"), and the anterior **medial, intermediate,** and **lateral cuneiforms** (ku-ne′ĭ-form; "wedge-shaped").

Metatarsus

The **metatarsus** of the foot, which corresponds to the metacarpus of the hand, consists of five small long bones called **metatarsals.** These bones are numbered 1 to 5 beginning on the medial side of the foot (Figure 8.12a). The first metatarsal at the base of the big toe is the largest, and it plays an important role in supporting the weight of the body. The metatarsals are more nearly parallel to one another than are the metacarpals in the palm. Distally, where the metatarsals articulate with the proximal phalanges of the toes, the enlarged head of the first metatarsal forms the "ball" of the foot.

METATARSAL STRESS FRACTURE One of the most common foot injuries, **metatarsal stress fracture,** results from repetitive stress on the foot, typically as a result of increasing one's running mileage too quickly. The second and third metatarsals are most often affected. Treatment generally involves resting the foot and wearing stiff or well-cushioned shoes.

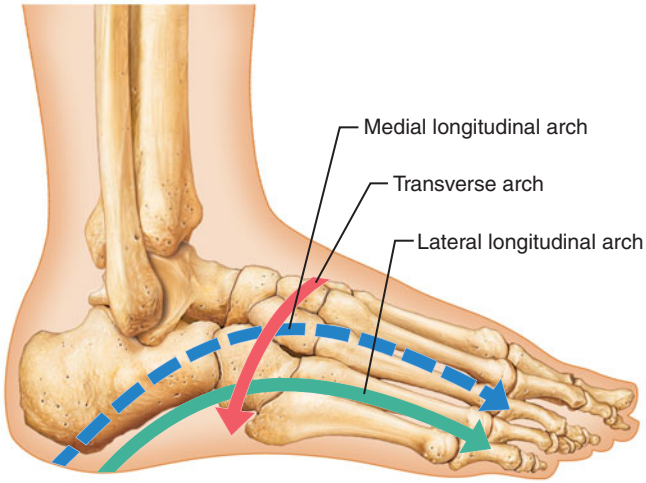
Phalanges of the Toes

The 14 phalanges of the toes are smaller than those of the fingers and thus are less nimble. Still, their general structure and arrangement are the same: There are three phalanges in each digit except the great toe (the *hallux*), which has only two phalanges. As in the hand, these toe bones are named *proximal, middle,* and *distal phalanges.*

Arches of the Foot

A structure composed of multiple components can support weight only if it is arched. The foot has three arches: the medial and lateral *longitudinal* arches and the *transverse* arch **(Figure 8.13)**. These arches are maintained by the interlocking shapes of the foot bones, by strong ligaments, and by the pull of some tendons during muscle activity; the ligaments and tendons also provide resilience. As a result, the arches "give" when weight is applied to the foot, then spring back when the weight is removed.

If you examine your wet footprints, you will see that the foot's medial margin, from the heel to the distal end of the first metatarsal, leaves no print. This is because the **medial longitudinal arch** (Figure 8.13b) curves well above the ground. The talus, near the talonavicular joint, is the keystone of this



(a) Lateral aspect of right foot

(b) X-ray, medial aspect of right foot; keystone of medial longitudinal arch at arrow.

FIGURE 8.13 Arches of the foot.

arch, which originates at the calcaneus, rises to the talus, and then descends to the three medial metatarsals. The **lateral longitudinal arch** is very low. It elevates the lateral edge of the foot just enough to redistribute some of the body weight to the calcaneus and some to the head of the fifth metatarsal (that is, to the two ends of the arch). The cuboid bone is the keystone of this lateral arch. The two longitudinal arches serve as pillars for the **transverse arch,** which runs obliquely from one side of the foot to the other, following the line of the joints between the tarsals and metatarsals. Together, the three arches form a half dome that distributes approximately half of a person's standing and walking weight to the heel bones and half to the heads of the metatarsals.

