9 Joints

A healthy knee joint (colored X ray).

The rigid elements of the skeleton meet at sites called **joints,** or **articulations.** The Greek root *arthro* means "joint," and the scientific study of joints is called *arthrology* (ar-throl′o-je). Two important functions of bone are support and movement. It is the articulation of bones at joints and the contraction of skeletal muscles that attach to the bones that cause movement. The graceful movements of dancers and gymnasts attest to the great variety of motions that joints allow. Even though joints are always the weakest points of any skeleton, their structure enables them to resist crushing, tearing, and the various forces that would drive them out of alignment.

CLASSIFICATION OF JOINTS

➤ Classify the joints by structure and by function.

Joints can be classified either by function or structure. The *functional classification* focuses on the amount of movement allowed. Accordingly, **synarthroses** (sin″ar-thro′sēz; *syn* = together; *arthro* = joint) are immovable joints, **amphiarthroses** (am″fe-ar-thro′sēz; amphi = of both kinds) are slightly movable joints, and **diarthroses** (di″ar-thro′sēz; *di* = two) are freely movable joints. Diarthroses predominate in the limbs, whereas synarthroses and amphiarthroses are largely restricted to the axial skeleton.

The *structural classification* is based on the material that binds the bones together and on the presence or absence of a joint cavity. Structurally, joints are classified as **fibrous, cartilaginous,** or **synovial joints** (Table 9.1).

In this chapter the discussion of joints is organized according to the structural classification, and functional properties are noted where appropriate.

FIBROUS JOINTS

➤ Describe the general structure of fibrous joints. Provide examples of the three types of fibrous joints.

In fibrous joints (Figure 9.1), the bones are connected by fibrous tissue, namely dense regular connective tissue. No joint cavity is present. Most fibrous joints are immovable or only slightly movable. The types of fibrous joints are *sutures, syndesmoses,* and *gomphoses.*

Sutures

In **sutures,** literally "seams," the bones are tightly bound by a minimal amount of fibrous tissue (Figure 9.1a). Sutures occur only between bones of the skull, and their fibrous tissue is continuous with the periosteum around these flat bones. At sutures, the edges of the joining bones are wavy and interlocking. Sutures not only knit the bones together but also allow growth so that the skull can expand with the brain during childhood. During middle age, the fibrous tissue ossifies, and the skull bones fuse together. At this stage, the closed sutures are more precisely called *synostoses* (sin″os-to′sēz), literally, "bony junctions." Because movement of the cranial bones would damage the brain, the immovable nature of sutures is a protective adaptation.

TABLE 9.1 Summary of Joint Classes

Structural Class	Structural Characteristics	Types	Mobility
Fibrous	Adjoining bones united by collagenic fibers	1. Suture (short fibers)	Immobile (synarthrosis)
		2. Syndesmosis (longer fibers)	Slightly mobile (amphiarthrosis) and immobile
		3. Gomphosis (periodontal ligament)	Immobile
Cartilaginous	Adjoining bones united by cartilage	1. Synchondrosis (hyaline cartilage)	Immobile
		2. Symphysis (fibrocartilage)	Slightly movable
Synovial	Adjoining bones separated by a joint cavity, covered with articular cartilage, and enclosed within an articular capsule lined with synovial membrane	1. Plane 2. Hinge 3. Pivot 4. Condyloid 5. Saddle 6. Ball and socket	Freely movable (diarthrosis); movements depend on design of joint

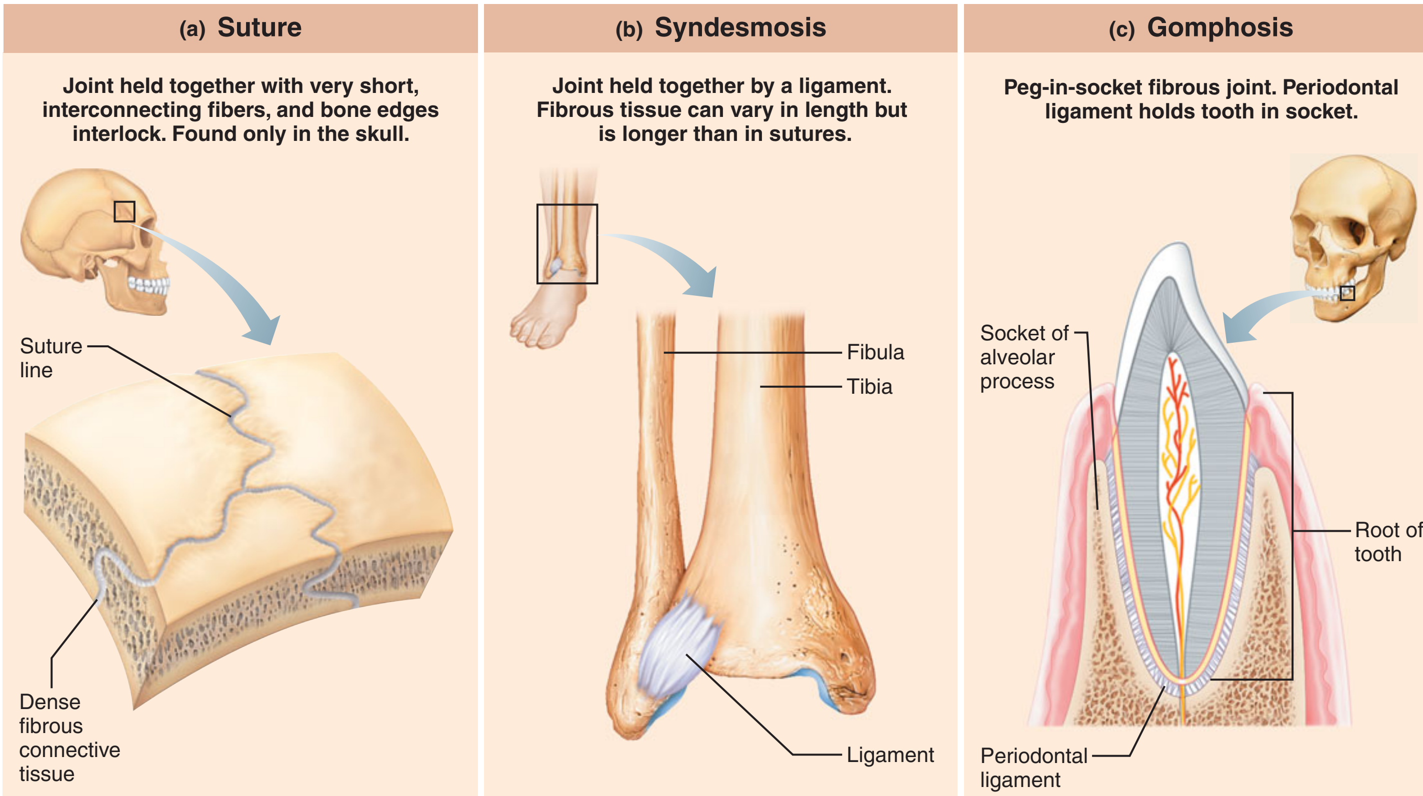


FIGURE 9.1 Fibrous joints.

Syndesmoses

In **syndesmoses** (sin″des-mo′sēz), the bones are connected exclusively by ligaments, bands of fibrous tissue longer than those that occur in sutures (Figure 9.1b). In fact, the name *syndesmosis* derives from the Greek word for "ligament."

The amount of movement allowed at a syndesmosis depends on the length of the connecting fibers. If the fibers are short, as in the distal tibiofibular articulation (Figure 9.1b), little to no movement is allowed. If the fibers are quite long, as in the interosseous membrane between the radius and ulna (see Figure 8.4 on p. 188), a large amount of movement is possible.

Gomphoses

A **gomphosis** (gom-fo′sis; "bolt") is a peg-in-socket joint. The only example is the articulation of a tooth with its socket (Figure 9.1c). In this case, the connecting ligament is the short *periodontal ligament.*

CARTILAGINOUS JOINTS

➤ Describe cartilaginous joints, and give examples of the two main types.

In cartilaginous (kar″tĭ-laj′ĭ-nus) joints, the articulating bones are united by cartilage **(Figure 9.2)**. Cartilaginous joints lack a joint cavity and are not highly movable. There are two types of cartilaginous joints: *synchondroses* and *symphyses.*

Synchondroses

A joint where *hyaline* cartilage unites the bones is a **synchondrosis** (sin″kon-dro′sis; "junction of cartilage"; Figure 9.2a). The epiphyseal plates are synchondroses. Functionally, these plates are classified as immovable synarthroses. Another example is the immovable joint between the first rib's costal cartilage and the manubrium of the sternum.

Symphyses

A joint where *fibrocartilage* unites the bones is a **symphysis** (sim′fĭ-sis; "growing together"). Examples include the intervertebral discs and the pubic symphysis of the pelvis (Figure 9.2b). Even though fibrocartilage is the main element of a symphysis, hyaline cartilage is also present in the form of articular cartilages on the bony surfaces. The articular cartilages function to reduce friction between the bones during movement. You learned in Chapter 6 that fibrocartilage resists both tension and compression stresses and can act as a resilient shock absorber. Symphyses, then, are slightly movable joints (amphiarthroses) that provide strength with flexibility.

check your understanding

1. Define each of the following terms: synarthrosis, syndesmosis, synchondrosis. Which of these terms is a functional classification of joints?

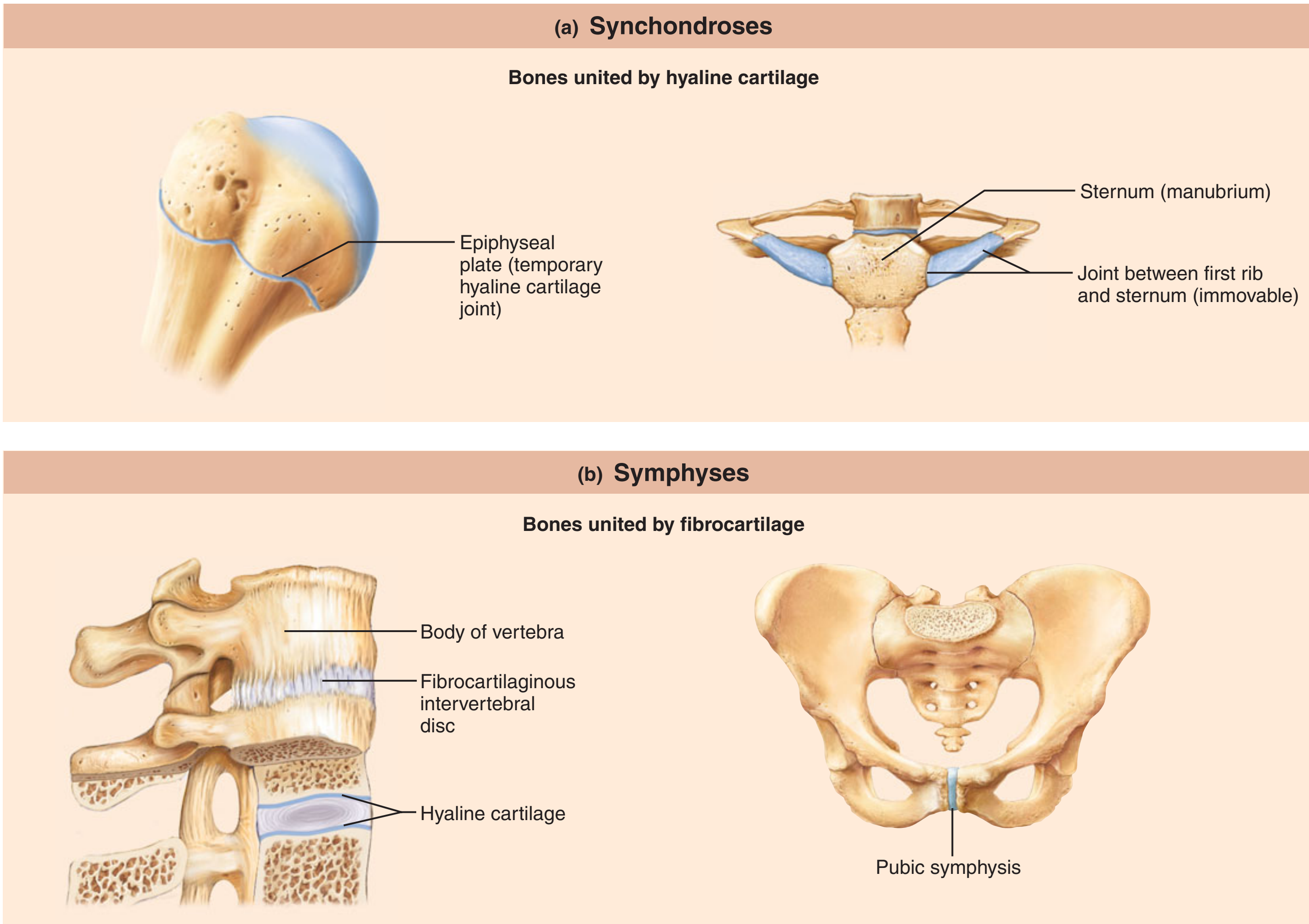


FIGURE 9.2 Cartilaginous joints.

2. What types of cartilage are found in a symphysis joint? Name one location of this type of joint.

For answers, see Appendix B.

SYNOVIAL JOINTS

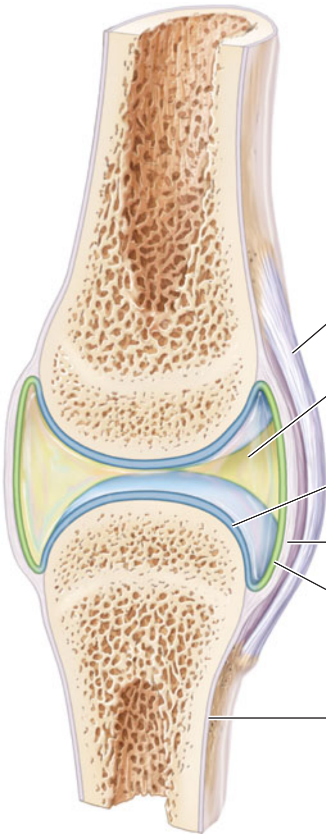
- Describe the structural characteristics shared by all synovial joints.
- Define bursa and tendon sheath.
- Explain how synovial joints function.
- List three factors that influence the stability of synovial joints.

Synovial joints (sĭ-no′ve-al; "joint eggs") are the most movable joints of the body, and all are diarthroses (freely movable). Each synovial joint contains a fluid-filled *joint cavity*. Most joints of the body are in this class, especially those in the limbs (see Table 9.2, pp. 218–220).

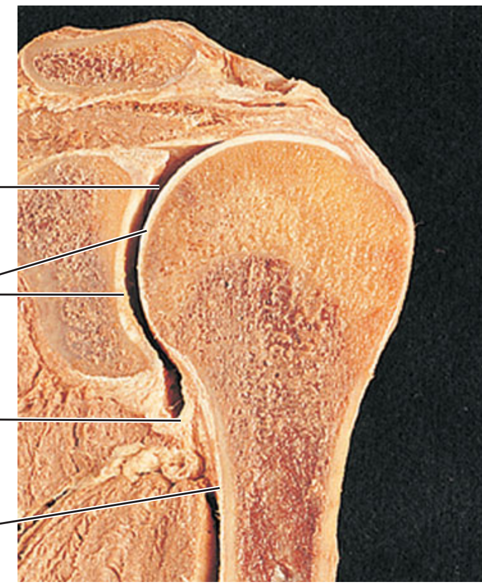
General Structure of Synovial Joints

Synovial joints (Figure 9.3) have the following basic features:

1. **Articular cartilage.** The ends of the opposing bones are covered by articular cartilages composed of hyaline cartilage. These spongy cushions absorb compressive forces placed on the joint and thereby keep the bone ends from being crushed.
2. **Joint cavity (synovial cavity).** A feature unique to synovial joints, the joint cavity is really just a potential space that holds a small amount of synovial fluid.
3. **Articular capsule.** The joint cavity is enclosed by a two-layered articular capsule, or joint capsule. The outer layer is a **fibrous capsule** of dense irregular connective tissue that is continuous with the periosteum layer of the joining bones. It strengthens the joint so that the bones are not pulled apart. The inner layer of the capsule is a **synovial membrane** composed of loose connective tissue. In addition to lining the joint capsule, this membrane covers all the internal joint surfaces not covered by cartilage. Its function is to make synovial fluid.