As previously mentioned, various tendons run inferior to the foot bones and help support the arches of the foot. The muscles associated with these tendons are less active during standing than walking. Therefore, people who stand all day at their jobs may develop fallen arches, or "flat feet." Running on hard surfaces can also cause arches to fall, unless one wears shoes that give proper arch support.

check your understanding

12. What specific feature of the hip bone articulates with the head of the femur?
13. What structures form the two bony "bumps" on either side of your ankle?
14. On what bone is each of the following features located: lateral malleolus, linea aspera, lesser trochanter, fibular notch, talar shelf, tibial tuberosity?
15. What is the keystone of the medial longitudinal arch of the foot? How do the arches of the foot distribute body weight?

For answers, see Appendix B.

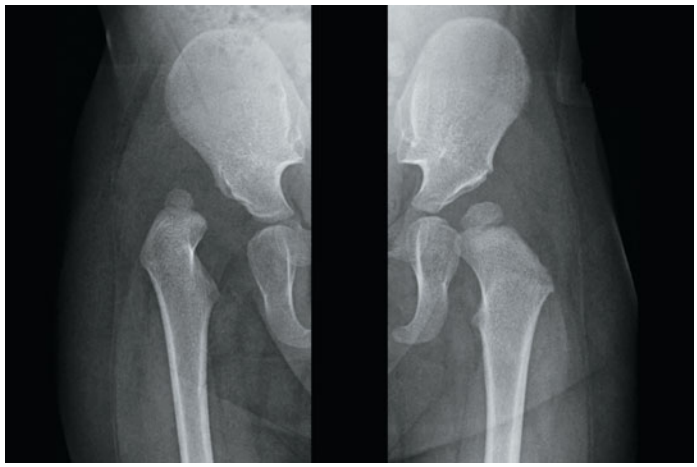
DISORDERS OF THE APPENDICULAR SKELETON

➤ Describe two congenital disorders: hip dysplasia and clubfoot.

Most disorders of the appendicular skeleton are bone fractures, which are discussed in association with individual bones (also see Table 6.2, p. 140). Two other significant disorders are birth defects.

Hip dysplasia (congenital dislocation of the hip) (*dysplasia* = misformed) is a relatively common birth defect; in fact, up to 4% of babies are treated for it. In this condition, which affects females more than males, either the acetabulum fails to form completely or the ligaments of the hip joint are loose. In either case the head of the femur tends to slip out of its socket **(Figure 8.14a)**. Early diagnosis and treatment are essential to avoid permanent crippling. Treatment generally involves using a splint or a harness of straps to hold the femur in its proper position, so that the acetabulum can grow properly and the ligaments can tighten on their own. In extreme cases or those that are diagnosed late, surgery may be needed to repair and tighten the ligaments of the hip.

In **clubfoot,** which occurs in about 1 of every 700 births, the soles of the feet turn medially and the toes point inferiorly (Figure 8.14b). This disorder may be genetically induced or may result from the abnormal positioning of the feet (such as being folded against the chest) during fetal development. Clubfoot is treated by applying one cast after another to adjust the position of the growing foot or, in extreme cases, by surgery.



(a) Hip dysplasia. Normal structure of the hip in an infant shown on the right; displaced femoral head apparent in the hip on the left.

(b) Club feet. Both feet turned in; child's left foot shows classic club foot positioning.

FIGURE 8.14 Congenital disorders of the lower limb.

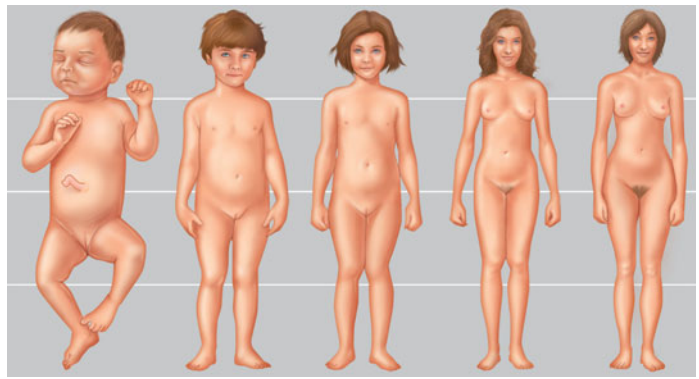


FIGURE 8.15 Changes in body proportions throughout life. During growth, the arms and legs grow faster than the head and trunk, as can be seen in this figure of different-aged individuals all drawn at the same height.

THE APPENDICULAR SKELETON THROUGHOUT LIFE

➤ Describe how the lengths of the limbs change, relative to the length of the head and trunk, as humans grow.

During youth, the growth of the appendicular skeleton not only increases the body's height but also changes the body's proportions **(Figure 8.15)**. More specifically, the **upper-lower (UL) body ratio** changes with age. In this ratio, the *lower body segment* (L) is the distance from the top of the pelvic girdle to the ground, whereas the *upper body segment* (U) is the difference between the lower body segment's height and the person's total height.

At birth, the UL ratio is about 1.7 to 1. Thus, the head and trunk are more than 1.5 times as long as the lower limbs. The lower limbs grow faster than the trunk from this time on, however, and by age 10, the UL ratio is about 1 to 1, and it changes little thereafter. During puberty, the female pelvis broadens in preparation for childbearing, and the entire male skeleton becomes more robust.

Once adult height is reached, a healthy appendicular skeleton changes very little until middle age. Then it loses mass, and osteoporosis and limb fractures become more common.

check your understanding

16. In males, what changes in the skeleton occur at puberty? In females?
17. Considering what you know about how the hip bones form, why can hip dysplasia be successfully treated by splinting if applied early?

For answers, see Appendix B.

RELATED CLINICAL TERMS

BUNION A deformity of the great toe involving lateral displacement of this digit and medial displacement of metatarsal 1. Also includes a bony swelling and a bursitis (p. 234) on the medial side of the head of the first metatarsal. Caused by tight or ill-fitting shoes (or, more rarely, by arthritis or genetic factors).

KNOCK-KNEE A deformity in which the two knees rub or knock together during walking. Knock-knee usually occurs in children because of irregular growth of the bones of the lower limb, injury to the ligaments, or injury to the bone ends at the knee.

LISFRANC INJURY Damage to the joints between the tarsal and metatarsal bones of the foot that results from violently twisting or bending the anterior part of the foot on the posterior part, as can occur in a fall. Generally involves the cuneiforms and the first three metatarsals. The metatarsal bases may be dislocated and the intercuneiform joints damaged, often with fractures of these bones.

PELVIMETRY Measurement of the dimensions of the inlet and outlet of the pelvis, usually to determine whether it is of adequate size to allow normal delivery of a baby.

PODIATRY The specialized field dealing with the study and care of the foot, including its anatomy, disorders, and medical and surgical treatment.

CHAPTER SUMMARY

You can use the following media study tool for additional help when you review specific key topics in Chapter 8.

PAL = ***Practice Anatomy Lab***™

1. The appendicular skeleton consists of the pectoral and pelvic girdles and the bones of the upper and lower limbs.

The Pectoral Girdle (pp. 183–185)

2. The pectoral girdles are specialized for mobility. Each consists of a clavicle and a scapula and attaches an upper limb to the bony thorax.
3. The clavicles hold the arms laterally away from the thorax and transmit pushing forces from the upper limbs to the thorax.
4. Each triangular scapula articulates with a clavicle and a humerus. The borders, angles, and features of the scapula are summarized in Table 8.1 on p. 186.

The Upper Limb (pp. 184–191)

5. Each upper limb consists of 30 bones and is specialized for mobility. See Table 8.1, p. 186, for summary.
6. The skeleton of the arm consists solely of the humerus. The head of the humerus articulates with the glenoid cavity of the scapula, forming the shoulder joint.
7. The bones of the forearm are the radius and ulna. The radius is lateral and the ulna medial. Articulations between these bones are highly mobile, allowing the radius to rotate around the ulna. Proximally, the ulna contributes heavily to the elbow joint. Distally, the radius contributes to the wrist joint.
8. The bones of the hand are the carpals, metacarpals, and phalanges.