(a) A typical synovial joint



(b) Frontal section through the shoulder joint

FIGURE 9.3 General structure of synovial joints.

4. **Synovial fluid.** The viscous liquid inside the joint cavity is called synovial fluid because it resembles raw egg white (*ovum* = egg). Synovial fluid is primarily a filtrate of blood, arising from capillaries in the synovial membrane. It also contains special glycoprotein molecules, secreted by the fibroblasts in the synovial membrane, that make synovial fluid a slippery lubricant that eases the movement at the joint. Synovial fluid not only occupies the joint cavity but also occurs *within* the articular cartilages. The pressure placed on joints during normal movement squeezes synovial fluid into and out of the articular cartilages, nourishing the cells in these cartilages (remember that cartilage is avascular) and lubricating their free surfaces.
5. **Reinforcing ligaments.** Some synovial joints are reinforced and strengthened by bandlike ligaments. Most often, the ligaments are intrinsic, or *capsular;* that is, they are thickened parts of the fibrous capsule itself. In other cases, the ligaments are *extracapsular* or *intracapsular.* Extracapsular ligaments are located just outside the capsule, for instance, the fibular and tibial collateral ligaments of the knee **(Figure 9.4)**. Intracapsular ligaments are internal to the capsule, for example, the anterior and posterior cruciate ligaments in the knee (see Figure 9.15e). Intracapsular ligaments are covered with a synovial membrane that separates them from the joint cavity through which they run.
6. **Nerves and vessels.** Synovial joints are richly supplied with sensory nerve fibers that innervate the articular capsule. Some of these fibers detect pain, as anyone who has suffered a joint injury is aware, but most monitor how much the capsule is being stretched. This monitoring of joint stretching is one of several ways by which the nervous system senses our posture and body movements

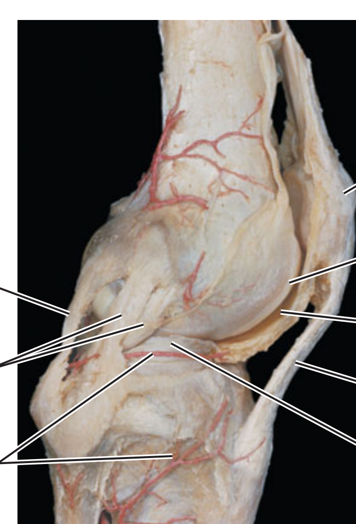
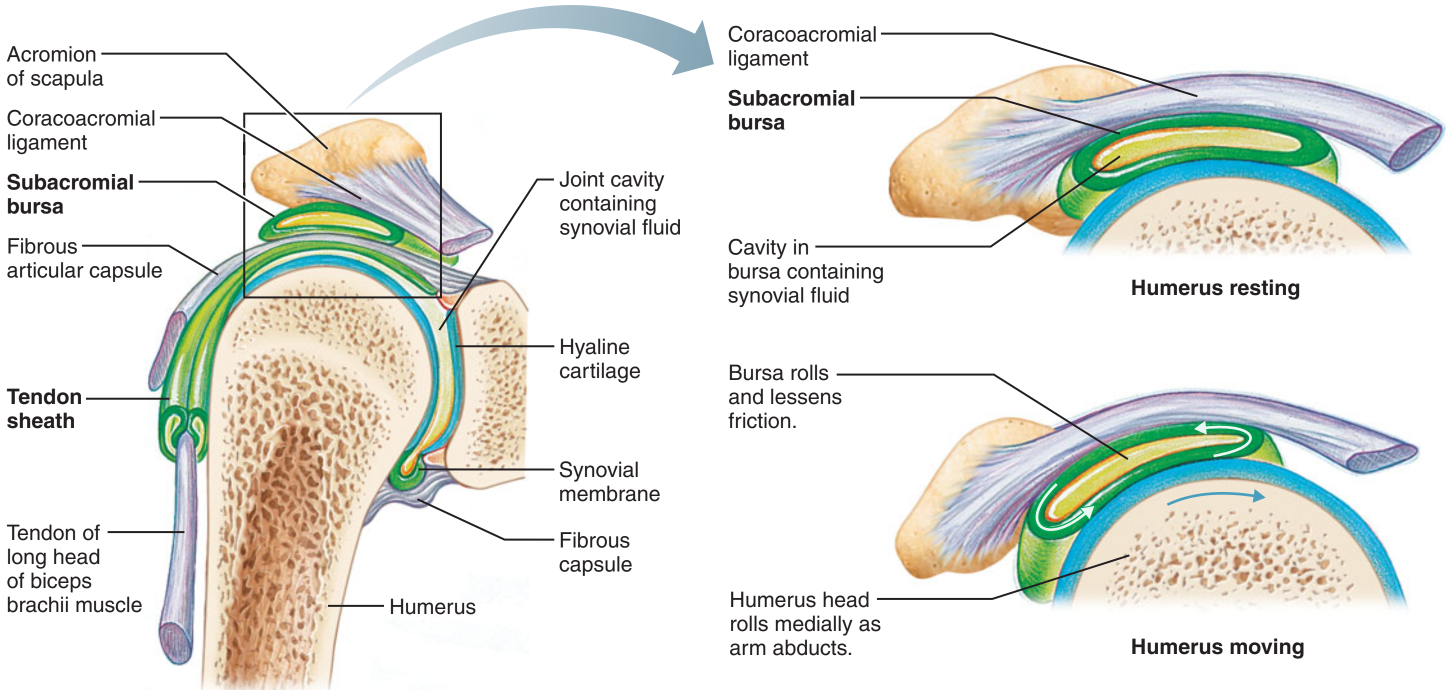


FIGURE 9.4 Dissection of the knee. Lateral View.



(a) Frontal section through the right shoulder joint

(b) Enlargement of (a), showing how a bursa eliminates friction where a ligament (or other structure) would rub against a bone

FIGURE 9.5 Bursae and tendon sheaths.

(see p. 350). Synovial joints also have a rich blood supply. Most of the blood vessels supply the synovial membrane, where extensive capillary beds produce the blood filtrate that is the basis of synovial fluid.

Each synovial joint is served by branches from several major nerves and blood vessels. These branches come from many different directions and supply overlapping areas of the joint capsule (Figure 9.4). Such overlap provides functional redundancy: When the normal movements at a joint compress a blood vessel, other vessels stay open and keep the joint nourished. Furthermore, when an injury to a joint destroys some vessels and nerves, others survive and keep the joint functioning.

Certain synovial joints contain a disc of fibrocartilage (Figure 9.4), called an **articular disc** or a **meniscus** (mĕ-nis′kus; "crescent"). Articular discs occur in the temporomandibular (jaw) joint, sternoclavicular joint, knee joint, and a few others (see Table 9.3). Such a disc extends internally from the capsule and completely or partly divides the joint cavity in two. Articular discs occur in joints whose articulating bone ends have somewhat different shapes. When two articulating surfaces fit poorly, they touch each other only at small points, where the loading forces become highly concentrated; this can damage the articular cartilages and lead to osteoarthritis. An articular disc fills the gaps and improves the fit, thereby distributing the load more evenly and minimizing wear and damage. These discs may also allow two different movements at the same joint—a distinct movement across each face of the disc, as is the case with the jaw joint.

Bursae and tendon sheaths contain synovial fluid and often are associated with synovial joints. Essentially closed bags of lubricant, these structures act like "ball bearings" to reduce friction between body elements that move over one another (Figure 9.5). A **bursa** (ber′sah), a Latin word meaning "purse," is a flattened fibrous sac lined by a synovial membrane. Bursae occur where ligaments, muscles, skin, tendons, or bones overlie each other and rub together. A **tendon sheath** is essentially an elongated bursa that wraps around a tendon like a bun around a hot dog (see Figure 9.5a). Tendon sheaths occur only on tendons that are subjected to friction, such as those that travel through joint cavities or are crowded together within narrow canals (as in the carpal tunnel of the wrist, for example).

General Function of Synovial Joints

Synovial joints are elaborate lubricating devices that allow joining bones to move across one another with a minimum of friction. Without this lubrication, rubbing would wear away the joint surfaces, and excessive friction could overheat and destroy the joint tissues, essentially "cooking" them.

Synovial joints are routinely subjected to *compressive* forces that occur when the muscles that move bones pull the bone ends together. As the opposing articular cartilages touch, synovial fluid is squeezed out of them, producing a film of lubricant between the cartilage surfaces. The two moving cartilage surfaces ride on this slippery film, not on each other. Synovial fluid is such an effective lubricant that the surfaces slide with less friction than ice sliding on ice. When the pressure on the joint ceases, the synovial fluid rushes back into the articular cartilages like water into a sponge, ready to be squeezed out again the next time a load is placed on the joint. This mechanism is called **weeping lubrication.**

check your understanding

3. List the six basic features of synovial joints.
4. How does an articular disc differ from articular cartilage?
5. What are the functions of synovial fluid?

For answers, see Appendix B.

Movements Allowed by Synovial Joints

- ➤ Name and describe the common types of body movements.
- ➤ Classify synovial joints into six categories according to the shapes of their joint surfaces and the types of movement they allow. Give examples of joints in each class.

As muscles contract, they cause bones to move at the synovial joints. The resulting movements are of three basic types: (1) *gliding* of one bone surface across another; (2) *angular movements,* which change the angle between the two bones; and (3) *rotation* about a bone's long axis. These movements are illustrated in Figure 9.6 and summarized in Table 9.2.

Gliding

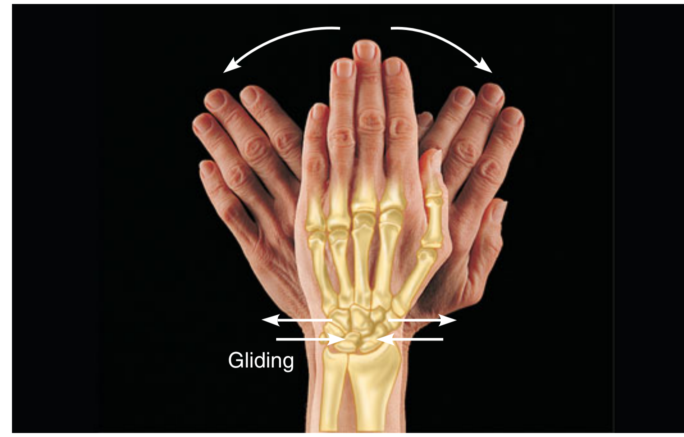
In **gliding,** the nearly flat surfaces of two bones slip across each other (Figure 9.6a). Gliding occurs at the joints between the carpals and tarsals and between the flat articular processes of the vertebrae.

Angular Movements

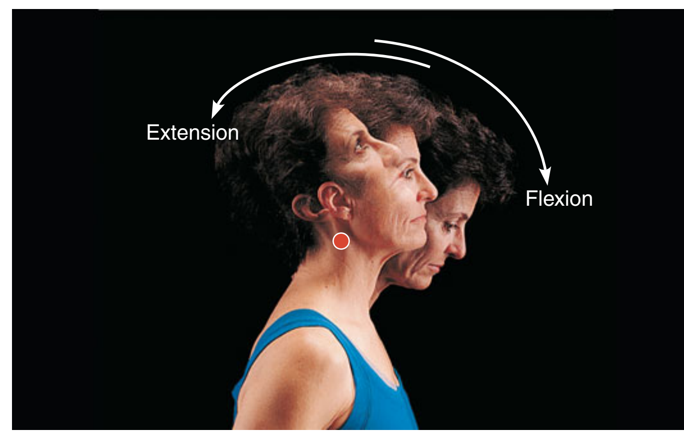
Angular movements (Figure 9.6b–e) increase or decrease the angle between two bones. These movements, which may occur in any plane of the body, include flexion, extension, abduction, adduction, and circumduction.

Flexion **Flexion** is movement that *decreases the angle* between the bones, bringing these bones closer together (Figure 9.6b–d). This motion usually occurs in the sagittal plane of the body. Examples include flexion of the neck or trunk (Figure 9.6b and c); flexion of the fingers, as in making a fist; and flexion of the forearm toward the arm at the elbow. In less obvious examples, the arm is flexed at the shoulder when moved in an anterior direction, Figure 9.6d, and the hip is flexed when the thigh moves anteriorly.

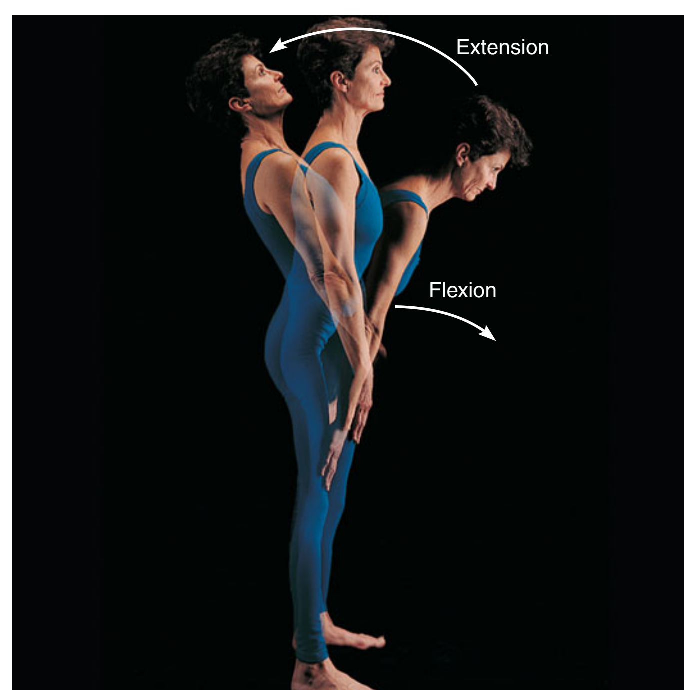
Extension **Extension** is the reverse of flexion and occurs at the same joints (see Figure 9.6b–d). It *increases the angle* between the joining bones and is a straightening action.



(a) Gliding movements at the wrist

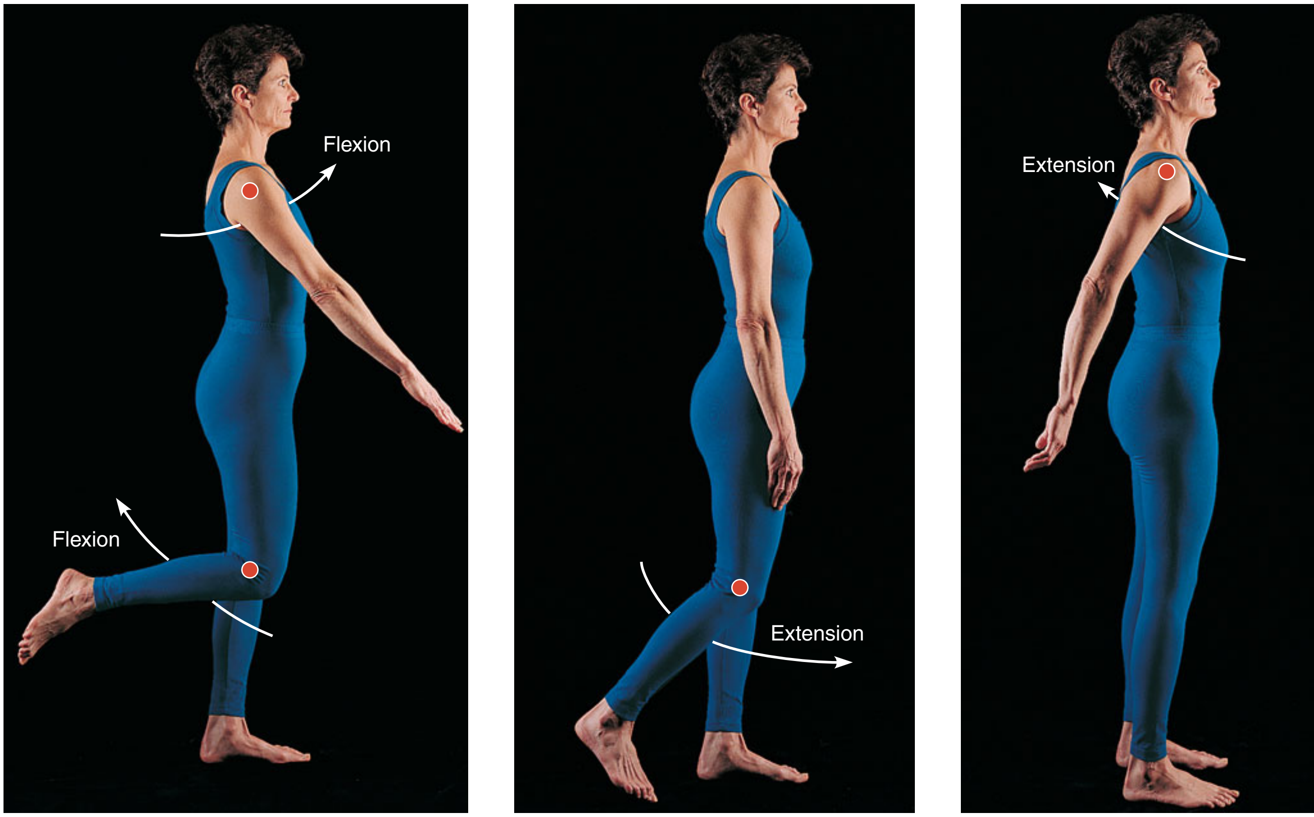


(b) Angular movements: flexion and extension of the neck



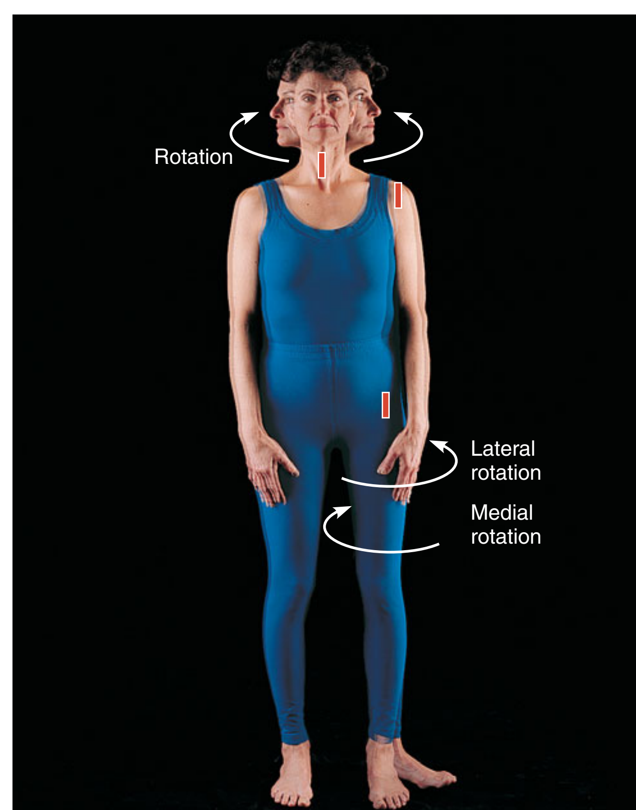
(c) Angular movements: flexion and extension of the trunk

FIGURE 9.6 Movements allowed by synovial joints. The axis around which each movement occurs is indicated by a red dot in (b), (d), and (e), and by a red bar in (f).



(d) Angular movements: flexion and extension at the shoulder and knee

(e) Angular movements: abduction, adduction, and circumduction of the upper limb at the shoulder



(f) Rotation of the head, neck, and lower limb

FIGURE 9.6 Movements allowed by synovial joints, *continued.* The axis around which each movement occurs is indicated by a red dot in (b), (d), and (e), and by a red bar in (f).

TABLE 9.2 Movements at Synovial Joints

Movement	Definition
GLIDING (Figure 9.6a)	Sliding the flat surfaces of two bones across each other
ANGULAR MOVEMENTS (Figure 9.6b–e)	
Flexion	Decreasing the angle between two bones
Extension	Increasing the angle between bones
Abduction	Moving a limb away from the body midline
Adduction	Moving a limb toward the body midline
Circumduction	Moving a limb or finger so that it describes a cone in space
ROTATION (Figure 9.6f)	Turning a bone around the longitudinal axis
Medial rotation	Rotating toward the medial plane
Lateral rotation	Rotating away from the medial plane

Straightening the fingers after making a fist is an example of extension. At the shoulder and the hip, extension moves the limb posteriorly (see the shoulder extension in Figure 9.6d). Bending a joint back beyond its normal range of motion is called **hyperextension** (literally, "superextension"). Individuals who have loose ligaments that allow a greater range of motion can be capable of hyperextending the joints.

Abduction **Abduction,** from Latin words meaning "moving away," is movement of a limb *away* from the body midline. Raising the arm or thigh laterally is an example of abduction (Figure 9.6e). For the fingers or toes, *abduction* means spreading them apart. In this case, the "midline" is the longest digit: the third finger or the second toe. Note that bending the trunk away from the body midline to the right or left is called *lateral flexion* instead of abduction.

Adduction **Adduction** ("moving toward") is the opposite of abduction: the movement of a limb *toward* the body midline (Figure 9.6e) or, in the case of the digits, toward the midline (longest digit) of the hand or foot.

Circumduction **Circumduction** ("moving in a circle") is moving a limb or finger so that it describes a cone in space (Figure 9.6e). This is a complex movement that combines flexion, abduction, extension, and adduction in succession.

Rotation

Rotation is the turning movement of a bone around the longitudinal axis. This is the only movement allowed between the first two cervical vertebrae. The entire vertebral column also rotates, twisting the whole trunk to the right or left. Rotation also occurs at the hip and shoulder joints (Figure 9.6f). Rotation of the limbs may be directed toward the median plane or away from it. For example, in **medial rotation** of the lower limb, the limb's anterior surface turns toward the median plane of the body; **lateral rotation** is the opposite movement.

Special Movements

Certain movements do not fit into any of the previous categories and occur at only a few joints. These special movements are described and illustrated in **Figure 9.7**.

Elevation and Depression **Elevation** means lifting a body part superiorly (Figure 9.7a). Moving the elevated part inferiorly is **depression.** During chewing, the mandible is alternately elevated and depressed.

Protraction and Retraction Nonangular movements in the anterior and posterior directions are called **protraction** and **retraction,** respectively (Figure 9.7b). The mandible is protracted when you jut out your jaw and retracted when you bring it back.

Supination and Pronation The terms **supination** (soo″pĭ-na′shun) and **pronation** (pro-na′shun) refer to movements of the radius around the ulna (Figure 9.7c). Supination occurs when the forearm rotates laterally so that the palm faces anteriorly (the hand is lying on its "back," supine). This is standard anatomical position. Pronation occurs when the forearm rotates medially so that the palm faces posteriorly (hand lying "belly" side down, as in a prone float). Pronation brings the radius across the ulna so that the two bones form an X.

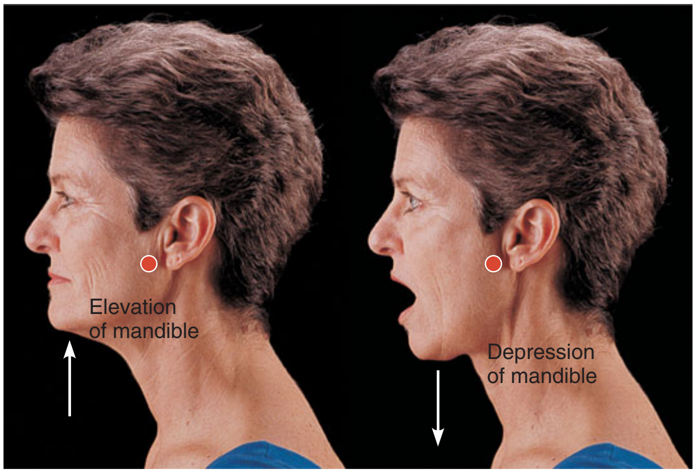
Opposition In the palm, the saddle joint between metacarpal 1 and the carpals allows a movement called *opposition* of the thumb (Figure 9.7d). This is the action by which you move your thumb across the palm enabling it to touch the tips of the other fingers on the same hand. This unique action is what makes the human hand such a fine tool for grasping and manipulating objects.

Inversion and Eversion **Inversion** and **eversion** are special movements of the foot (Figure 9.7e). To invert the foot, turn the sole medially; to evert the foot, turn the sole laterally.

Dorsiflexion and Plantar Flexion Up-and-down movements of the foot at the ankle are also given special names. Lifting the foot so that its superior surface approaches the shin is called **dorsiflexion,** whereas depressing the foot or elevating the heel (pointing the toes) is called **plantar flexion** (Figure 9.7f). Dorsiflexion of the foot corresponds to hand extension at the wrist, whereas plantar flexion corresponds to hand flexion.

Synovial Joints Classified by Shape

The shapes of the articulating bone surfaces determine the movements allowed at a joint. Based on such shapes, the synovial joints can be classified as *plane, hinge, pivot, condyloid, saddle,* and *ball-and-socket joints*. See *Focus on Types of Synovial Joints* **(Figure 9.8)**.

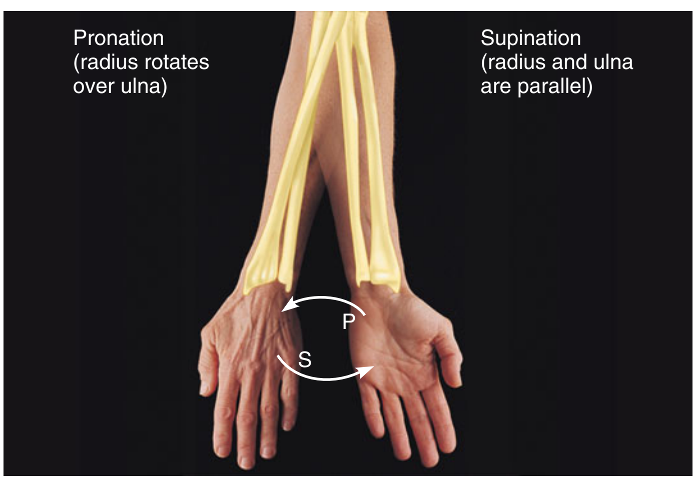


(a) Elevation
Lifting a body part superiorly

Depression
Moving a body part inferiorly

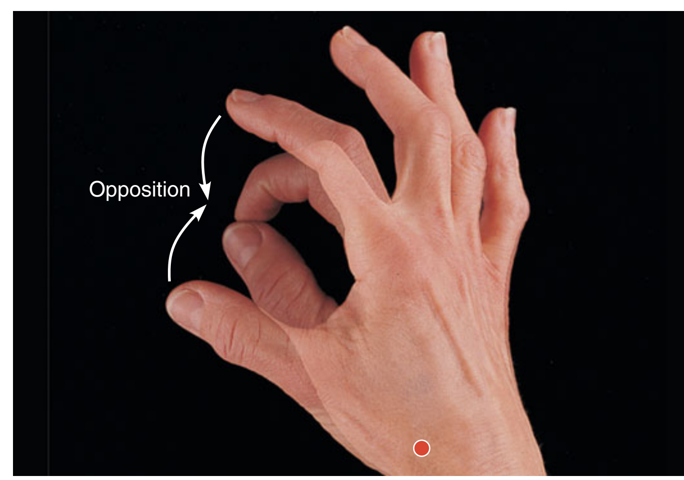
(b) Protraction
Moving a body part in the anterior direction

Retraction
Moving a body part in the posterior direction

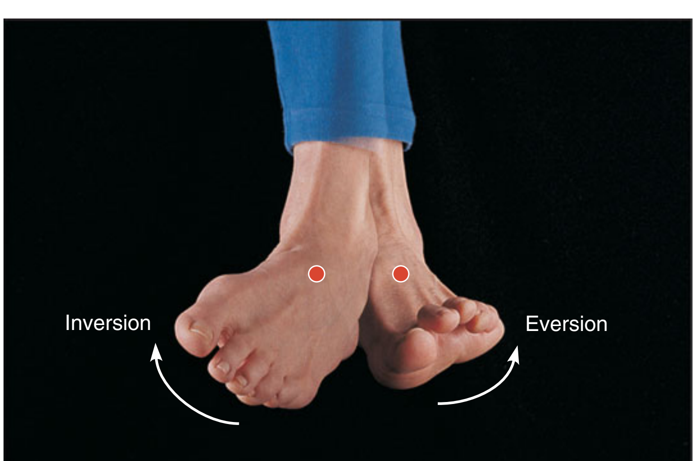


(c) Pronation (P)
Rotating the forearm so the palm faces posteriorly

Supination (S)
Rotating the forearm so the palm faces anteriorly

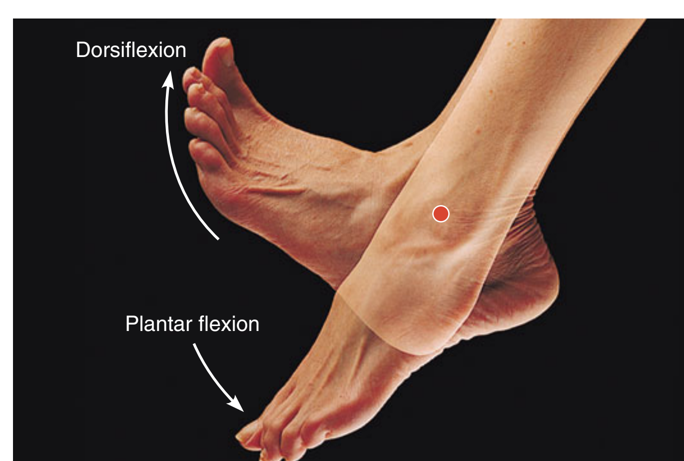


(d) Opposition
Moving the thumb to touch the tips of the other fingers



(e) Inversion
Turning the sole of the foot medially

Eversion
Turning the sole of the foot laterally



(f) Dorsiflexion
Lifting the foot so its superior surface approaches the shin

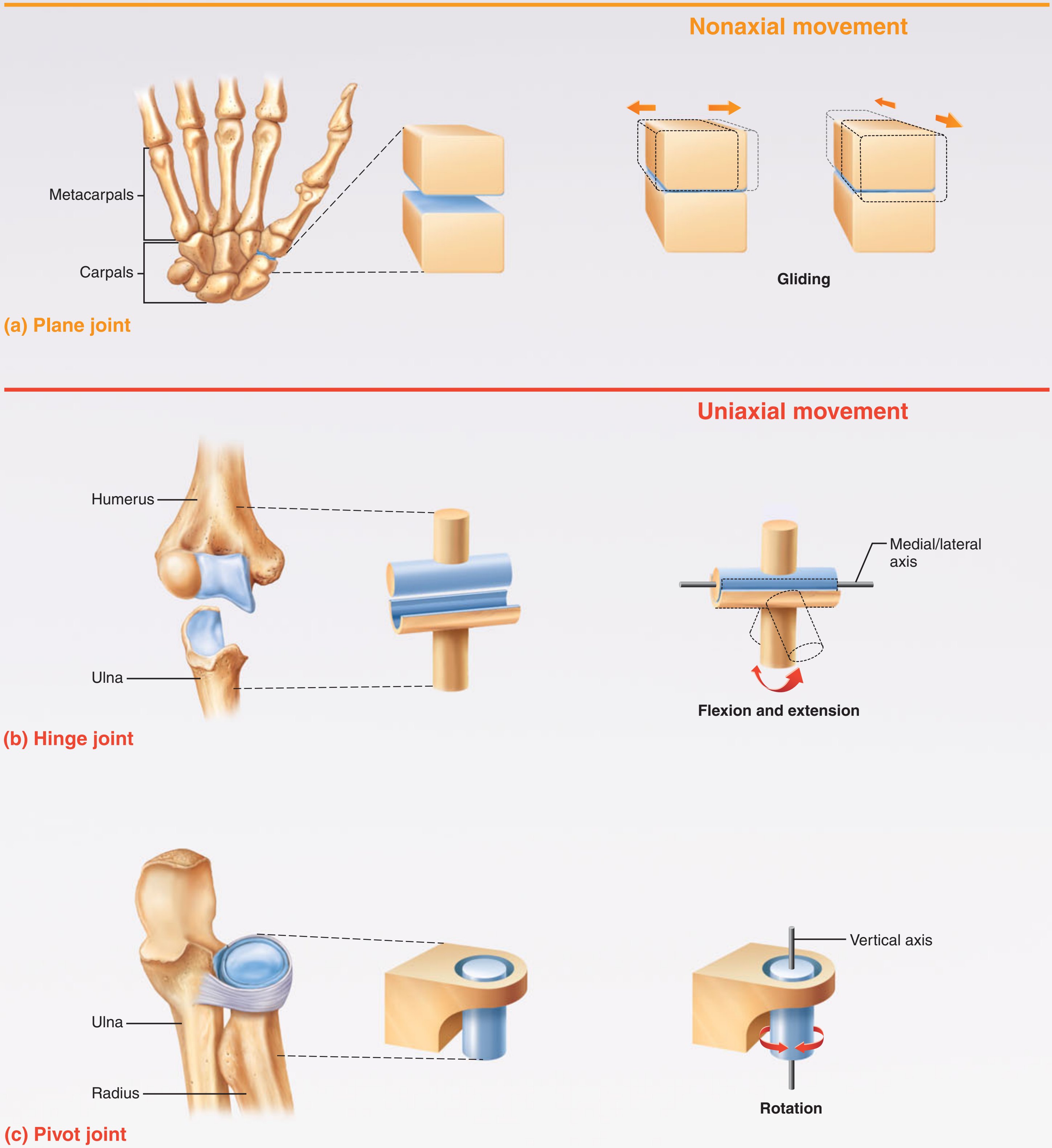
Plantar flexion
Depressing the foot elevating the heel

FIGURE 9.7 Some special body movements. The red dot indicates the axis of rotation.