The Pelvic Girdle (pp. 191–194, 195)

9. The pelvic girdle, specialized for bearing weight, is composed of two hip bones that connect the lower limbs to the vertebral column. Together with the sacrum, the hip bones form the basinlike bony pelvis.
10. Each hip bone (coxal bone) consists of an ilium, ischium, and a pubis fused together. The cuplike acetabulum is at the Y-shaped region of fusion of these three bones.
11. The ilium is the superior flaring part of the hip bone. Each ilium forms a secure joint with the sacrum. The ischium is a curved bar of bone; when a person sits, the weight is borne by the ischial tuberosities. The V-shaped pubic bones join anteriorly at the pubic symphysis.
12. The pelvic inlet or pelvic brim, an oval ridge that includes the pubic crest, arcuate line of the ilium, and sacral promontory, separates the superior false pelvis from the inferior true pelvis.
13. The male pelvis is relatively deep and narrow, with larger, heavier bones; the female pelvis, which forms the birth canal, is comparatively shallower and wider (see Table 8.2, p. 195).

The Lower Limb (pp. 194–201)

14. The lower limb consists of the thigh, leg, and foot, and is specialized for weight bearing and locomotion. See Table 8.3, p. 196, for a summary.
15. The long, thick femur is the only bone of the thigh. Its ball-shaped head articulates with the acetabulum.
16. The bones of the leg are the tibia (which participates in both the knee and ankle joints), located medially, and the slender fibula laterally.
17. The bones of the foot are the tarsals, metatarsals, and phalanges. The most important tarsals are the calcaneus (heel bone) and the talus. The talus articulates with the leg bones at the ankle joint.
18. The foot is supported by three arches that distribute the weight of the body to the heel and ball of the foot.

PAL **Human Cadaver/Appendicular Skeleton**

Disorders of the Appendicular Skeleton (pp. 201–202)

19. Hip dysplasia (congenital dislocation of the hip) and clubfoot are common birth defects.

The Appendicular Skeleton Throughout Life (p. 202)

20. Fast growth of the lower limbs causes the upper-lower (UL) body ratio to change from 1.7:1 at birth to 1:1 at 10 years and beyond.

REVIEW QUESTIONS

Multiple Choice/Matching Questions

For answers, see Appendix B.

1. Match the bones listed in column B to their descriptions in column A. Answers in column B may be used more than once.

Column A	Column B
—— **(1)** bone of the axial skeleton to which the pectoral girdle attaches	**(a)** clavicle
—— **(2)** its features include the glenoid cavity and acromion process	**(b)** ilium
—— **(3)** its features include the ala, crest,and greater sciatic notch	**(c)** ischium
—— **(4)** membrane bone that transmits forces from upper limb to bony thorax	**(d)** pubis
—— **(5)** bone of pelvic girdle that articulates with the axial skeleton	**(e)** sacrum
—— **(6)** bone that bears weight during sitting	**(f)** scapula
—— **(7)** most anteroinferior bone of the pelvic girdle	**(g)** sternum
—— **(8)** bone of the axial skeleton to which the pelvic girdle attaches	

2. Match the bones in column B to their descriptions in column A. Answers in column B may be used more than once.

Column A	Column B
—— **(1)** articulates with the acetabulum and the tibia	**(a)** carpals
—— **(2)** its malleolus forms the lateral aspect of the ankle	**(b)** femur
—— **(3)** bone that articulates with the hand and wrist	**(c)** fibula
—— **(4)** the wrist bones	**(d)** humerus
—— **(5)** bone shaped much like a monkey wrench	**(e)** radius
—— **(6)** articulates with the capitulum of the humerus	**(f)** tarsals
—— **(7)** largest bone is the calcaneus	**(g)** tibia
	(h) ulna

3. Which of the following bony features is *not* near or in the shoulder joint? (a) acromion, (b) greater tubercle, (c) glenoid cavity, (d) anatomical neck of humerus, (e) deltoid tuberosity.