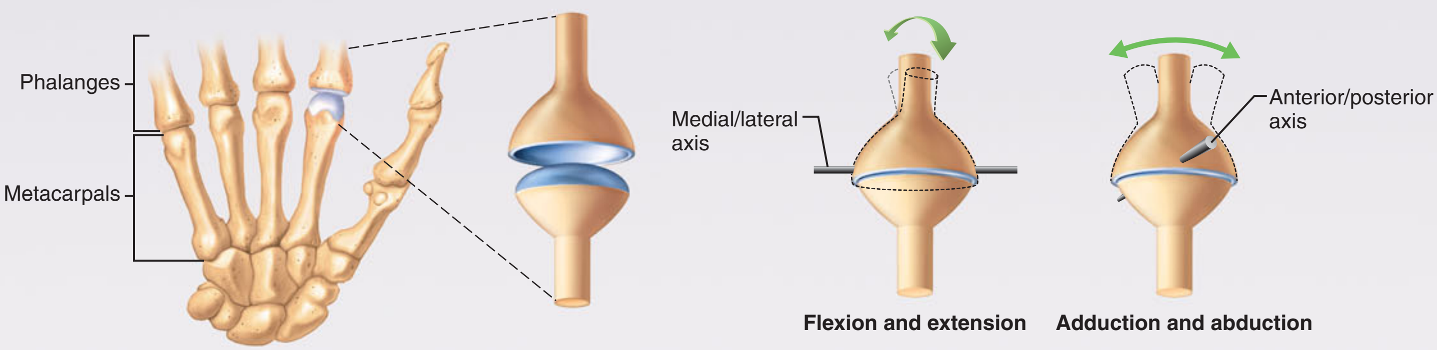
FOCUS Types of Synovial Joints

FIGURE 9.8

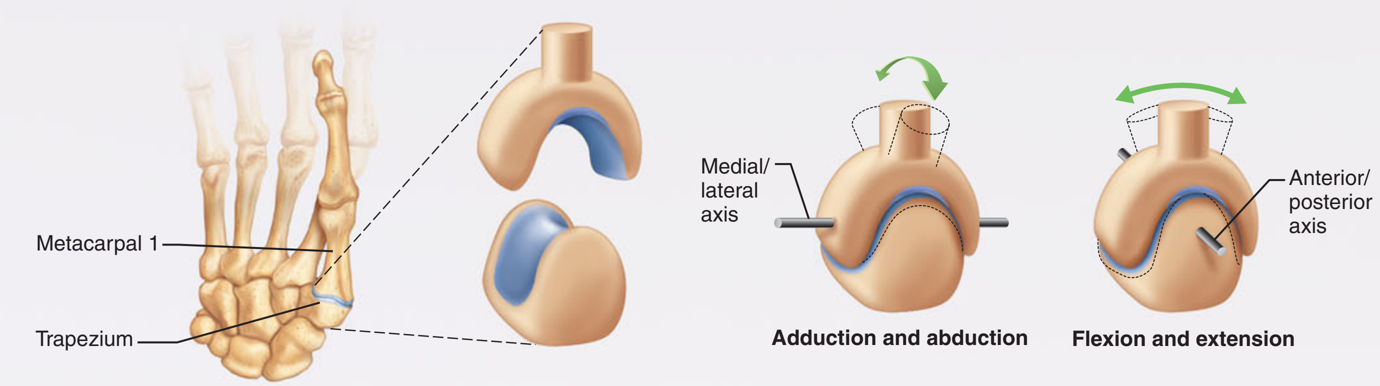
The shapes of the joint surfaces define the types of movements that can occur at a synovial joint; they also determine the classification of synovial joints into six structural types.



Biaxial movement

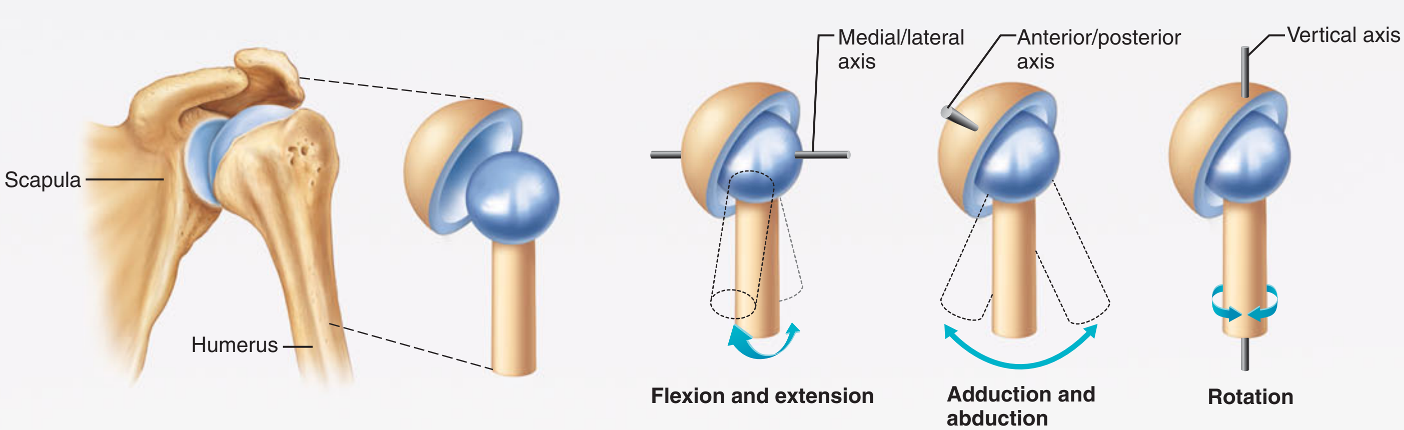


(d) Condyloid joint



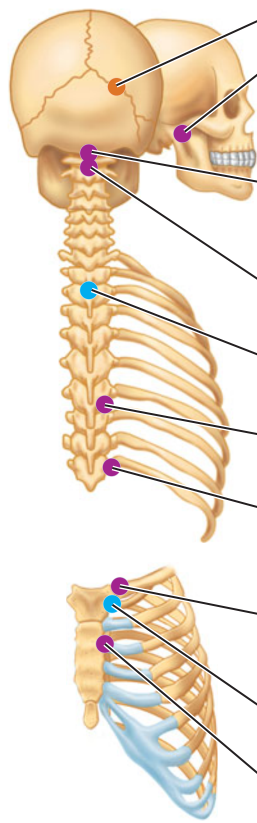
(e) Saddle joint

Multiaxial movement



(f) Ball-and-socket joint

TABLE 9.3 Structural and Functional Characteristics of Body Joints

Illustration	Joint	Articulating Bones	Structural Type	Functional Type; Movements Allowed
	Skull	Cranial and facial bones	Fibrous; suture	Synarthrotic; no movement
	Temporo-mandibular	Temporal bone of skull and mandible	Synovial; modified hinge (contains articular disc)	Diarthrotic; gliding and uniaxial rotation; slight lateral movement, elevation, depression, protraction, and retraction of mandible
	Atlanto-occipital	Occipital bone of skull and atlas	Synovial; condyloid	Diarthrotic; biaxial; flexion, extension, lateral flexion, circumduction of head on neck
	Atlantoaxial	Atlas (C_1) and axis (C_2)	Synovial; pivot	Diarthrotic; uniaxial; rotation of the head
	Intervertebral	Between adjacent vertebral bodies	Cartilaginous; symphysis	Amphiarthrotic; slight movement
	Intervertebral	Between articular processes	Synovial; plane	Diarthrotic; gliding
	Vertebrocostal	Vertebrae (transverse processes or bodies) and ribs	Synovial; plane	Diarthrotic; gliding of ribs
	Sternoclavicular	Sternum and clavicle	Synovial; shallow saddle (contains articular disc)	Diarthrotic; multiaxial (allows clavicle to move in all axes)
	Sternocostal (first)	Sternum and rib 1	Cartilaginous; synchondrosis	Synarthrotic; no movement
	Sternocostal	Sternum and ribs 2–7	Synovial; double plane	Diarthrotic; gliding

● Fibrous joints ● Cartilaginous joints ● Synovial joints

Plane Joints

In a **plane joint** (Figure 9.8a), the articular surfaces are essentially flat planes, and only short gliding or translational movements are allowed. Plane joints are the gliding joints introduced earlier, such as the intertarsal joints, intercarpal joints, and the joints between the articular processes of the vertebrae. The movement may be in multiple directions, as indicated by the arrows in Figure 9.8a, but it occurs only along the plane of the joint surface.

Hinge Joints

In a **hinge joint** (Figure 9.8b), the cylindrical end of one bone fits into a trough-shaped surface on another bone. Angular movement is allowed in just one plane, like a door on a hinge. Examples are the elbow joint, ankle joint, and the joints between the phalanges of the fingers. Hinge joints are classified as **uniaxial** because they allow movement around one axis only, as indicated by the single arrow in Figure 9.8b.

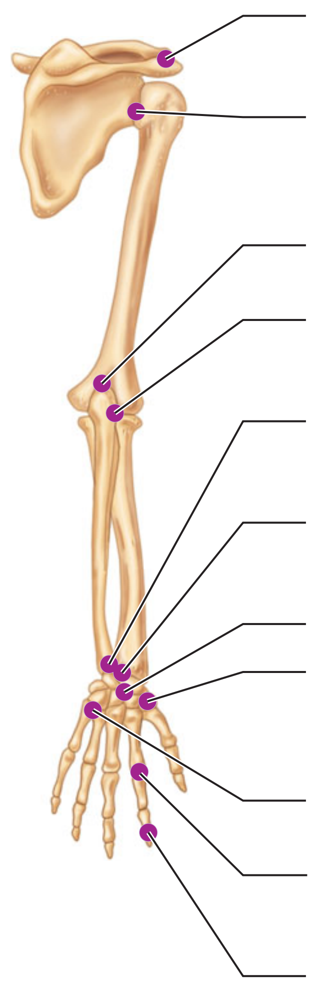
Pivot Joints

In a **pivot joint** (Figure 9.8c), the rounded end of one bone fits into a ring that is formed by another bone plus an encircling ligament. Because the rotating bone can turn only around its long axis, pivot joints are also uniaxial joints (see the single arrow in Figure 9.8c). One example of a pivot joint is the proximal radioulnar joint, where the head of the radius rotates within a ringlike ligament secured to the ulna. Another example is the joint between the atlas and the dens of the axis (see Figure 7.22a on p. 171).

Condyloid Joints

In a **condyloid joint** (kon′dĭ-loid; "knuckle-like"), the egg-shaped articular surface of one bone fits into an oval concavity in another (Figure 9.8d). Condyloid joints allow movement (1) back and forth (flexion-extension) and (2) from side to side (abduction-adduction), but the bone cannot rotate around its long axis. Because movement occurs around two axes, indicated by the two arrows in Figure 9.8d, these joints

TABLE 9.3 *continued*

Illustration	Joint	Articulating Bones	Structural Type	Functional Type; Movements Allowed
	Acromio-clavicular	Acromion process of scapula and clavicle	Synovial; plane (contains articular disc)	Diarthrotic; gliding and rotation of scapula on clavicle
	Shoulder (glenohumeral)	Scapula and humerus	Synovial; ball and socket	Diarthrotic; multiaxial; flexion, extension, abduction, adduction, circumduction, rotation of humerus/arm
	Elbow	Ulna (and radius) with humerus	Synovial; hinge	Diarthrotic; uniaxial; flexion, extension of forearm
	Radioulnar (proximal)	Radius and ulna	Synovial; pivot	Diarthrotic; uniaxial; rotation of radius around long axis of forearm to allow pronation and supination
	Radioulnar (distal)	Radius and ulna	Synovial; pivot (contains articular disc)	Diarthrotic; uniaxial; rotation (convex head of ulna rotates in ulnar notch of radius)
	Wrist (radiocarpal)	Radius and proximal carpals	Synovial; condyloid	Diarthrotic; biaxial; flexion, extension, abduction, adduction, circumduction of hand
	Intercarpal	Adjacent carpals	Synovial; plane	Diarthrotic; gliding
	Carpometacarpal of digit 1 (thumb)	Carpal (trapezium) and metacarpal 1	Synovial; saddle	Diarthrotic; biaxial; flexion, extension, abduction, adduction, circumduction, opposition of metacarpal 1
	Carpometacarpal of digits 2–5	Carpal(s) and metacarpal(s)	Synovial; plane	Diarthrotic; gliding of metacarpals
	Knuckle (metacarpo-phalangeal)	Metacarpal and proximal phalanx	Synovial; condyloid	Diarthrotic; biaxial; flexion, extension, abduction, adduction, circumduction of fingers
	Finger (interphalangeal)	Adjacent phalanges	Synovial; hinge	Diarthrotic; uniaxial; flexion, extension of fingers

● Fibrous joints ● Cartilaginous joints ● Synovial joints

are **biaxial** (*bi* = two), as in the knuckle, or metacarpophalangeal joint (you can spread your fingers apart and together as well as flex and extend them), and the wrist joints (again, abduction/adduction and flexion/extension are possible).

Saddle Joints

In a **saddle joint,** each articular surface has both convex and concave areas, just like a saddle (Figure 9.8e). Nonetheless, these biaxial joints allow essentially the same movements as condyloid joints. The best example of a saddle joint is the first carpometacarpal joint, in the ball of the thumb. It is the structure of this joint that allows for opposition of the thumb.

Ball-and-Socket Joints

In a **ball-and-socket joint** (Figure 9.8f), the spherical head of one bone fits into a round socket in another. These are **multiaxial** joints that allow movement in all axes, including rotation (see the three arrows in Figure 9.8f). The shoulder and hip are ball-and-socket joints.

Factors Influencing the Stability of Synovial Joints

Because joints are regularly pushed and pulled, they must be stabilized to prevent dislocation (misalignment). The stability of a synovial joint depends on three factors: the shapes of the

TABLE 9.3 Structural and Functional Characteristics of Body Joints *continued*

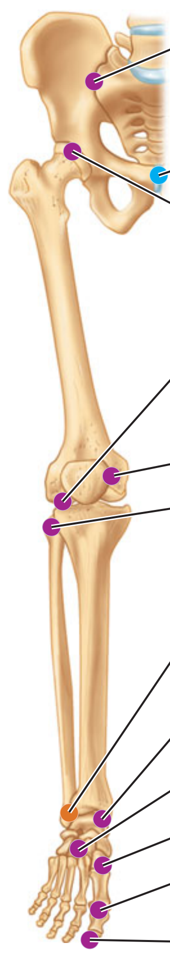


Illustration	Joint	Articulating Bones	Structural Type*	Functional Type; Movements Allowed
	Sacroiliac	Sacrum and coxal bone	Synovial in childhood; increasingly fibrous in adult	Diarthrotic in childhood; modified amphiarthrotic in adult (more during pregnancy)
	Pubic symphysis	Pubic bones	Cartilaginous; symphysis	Amphiarthrotic; slight movement (enhanced during pregnancy)
	Hip (coxal)	Coxal bone and femur	Synovial; ball and socket	Diarthrotic; multiaxial; flexion, extension, abduction, adduction, rotation, circumduction of femur/thigh
	Knee (tibiofemoral)	Femur and tibia	Synovial; modified hinge (contains articular disc)	Diarthrotic; biaxial; flexion, extension of leg, some rotation allowed
	Knee (femoropatellar)	Femur and patella	Synovial; plane	Diarthrotic; gliding of patella
	Tibiofibular (proximal)	Tibia and fibula (proximally)	Synovial; plane	Diarthrotic; gliding of fibula
	Tibiofibular (distal)	Tibia and fibula (distally); both anterior and posterior ligaments exist	Fibrous; syndesmosis	Synarthrotic; slight "give" during dorsiflexion of foot
	Ankle	Tibia and fibula with talus	Synovial; hinge	Diarthrotic; uniaxial; dorsiflexion and plantar flexion of foot
	Intertarsal	Adjacent tarsals	Synovial; plane	Diarthrotic; gliding; inversion and eversion of foot
	Tarsometatarsal	Tarsal(s) and metatarsal(s)	Synovial; plane	Diarthrotic; gliding of metatarsals
	Metatarso-phalangeal	Metatarsal and proximal phalanx	Synovial; condyloid	Diarthrotic; biaxial; flexion, extension, abduction, adduction, circumduction of great toe
	Toe (interpha-langeal)	Adjacent phalanges	Synovial; hinge	Diarthrotic; unaxial; flexion, extension of toes

● Fibrous joints ● Cartilaginous joints ● Synovial joints

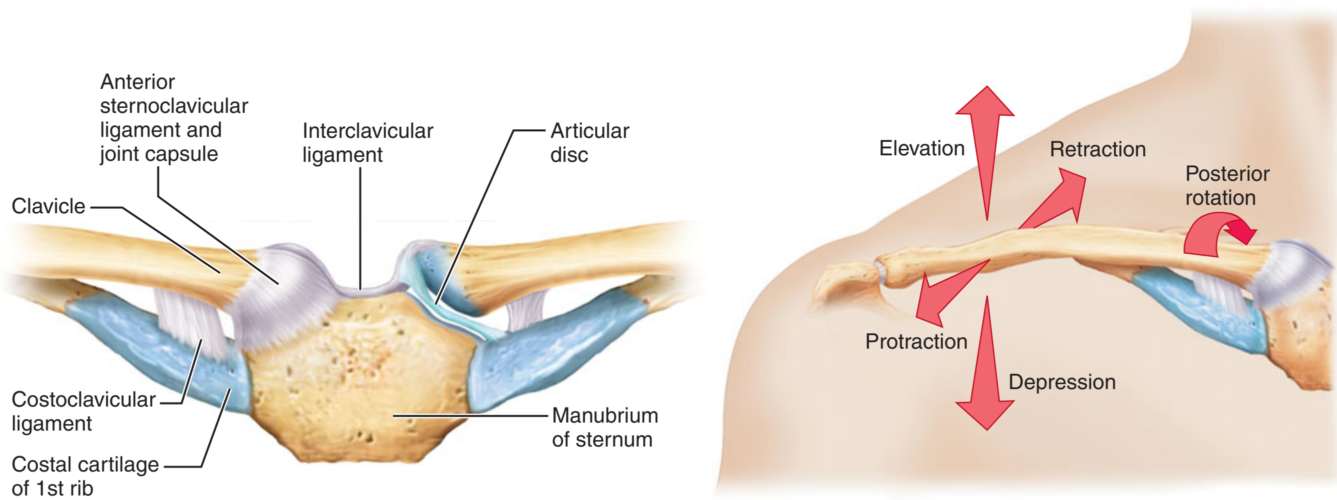
articular surfaces, the number and position of stabilizing ligaments, and muscle tone.

Articular Surfaces

The articular surfaces of the bones in a joint fit together in a complementary manner. Although their shapes determine what kinds of movement are possible at the joint, articular surfaces seldom play a major role in joint stability: Most joint sockets are just too shallow. Still, some joint surfaces have deep sockets or grooves that do provide stability. The best example is the ball and deep socket of the hip joint; other examples are the elbow and ankle joints.

Ligaments

The capsules and ligaments of synovial joints help hold the bones together and prevent excessive or undesirable motions. Ligaments located on the medial or inferior side of a joint resist excessive abduction; lateral and superiorly located ligaments resist adduction. Anterior ligaments resist excessive extension and lateral rotation; posterior ligaments resist excessive flexion and medial rotation. As a rule, the more ligaments a joint has, the stronger it is. When other stabilizing factors are inadequate, however, undue tension is placed on the ligaments, and they fail. Once stretched, ligaments, like taffy, stay stretched. However, a ligament can stretch only about 6% beyond its normal length before it snaps apart. People who can bend the thumb back to touch the forearm or place both heels behind the neck are sometimes called "double-jointed," but of course they don't have more joints than usual. The joint ligaments and joint capsules of "double-



(a) Sternoclavicular joint, anterior view

(b) Sternoclavicular movements

FIGURE 9.9 The sternoclavicular joint.

jointed" individuals are simply looser and more stretchable than those of most people.

Muscle Tone

Another important factor in joint stabilization is **muscle tone,** a constant, low level of contractile force generated by a muscle even when it is not causing movement. Muscle tone helps stabilize joints by keeping tension on the muscle tendons that cross over joints just external to the joint capsule. In this manner the muscle functions like a ligament holding the adjoining bone surfaces together. This stabilizing factor is especially important in reinforcing the shoulder and knee joints and in supporting the joints in the arches of the foot.

check your understanding

6. Name all the movements that occur at these joints: (a) elbow, (b) hip, (c) ankle, (d) atlantoaxial joint, (e) metacarpophalangeal joint.
7. Classify each of the joints named in question 6 according to joint shape. For each joint, indicate whether it is uniaxial, biaxial, or multiaxial.
8. Define pronation and supination. At what joint do these movements occur?

For answers, see Appendix B.

SELECTED SYNOVIAL JOINTS

➤ Describe the key features of the temporomandibular, sternoclavicular, shoulder, elbow, wrist, hip, knee, and ankle joints.

Table 9.3 on pp. 218–220 summarizes the structural and functional characteristics of the major joints in the human body. This section covers several important synovial joints in detail: sternoclavicular joints, temporomandibular, shoulder, elbow, wrist, hip, knee, and ankle. While reading about them, keep in mind that they all contain articular cartilages, fibrous capsules, and synovial membranes.

Sternoclavicular Joint

The **sternoclavicular joint (SC)** is a saddle joint (Figure 9.9a). This unusual type of joint is found in only two locations: the sternoclavicular joint and the joint between the trapezium and metacarpal 1 (the thumb). The saddle-shaped clavicular facet of the sternum and the superior surface of the first costal cartilage articulate with the medial surface of the clavicle. An articular disc within the joint cavity divides the cavity. Four ligaments surround the joint: the **anterior** and **posterior sternoclavicular ligaments;** the **interclavicular ligament,** extending between the medial end of the left and right clavicles; and the **costoclavicular ligament,** extending from the first costal cartilage to the inferior surface of the clavicle. Muscles originating from the sternum, sternocleidomastoid, sternohyoid, and sternothyroid also contribute to the stability of this joint.

This uniquely shaped joint allows for multiple complex movements (Figure 9.9b) and is critical for the mobility of the upper extremity. To demonstrate the three planes of movement of the sternoclavicular joint, place one hand on the junction of the sternum and the clavicle. First, shrug your shoulders to feel elevation and depression of the sternoclavicular joint; second, reach your arm forward and backward maximally to feel protraction and retraction; and finally, abduct or flex your arm to feel posterior rotation (this movement is quite subtle). The SC joint also forms the only bony attachment of the axial skeleton to the pectoral girdle. The sternoclavicular joint is a well reinforced, extremely stable joint. Forceful blows directed medially more commonly result in fracture of the clavicle than dislocation of the SC joint.

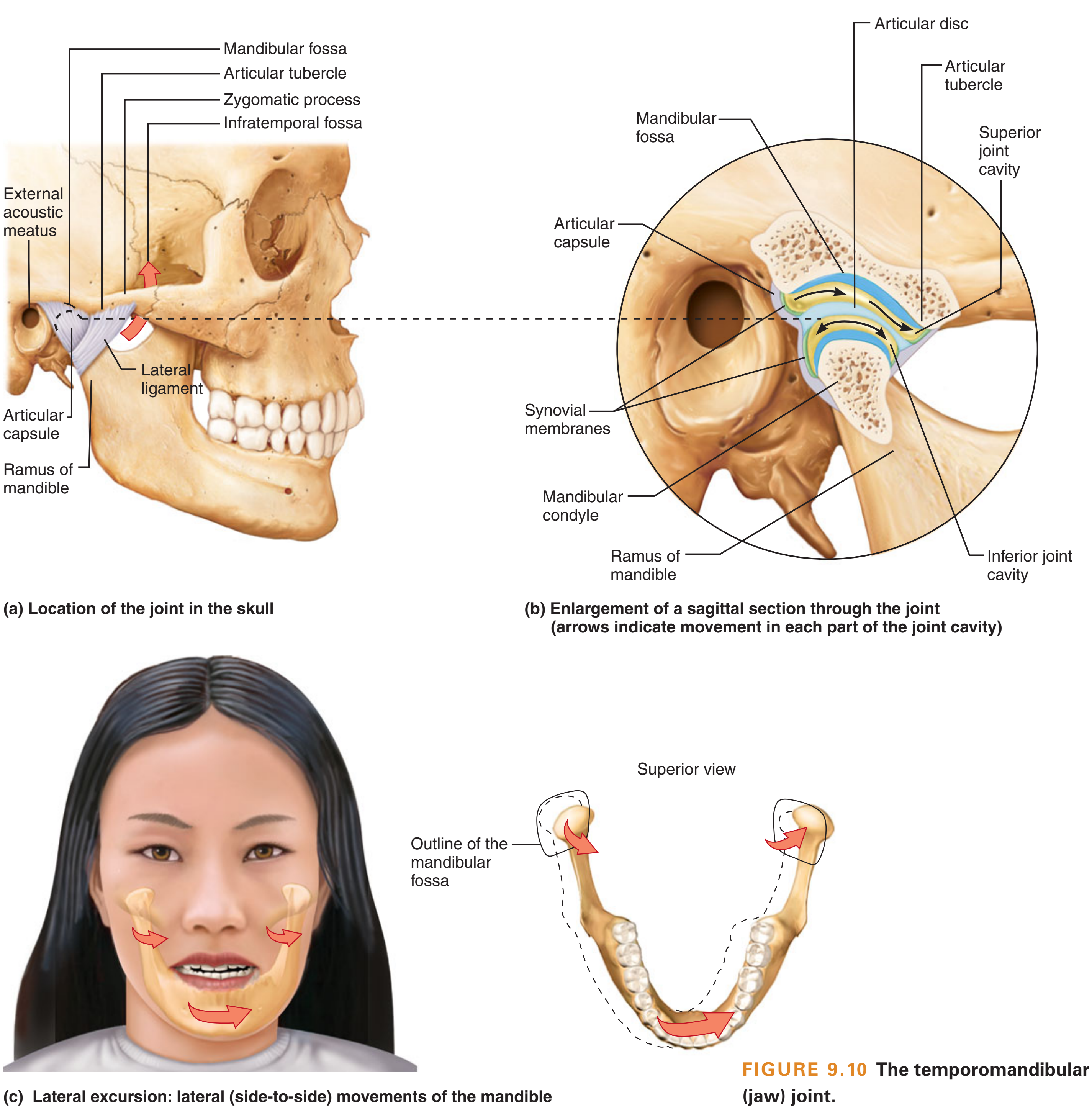


FIGURE 9.10 The temporomandibular (jaw) joint.

Temporomandibular Joint

The **temporomandibular joint (TMJ),** or jaw joint, is a modified hinge joint. It lies just anterior to the ear (Figure 9.10). At this joint, the head of the mandible articulates with the inferior surface of the squamous temporal bone. The head of the mandible is egg-shaped, whereas the articular surface on the temporal bone has a more complex shape: Posteriorly, it forms the concave **mandibular fossa.** Anteriorly, it forms a dense knob called the **articular tubercle.** Enclosing the joint is a loose articular capsule, the lateral aspect of which is thickened into a **lateral ligament.** Within the capsule is an articular disc, which divides the synovial cavity into superior and inferior compartments (Figure 9.10b). The two surfaces of the disc allow distinct kinds of movement at the TMJ. First, the concave inferior surface receives the mandibular head and allows the familiar hingelike movement of depressing and elevating the mandible while opening and closing the mouth. Second, the superior surface of the disc glides anteriorly with the mandibular head whenever the mouth is opened wide. This anterior movement braces the mandibular head against the dense bone of the articular tubercle, so that the mandible is not forced superiorly through the thin roof of the mandibular fossa when one bites hard foods such as nuts or hard candies. To demonstrate the anterior gliding of your mandible, place a finger on the mandibular head just anterior to your ear opening, and yawn. The superior compartment also allows for the side-to-side gliding movements of this joint. As the posterior teeth are drawn into occlusion during grinding, the mandible moves with a side-to-side motion called *lateral excursion* (Figure 9.10c). This lateral joint movement is unique to the masticatory apparatus of mammals and is readily apparent in horses and cows as they chew.

TEMPOROMANDIBULAR DISORDERS Because of its shallow socket, the TMJ is the most easily dislocated joint in the body. Even a deep yawn can dislocate it. This joint almost always dislocates anteriorly; that is, the mandibular head glides anteriorly, ending up in a skull region called the infratemporal fossa (see Figure 9.10a). In such cases, the mouth remains wide open and cannot close. To realign a dislocated TMJ, the physician places his or her thumbs in the patient's mouth between the lower molars and the cheeks, and then pushes the mandible inferiorly and posteriorly.

At least 5% of Americans suffer from painful conditions of the TMJ called **temporomandibular disorders.** The most common symptoms are pain in the ear and face, tenderness of the jaw muscles, popping or clicking sounds when the mouth opens, and stiffness of the TMJ. Usually caused by painful spasms of the chewing muscles, temporomandibular disorders affect people who respond to stress by grinding their teeth. However, it can also result from an injury to the TMJ or from poor occlusion of the teeth. Treatment usually focuses on getting the jaw muscles to relax using massage, stretching the muscles, applying moist heat or ice, administering muscle-relaxant drugs, and adopting general stress-management techniques. Patients often wear a bite plate while sleeping to stop grinding the teeth. In severe cases, surgery on the joint may be necessary.

check your understanding

9. Both the sternoclavicular and temporomandibular joints contain an articular disc. What is the function of this disc in each of these joints?
10. Which other joint described in this chapter contains an articular disc?

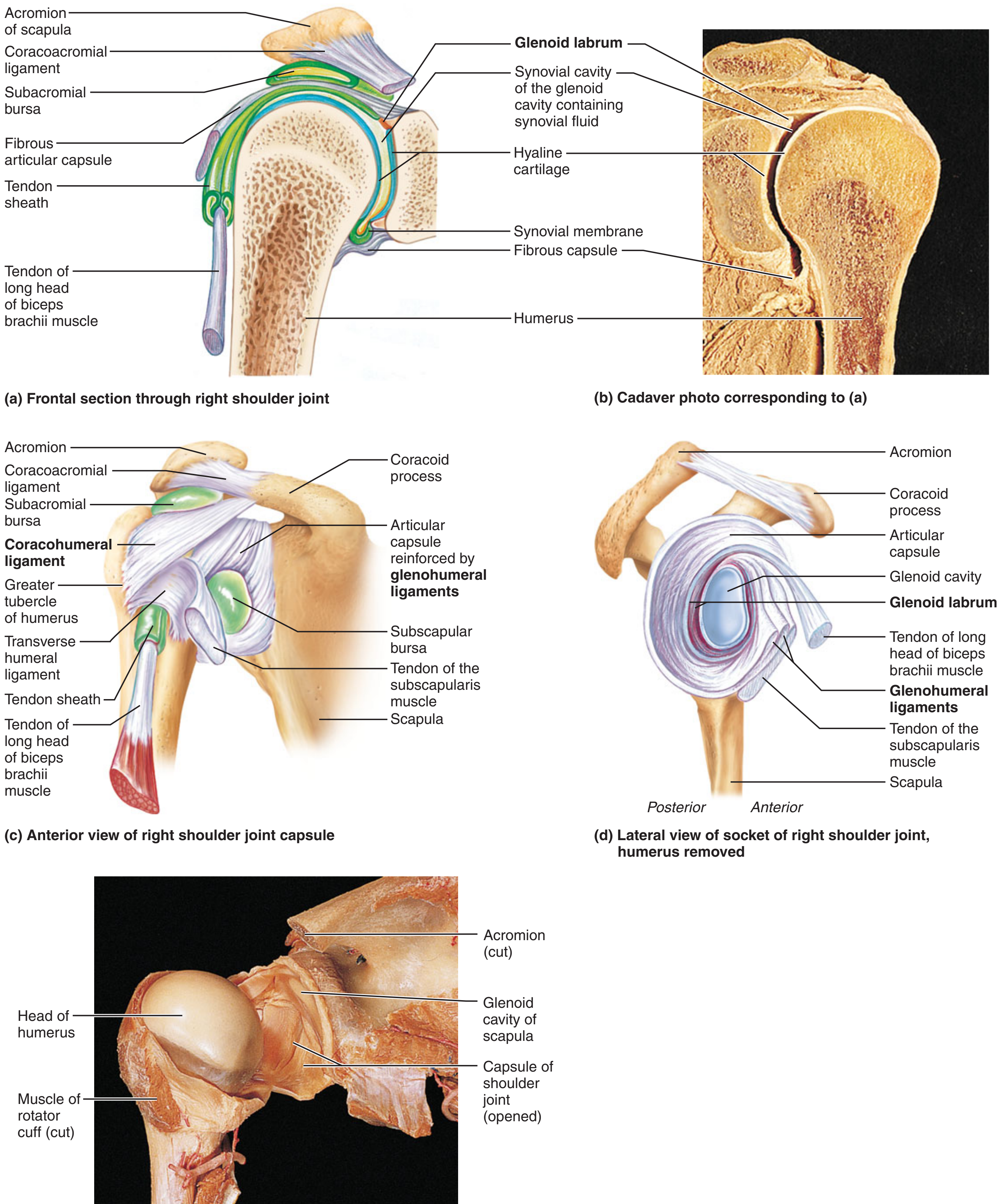
For answers, see Appendix B.