4. Which of the following bony features is not in or near the hip joint? (a) acetabulum, (b) sacral promontory, (c) greater trochanter, (d) neck of femur.

5. Which of the bones listed does *not* have a head? (a) radius, (b) femur, (c) ulna, (d) tibia, (e) fibula.

6. The greater and lesser tubercles are located on the (a) humerus, (b) coxal bone, (c) femur, (d) ankle, (e) tibia.

7. From the list of bones given, indicate all those that have a styloid process. (a) clavicle, (b) scapula, (c) radius, (d) ulna, (e) tibia, (f) fibula.

8. The lateral malleolus is the (a) proximal portion of the fibula, (b) distal portion of the tibia, (c) distal portion of the fibula, (d) proximal portion of the ulna, (e) bone in the middle ear cavity.

9. In the forearm, the radius is the —— bone; therefore, the radial notch of the ulna points ——. (a) lateral/medially, (b) lateral/laterally, (c) medial/medially, (d) medial/laterally.

10. The scaphoid and lunate articulate with the (a) metacarpals, (b) radius and ulna, (c) radius, (d) tibia, (e) trapezium.

Short Answer Essay Questions

11. The major function of the pectoral girdle is mobility. (a) What is the major function of the pelvic girdle? (b) Relate these functional differences to the anatomical differences between the girdles.

12. List three differences between the male and female pelves.

13. Describe the function of the arches of the foot.

14. Briefly describe the anatomical characteristics and impairment of function seen in hip dysplasia.

15. Define and distinguish the true pelvis from the false pelvis.

16. Lance was a bright anatomy student, but he sometimes called the leg bones "fibia" and "tibula." Correct this common mistake.

17. Draw the scapula in posterior view, and label all the borders, angles, fossae, and important features visible in this view.

18. Identify the associated bone and the location of each of the following bone features: (a) greater trochanter, (b) linea aspera, (c) trochlea, (d) coronoid process, (e) deltoid tuberosity, (f) greater tubercle, (g) greater sciatic notch.

19. (a) Which body regions do anatomists call the arm and the leg? (b) What is the *medial* side of the hand?

20. Tom Williams, a teaching assistant in anatomy class, picked up a bone and pretended it was a telephone. He put the big hole in this bone up to his ear and said, "Hello, obturator, obturator (operator, operator)." Name the bone and the structure he was helping the students to learn.

21. Name all the bones of the appendicular skeleton that have a tuberosity.

22. The hand and foot are structurally similar in many ways; they also show clear differences in structure related to their different functions. Describe the structural features of the foot that are clearly related to its weight-bearing and locomotory functions.

CRITICAL REASONING & CLINICAL APPLICATION QUESTIONS

1. Malcolm injured himself after trying to break his fall with outstretched arms. The emergency room physician took one look at his shoulder and saw that Malcolm had a broken clavicle (and no other injury). Describe the position of Malcolm's shoulder. What part of the clavicle was most likely broken? Malcolm was worried about injury to the main blood vessels to his arm (the subclavian vessels), but he was told such injury was unlikely. Why could the doctor predict this?
2. Racheal, a hairdresser, developed flat feet. Explain why.
3. Justiniano worked in a poultry-packing plant, where his job was cutting open chickens and stripping out their visceral organs. After work, he typed for long hours on his computer keyboard, because he was writing a novel based on his work in the plant. Soon, his wrist and hand began to hurt whenever he flexed them, and he began to awaken at night with pain and tingling on the thumb half of his hand. What condition did he probably have?
4. Compare the bones of the upper limb with the bones of the lower limb. How are they similar; how are they different? How do these differences relate to different functions of the upper versus the lower limb?
5. The most common bone fracture in people under 75 years old is a wrist fracture, either fracture of the scaphoid or fracture of the distal radius (Colles' fracture). This injury results from falling on an outstretched hand. Why is the radius injured in this type of fall and not the ulna?