Shoulder (Glenohumeral) Joint

In the **shoulder joint** (Figure 9.11), stability has been sacrificed to provide the most freely moving joint of the body. This ball-and-socket joint is formed by the head of the humerus and the shallow glenoid cavity of the scapula. Even though the glenoid cavity is slightly deepened by a rim of fibrocartilage called the **glenoid labrum** (*labrum* = lip) (Figure 9.11a and d), this shallow cavity contributes little to joint stability. The articular capsule (Figure 9.11c) is remarkably thin and loose (qualities that contribute to the joint's freedom of movement) and extends from the margin of the glenoid cavity to the anatomical neck of the humerus. The only strong thickening of the capsule is the superior **coracohumeral ligament,** which helps support the weight of the upper limb. The anterior part of the capsule thickens slightly into three rather weak **glenohumeral ligaments** (Figure 9.11d).

Muscle tendons that cross the shoulder joint contribute most to the joint's stability. One of these is the tendon of the long head of the biceps brachii muscle (see Figure 9.11a and d). This tendon attaches to the superior margin of the glenoid labrum, travels within the joint cavity, and runs in the intertubercular sulcus of the humerus, in the process securing the head of the humerus tightly against the glenoid cavity. Four other tendons and the associated muscles make up the **rotator cuff** (see Figure 9.11e), which encircles the shoulder joint and merges with the joint capsule. The rotator cuff muscles include the subscapularis, supraspinatus, infraspinatus, and teres minor (see Chapter 11, p. 302). Moving the arm vigorously can severely stretch or tear the rotator cuff. Baseball pitchers who throw too hard and too often can easily injure the rotator cuff.

SHOULDER DISLOCATIONS One price of mobility in the shoulder is that **shoulder dislocations** are common injuries. Because the structures reinforcing this joint are weakest anteriorly and inferiorly, the head of the humerus easily dislocates forward and downward. The glenoid cavity provides poor support when the humerus is rotated laterally and abducted, as when a football player uses the arm to tackle an opponent or a baseball fielder hits the ground diving for a ball. These situations cause many shoulder dislocations, as do blows to the top and back of the shoulder. A **shoulder separation** is a dislocation of the acromioclavicular joint. It results from falling onto an outstretched hand or onto the side of the shoulder.



(a) Frontal section through right shoulder joint

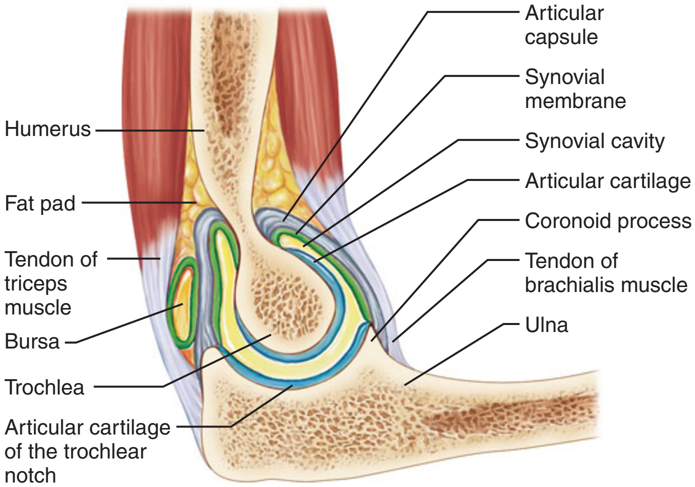
(b) Cadaver photo corresponding to (a)

(c) Anterior view of right shoulder joint capsule

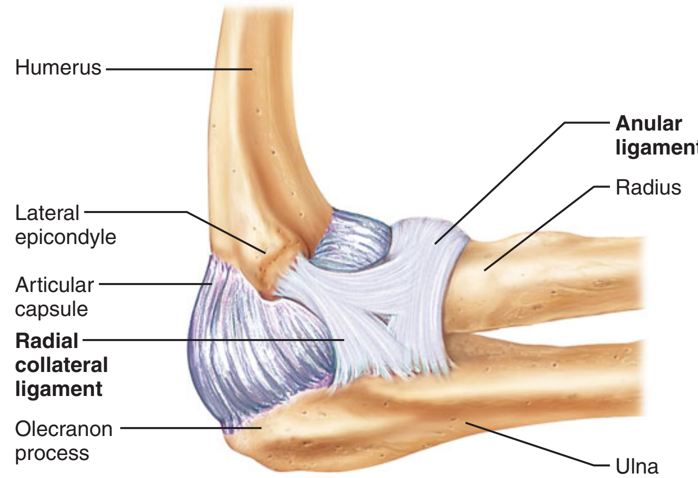
(d) Lateral view of socket of right shoulder joint, humerus removed

(e) Posterior view of an opened left shoulder joint

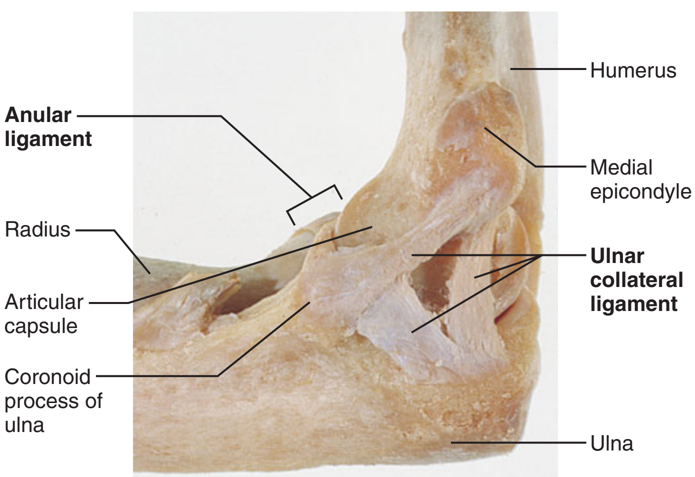
FIGURE 9.11 The shoulder joint.



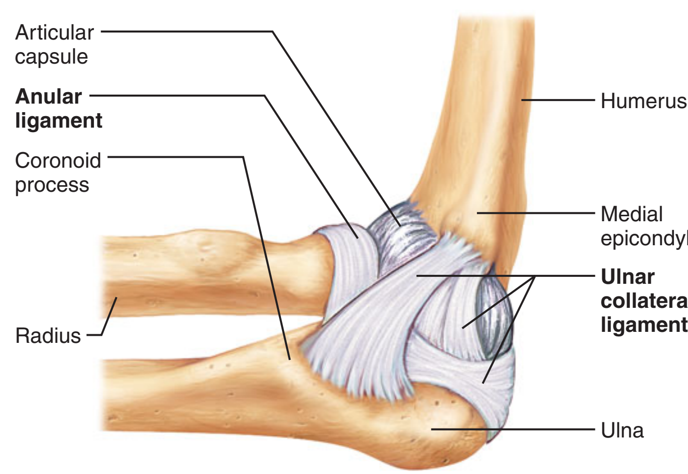
(a) Mid-sagittal section through right elbow (lateral view)



(b) Lateral view of right elbow joint



(c) Cadaver photo of medial view of right elbow



(d) Medial view of right elbow

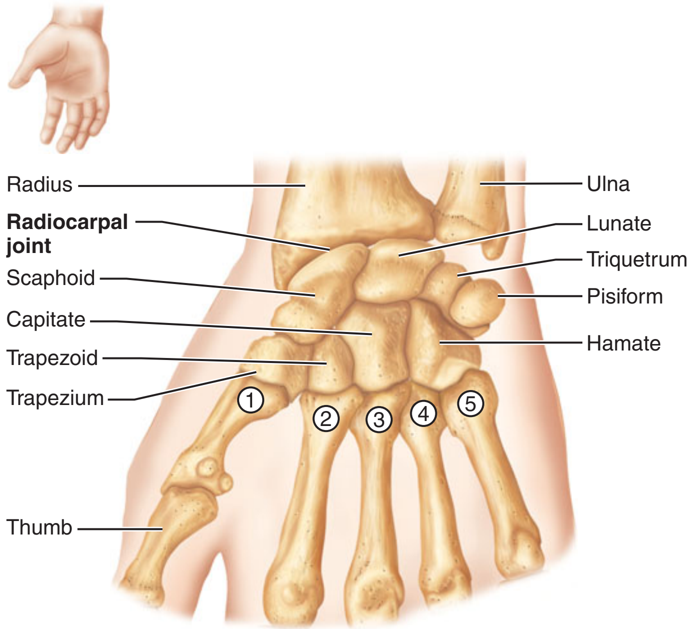
FIGURE 9.12 The elbow joint.

Elbow Joint

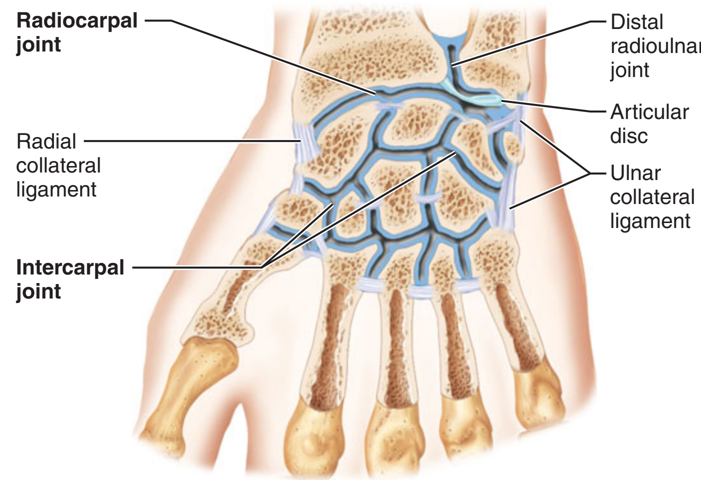
The **elbow joint** *(humeroulnar joint)* **(Figure 9.12)** is a hinge that allows only extension and flexion. Even though both the radius and ulna articulate with the condyles of the humerus, it is the close gripping of the humerus by the ulna's trochlear notch that forms the hinge and stabilizes the joint. The articular capsule attaches to the humerus and ulna and to the **anular ligament** (an′u-lar; "ringlike") of the radius, a ring around the head of the radius (Figure 9.12b–d). Laterally and medially, the capsule thickens into strong ligaments that prevent lateral and medial movements: the **radial collateral ligament,** a triangular band on the lateral side (Figure 9.12b), and the **ulnar collateral ligament** on the medial side (Figure 9.12c and d). Tendons of several arm muscles, such as the biceps brachii and triceps brachii, cross the elbow joint and provide stability (Figure 9.12a).

ELBOW TRAUMA Although the elbow is a very stable joint, it often experiences trauma. Only the jaw and shoulder are dislocated more frequently. Elbow dislocation is usually caused by falling onto an outstretched arm and breaking the fall with the hand. This fall pushes the ulna posteriorly. Such a fall may dislocate the radius posteriorly as well, and it often fractures the articulating elements.

Athletes who repeatedly swing a racket or throw a ball subject their forearms to strong outward-bending forces that can weaken and ultimately rupture the ulnar collateral ligament.

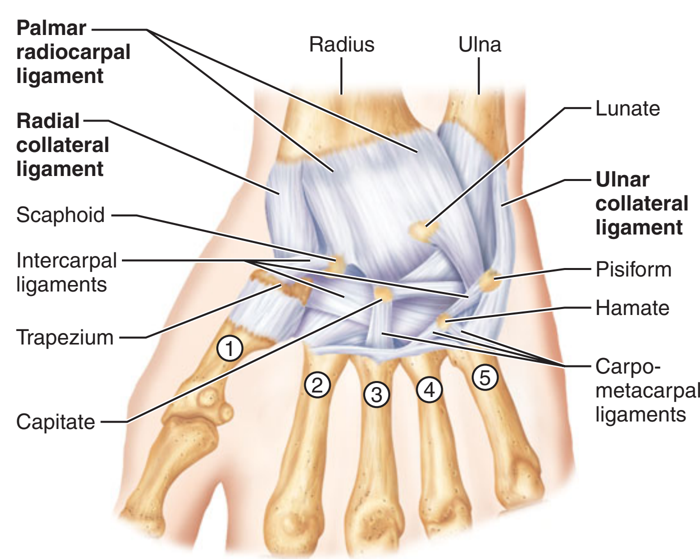


(a) Right wrist, anterior (palmar) view



(b) Wrist joints, coronal section

FIGURE 9.13 The wrist joints.



(c) Ligaments of the wrist, anterior (palmar) view

Wrist Joint

The **wrist joint** has two major joint surfaces: the **radiocarpal joint** and the **intercarpal** or **midcarpal joint.** The radiocarpal joint is the joint between the radius and the proximal carpals, the scaphoid and lunate (**Figure 9.13a** and **b**). This joint is a condyloid joint, permitting movements of flexion, extension, adduction, abduction, and circumduction. The intercarpal joint is located between the proximal and distal rows of carpals (Figure 9.13b). Gliding occurs at this joint as the adjacent carpals slide by each other.

The wrist is stabilized by several ligaments (Figure 9.13c). Four major ligaments extending from the forearm bones to the carpals reinforce this joint: the **palmar radiocarpal ligament** anteriorly, the **dorsal radiocarpal ligament** posteriorly, the **radial collateral ligament** laterally, and the **ulnar collateral ligament** medially. There are multiple smaller ligaments extending between carpal bones that connect the carpals to each other and to the metacarpals (Figure 9.13c).

check your understanding

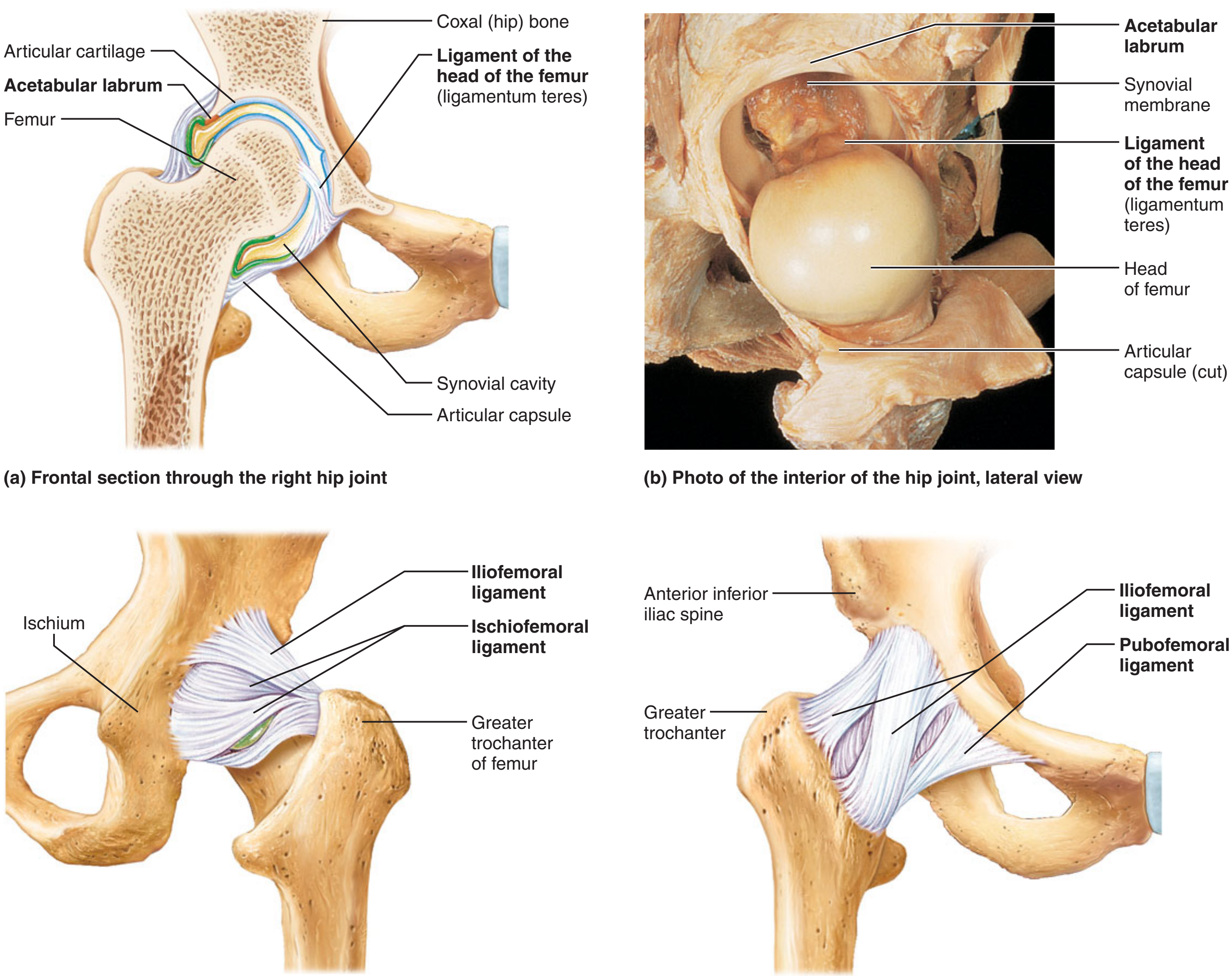
11. Of the shoulder, elbow, or wrist, which joint is the most stable? Which is the least stable?
12. What structures contribute most to stability of the shoulder joint?
13. Which forearm bone forms part of the elbow joint? Which forms part of the wrist joint?

For answers, see Appendix B.

Hip Joint

The **hip** (coxal) **joint,** like the shoulder joint, has a ball-and-socket structure **(Figure 9.14)**. It has a wide range of motion, but not nearly as wide as that of the shoulder joint. Movements occur in all possible axes but are limited by the joint's ligaments and deep socket.

The hip joint is formed by the spherical head of the femur and the deeply cupped acetabulum of the hip bone. The depth of the acetabulum is enhanced by a circular rim of fibrocartilage called the **acetabular labrum** (Figure 9.14a and b). Because the diameter of this labrum is smaller than that of the head of the femur, the femur cannot easily slip out of the



(a) Frontal section through the right hip joint

(b) Photo of the interior of the hip joint, lateral view

(c) Posterior view of right hip joint, capsule in place

(d) Anterior view of right hip joint, capsule in place

FIGURE 9.14 The hip joint.

socket, and hip dislocations are rare. The joint capsule runs from the rim of the acetabulum to the neck of the femur (Figure 9.14c and d).

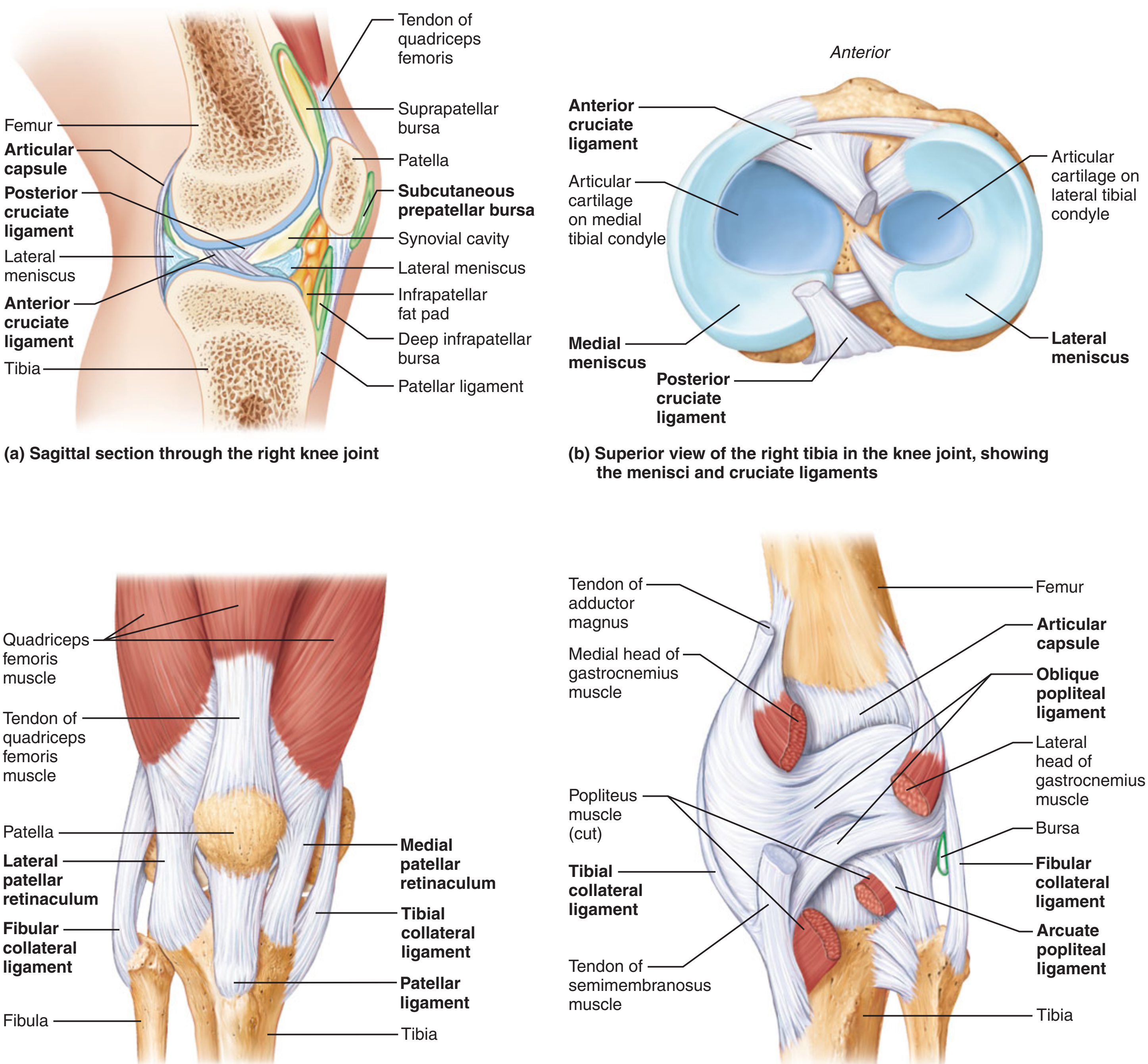
Three external ligamentous thickenings of this capsule reinforce the joint: the **iliofemoral ligament,** a strong, V-shaped, anteriorly located ligament; the **pubofemoral ligament,** a triangular thickening of the capsule's inferior region (Figure 9.14d); and the **ischiofemoral ligament,** a spiraling, posteriorly located ligament (Figure 9.14c). These three ligaments are arranged in such a way that they "screw" the head of the femur into the acetabulum when a person stands erect, thereby increasing the stability of the joint.

The **ligament of the head of the femur** (Figure 9.14a and b) is a flat, intracapsular band that runs from the head of the femur to the inferior region of the acetabulum. This ligament remains slack during most hip movements, so it is not important in stabilizing the joint. Its mechanical function is unknown, but it does contain an artery that helps supply the head of the femur. Damage to this artery may lead to arthritis of the hip joint.

Muscle tendons that cross the hip joint contribute to its stability, as do the fleshy parts of many hip and thigh muscles that surround the joint. In this joint, however, stability comes chiefly from the cupped socket and the capsular ligaments.

Knee Joint

The **knee joint,** the largest and most complex joint in the body (Figure 9.15), primarily acts as a hinge. However, it also permits some medial and lateral rotation when in the flexed position and during the act of leg extension. Structurally, it is compound and bicondyloid, because both the femur and tibia have two condylar surfaces. In this joint, the wheel-shaped



(a) Sagittal section through the right knee joint

(b) Superior view of the right tibia in the knee joint, showing the menisci and cruciate ligaments

(c) Anterior view of right knee

(d) Posterior view of the joint capsule, including ligaments

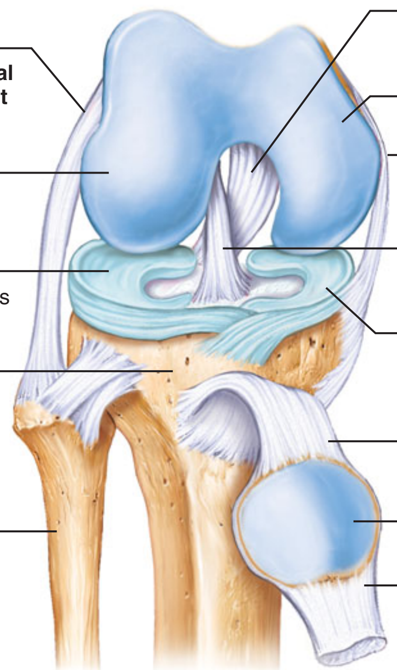
FIGURE 9.15 The knee joint.

condyles of the femur roll along the almost-flat condyles of the tibia like tires on a road. Sharing the knee cavity is an articulation between the patella and the inferior end of the femur (Figure 9.15a); this *femoropatellar joint* is a plane joint that allows the patella to glide across the distal femur as the knee bends.

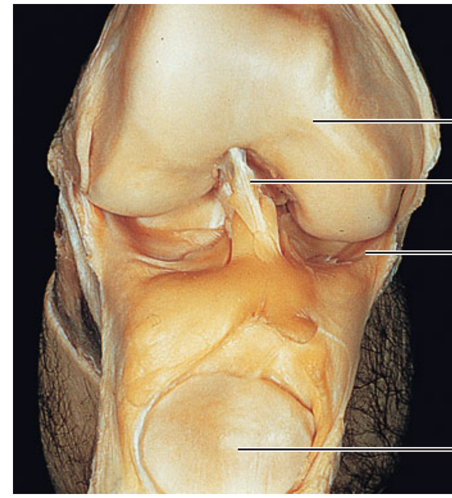
The synovial cavity of the knee joint has a complex shape (Figure 9.15a), with several incomplete subdivisions and several extensions that lead to "blind alleys." At least a dozen bursae are associated with this joint, some of which are shown in the figure. The **subcutaneous prepatellar bursa** is often injured when the knee is bumped anteriorly.

Two fibrocartilage menisci occur within the joint cavity, between the femoral and tibial condyles. These C-shaped **lateral** and **medial menisci** attach externally to the condyles of the tibia (Figure 9.15b). Besides evening the distribution of both compressive load and synovial fluid, the menisci help to stabilize the joint by guiding the condyles during flexion, extension, and rotation movements and preventing side-to-side rocking of the femur on the tibia.

The articular capsule of the knee joint can be seen on the posterior and lateral aspects of the knee (Figure 9.15d), where it covers most parts of the femoral and tibial condyles.



(e) Anterior view of flexed knee, showing the cruciate ligaments (articular capsule removed, and quadriceps tendon cut and reflected distally)



(f) Photograph of an opened knee joint; view similar to (e)

FIGURE 9.15 The knee joint, *continued.*

Anteriorly, however, the capsule is absent. Instead, this anterior area is covered by three broad ligaments that run inferiorly from the patella to the tibia (Figure 9.15c): the **patellar ligament,** flanked by the **medial** and **lateral patellar retinacula** (ret″ĭ-nak′u-lah; "retainers"). The patellar ligament is actually a continuation of the tendon of the main muscles on the anterior thigh, the quadriceps femoris. Physicians tap the patellar ligament to test the knee-jerk reflex.

The joint capsule of the knee is reinforced by several capsular and extracapsular ligaments, all of which become taut when the knee is extended to prevent hyperextension of the leg at the knee.

1. The extracapsular **fibular** and **tibial collateral ligaments** are located on the lateral and medial sides of the joint capsule, respectively (Figure 9.15c–e). The fibular collateral ligament descends from the lateral epicondyle of the femur to the head of the fibula. The tibial collateral ligament runs from the medial epicondyle of the femur to the medial condyle of the tibia. Besides halting leg extension and preventing hyperextension, these collateral ligaments prevent the leg from moving laterally and medially at the knee.
2. The **oblique popliteal ligament** (pop′lĭ-te″al; "back of the knee") crosses the posterior aspect of the capsule (Figure 9.15d). Actually it is a part of the tendon of the semimembranosus muscle that fuses with the joint capsule and helps stabilize the joint.
3. The **arcuate popliteal ligament** arcs superiorly from the head of the fibula over the popliteus muscle to the posterior aspect of the joint capsule (Figure 9.15d).

In addition, the knee joint is stabilized by two strong *intracapsular* ligaments called *cruciate ligaments* (kru′she″āt) because they cross each other like an X (*crus* = cross) (Figure 9.15a, b, and e). Each runs from the tibia to the femur and is named for its site of attachment to the tibia. The **anterior cruciate ligament** attaches to the *anterior* part of the tibia, in the intercondylar area. From there, it passes posteriorly to attach to the femur on the medial side of the lateral condyle. The **posterior cruciate ligament** arises from the *posterior* intercondylar area of the tibia and passes anteriorly to attach to the femur on the lateral side of the medial condyle.

Functionally, the cruciate ligaments act as restraining straps to prevent undesirable movements at the knee joint (Figure 9.16). The anterior cruciate helps prevent anterior sliding of the tibia. The posterior cruciate, which is even stronger than the anterior cruciate, prevents forward sliding of the femur or backward displacement of the tibia. The two cruciates also function together to lock the knee when one stands (discussed shortly).

The tendons of many muscles reinforce the joint capsule and act as critical stabilizers of the knee joint. Most important are the tendons of the quadriceps femoris and semimembranosus muscles (see Figure 9.15c and d). The greater the strength and tone of these muscles, the less the chance of knee injury.

The knees have a built-in locking device that provides steady support for the body in the standing position. As a person stands up, the flexed leg begins to extend at the knee, and the femoral condyles roll like ball bearings on the tibial condyles. Then, as extension nears completion, the lateral femoral condyle stops rolling before the medial condyle stops. This causes the femur to rotate medially on the tibia

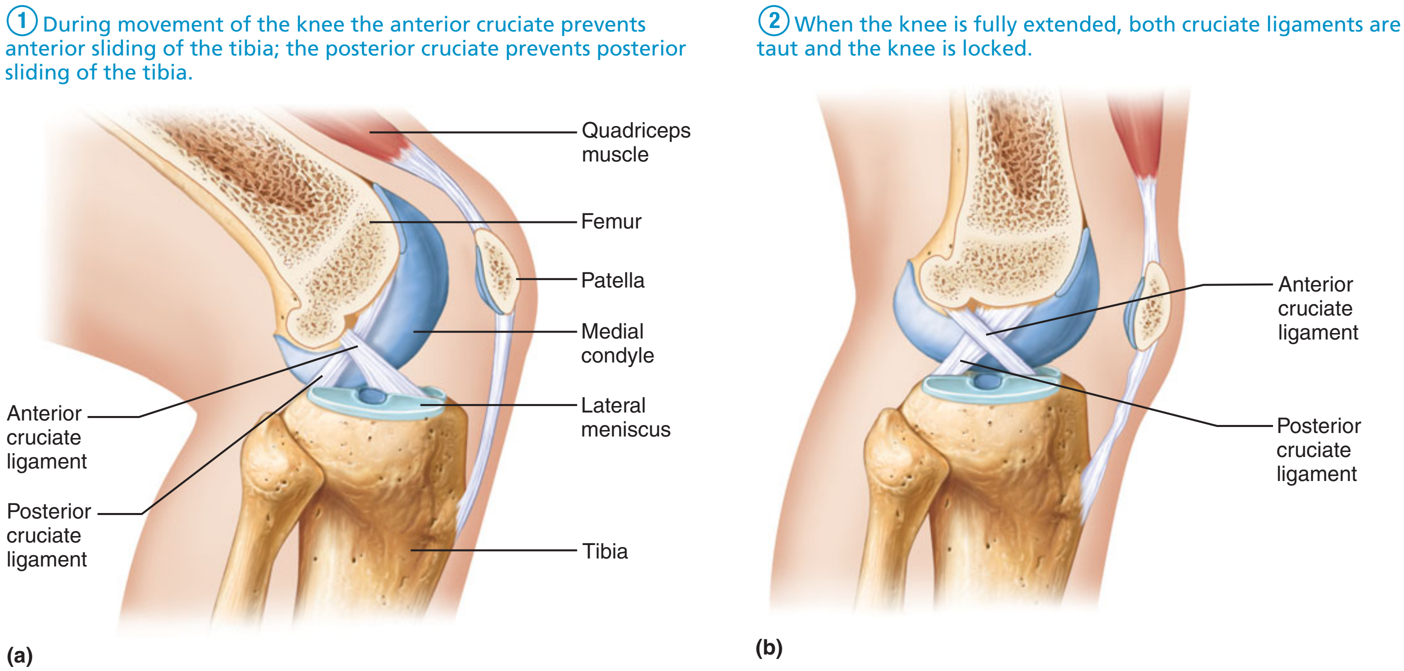


FIGURE 9.16 Stabilizing function of the cruciate ligaments.

until both cruciate and both collateral ligaments stretch tight and halt all movement (Figure 9.16b). The tension in these ligaments locks the knee into a rigid structure that cannot be flexed again until it is unlocked by a muscle called the popliteus (see Table 11.16, pp. 320–325), which rotates the femur laterally on the tibia.

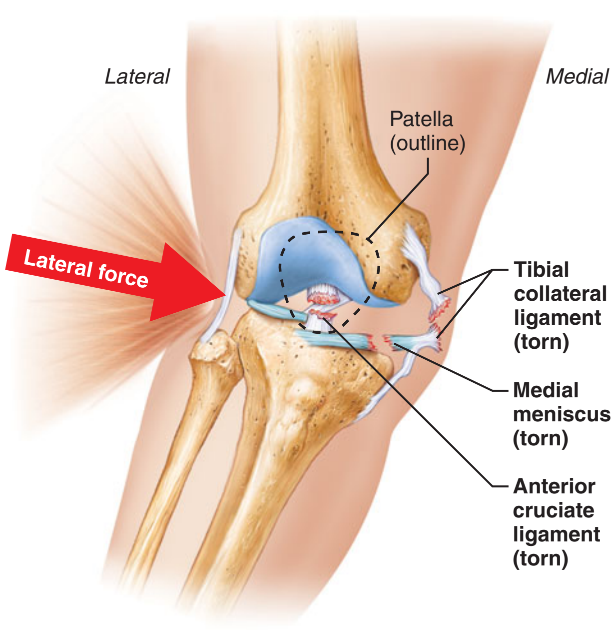


FIGURE 9.17 The "unhappy triad": ruptured ACL, ruptured tibial collateral ligament, and torn meniscus. A common injury in American football.

KNEE INJURIES Knee injuries occur frequently in contact sports because even though ligaments and muscles strongly hold the knee together, its articular surfaces offer no stability. That is, the nearly flat tibial surface has no socket to secure the femoral condyles. Thus, the knee joint is especially vulnerable to *horizontal* blows, such as occur in tackling and body blocks in football. Most dangerous are *lateral* blows **(Figure 9.17)**, which tear the tibial collateral ligament and the medial meniscus attached to it, as well as the anterior cruciate ligament (ACL), an injury coined the "unhappy triad."

Injuries to the ACL alone are increasing rapidly in noncontact sports. Of particular interest is the greater incidence of ACL injuries in women athletes as women's sports become more vigorous and competitive. Numerous factors are implicated in the higher incidence of ACL injuries in women: wider pelvis, narrower intercondylar fossa, effects of female hormones on joint laxity, and slower muscle reaction times. This injury is a common noncontact injury in soccer, basketball, and volleyball. Most ACL injuries result when a runner stops and changes direction quickly, twisting a hyper-extended leg. A torn ACL heals poorly, so it must be replaced surgically, usually with a graft from either the patellar ligament, the Achilles tendon, or the semitendinosus tendon (see pp. 315, 323, and 319). Training regimens are being developed to decrease the incidence of ACL injuries in women athletes. Injuries to the *posterior* cruciate ligament, caused by posteriorly directed blows to the upper tibia, are less common and more able to heal on their own.

Ankle Joint

The **ankle** (talocrural) **joint** is a hinge joint between (1) the united inferior ends of the tibia and fibula, and (2) the talus of the foot **(Figure 9.18)**. This joint allows only dorsiflexion and plantar flexion. Inversion and eversion occur at the intertarsal joints (Figure 9.18a). The ankle joint has a capsule that is thin anteriorly and posteriorly, but thickened with ligaments medially and laterally. The strong **medial (deltoid) ligament** (Figure 9.18b) runs from the medial malleolus of the tibia down to a long line of insertion on the navicular and talus bones, and on the sustentaculum tali of the calcaneus bone. On the other side of the ankle, the **lateral ligament** (Figure 9.18c) consists of three bands that run from the fibula's lateral malleolus to the foot bones: the horizontal **anterior** and **posterior talofibular ligaments,** and the **calcaneofibular ligament,** which runs inferoposteriorly to reach the calcaneus. Functionally, the medial and lateral ligaments prevent anterior and posterior slippage of the talus and the foot.

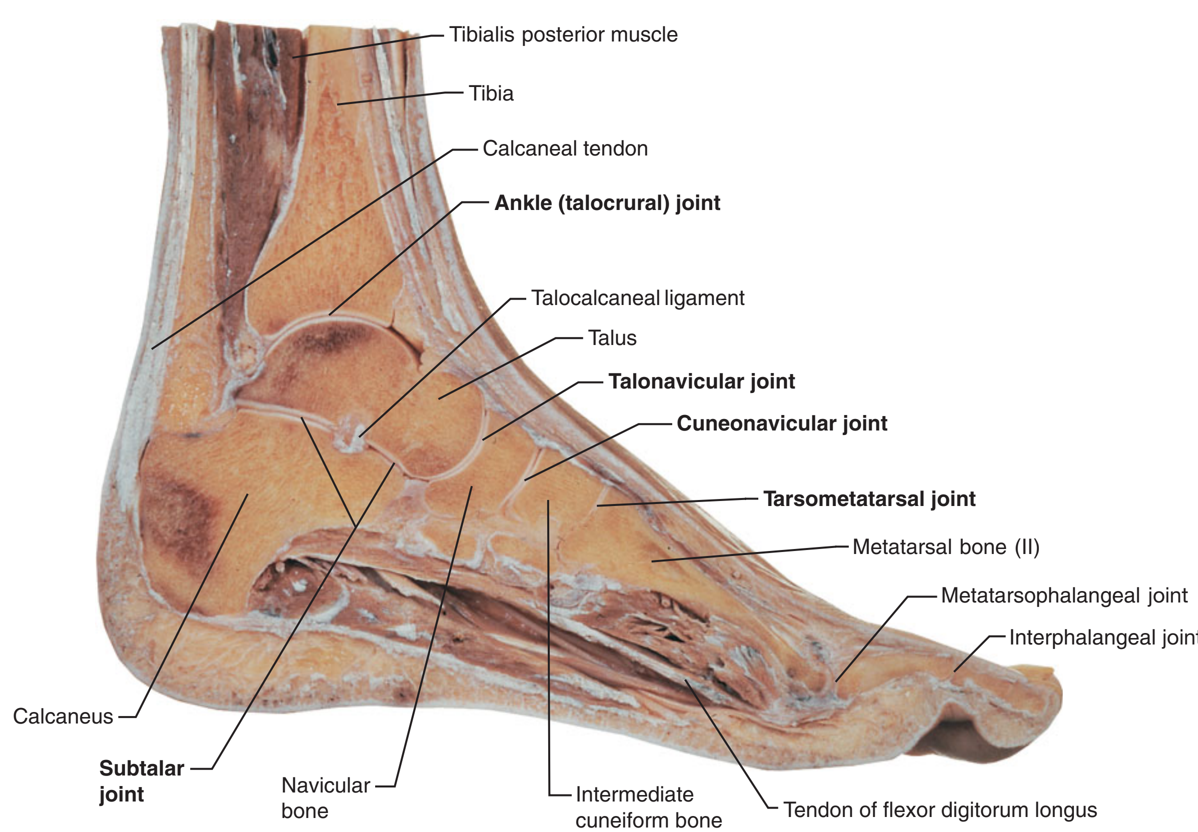
Forming the deep, U-shaped socket of the ankle joint, the inferior ends of the tibia and fibula are joined by ligaments of their own: the **anterior** and **posterior tibiofibular ligaments** and the lower part of the interosseus membrane (Figure 9.18c and d). These ligaments, called the syndesmosis part of the ankle joint, stabilize the socket so that forces can be transmitted to it from the foot.

ANKLE SPRAINS The ankle is the most frequently injured joint in the lower limb, and ankle sprains are the most common sports injuries. (A sprain is a stretched or torn ligament in a joint; see the next section, "Disorders of Joints.") Most ankle sprains are caused by excessive inversion of the foot and involve the lateral ligament. *Syndesmosis ankle sprains,* by contrast, are caused by extreme dorsiflexion, internal rotation, or external rotation of the foot; all these actions move the talus in ways that wedge the tibia away from the fibula and stretch the tibiofibular ligaments. Ankle sprains are treated with the RICE regimen: rest, ice, compression, and elevation, followed by ankle-strengthening exercises as recovery begins.

check your understanding

14. Name the intracapsular ligaments found in the hip and the knee.
15. What ligament is injured in an ankle sprain resulting from forceful inversion?
16. The articular surfaces of the knee contribute little to the stability of this joint. What additional structural features aid in stabilizing the knee?

For answers, see Appendix B.



(a) Cadaver photo of ankle and foot, sagittal section

FIGURE 9.18 The ankle joint.

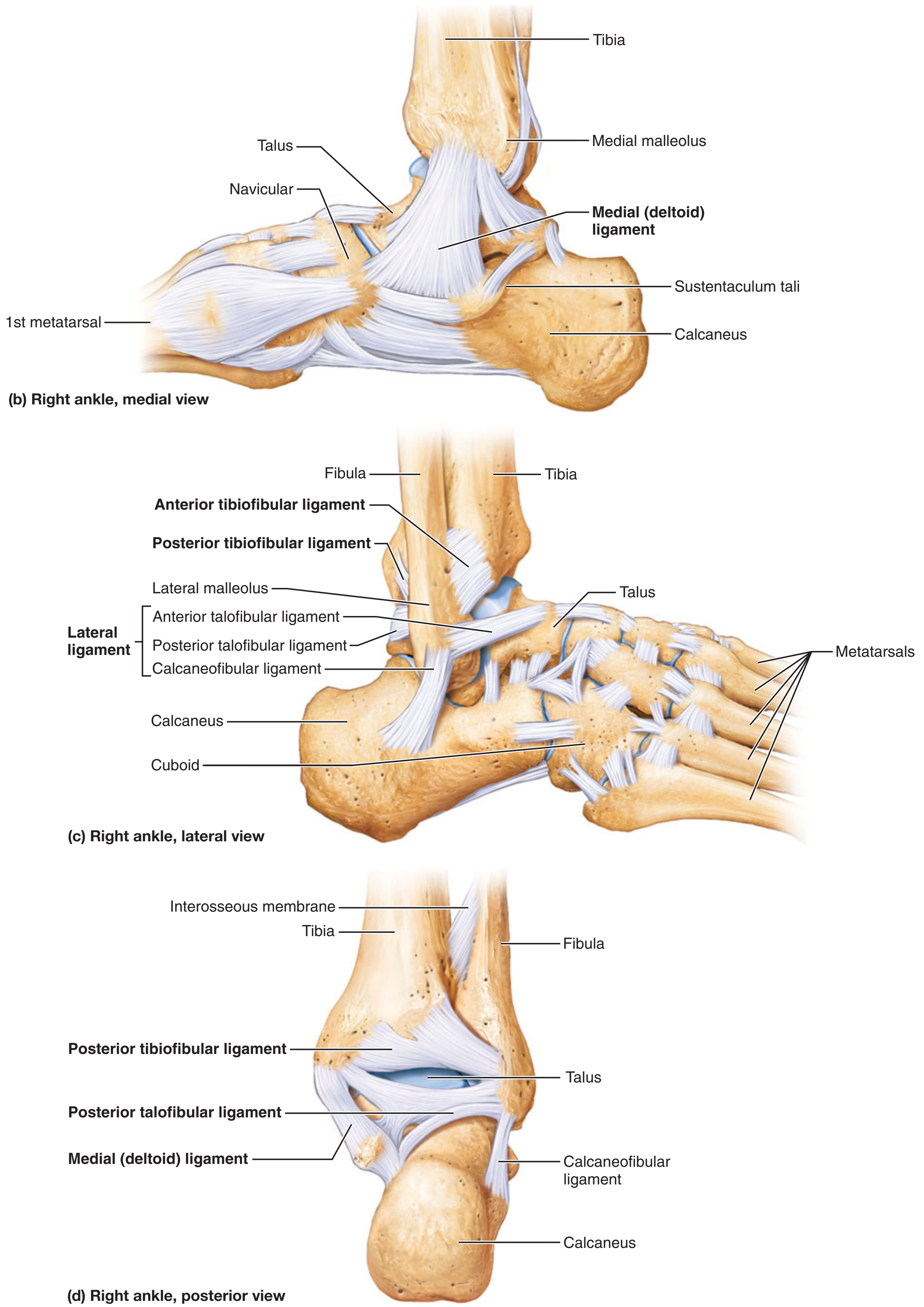


FIGURE 9.18 The ankle joint, *continued.*

DISORDERS OF JOINTS

- ➤ Name the most common injuries to joints, and discuss the problems associated with each.
- ➤ Name and describe the types of arthritis.

The structure and function of joints make them especially vulnerable to a variety of disorders. Because they experience the same strong forces as the hard skeleton, yet consist of soft tissue, joints are prone to *injuries* from traumatic stress. And because their function in movement subjects them to friction and wear, joints can be afflicted by *inflammatory and degenerative processes.*

Joint Injuries

This section briefly explores three types of joint injuries: torn cartilage, sprains, and dislocations.

Torn Cartilage

Even though most cartilage injuries involve tearing of the meniscus in the knee, tears and overuse injuries in the articular cartilages of other joints are becoming increasingly common in competitive athletes, particularly gymnasts.

Cartilage tears in the knee often happen when a meniscus is simultaneously subjected to both high compression and shear stresses. For example, a tennis player lunging to return a ball can rotate the flexed knee medially with so much force that it tears both the joint capsule and the medial meniscus attached to it **(Figure 9.19)**. Because cartilage is avascular, it can rarely repair itself; thus, torn cartilage usually stays torn. Because cartilage fragments (also called *loose bodies*) can cause joints to lock or bind, the recommended treatment often is surgical removal of the damaged cartilage.

Repair is achieved using a remarkable outpatient procedure called **arthroscopic surgery** (ar-thro-skop′ik; "looking into joints"). Using miniaturized video and surgical equipment inserted into the joint through a single small incision, the surgeon removes the cartilage fragments and repairs the ligaments, in the process minimizing scarring and tissue damage and speeding healing. Arthroscopic surgery has applications in many joints, not just the knee.

AUTOLOGOUS CARTILAGE IMPLANTATION
Damaged joint cartilages heal poorly (p. 125), and coaxing them to heal better is a major goal of medical research. Although much progress remains to be made, it has been found that a patient's own chondrocytes, when cultured in the lab and then grafted onto joint surfaces, can produce enough new hyaline cartilage to fill small holes or breaks in the articular cartilages of the knee. This is called *autologous cartilage implantation,* and its long-term goal is to grow thicker sheets of cartilage to cover entire joint surfaces.

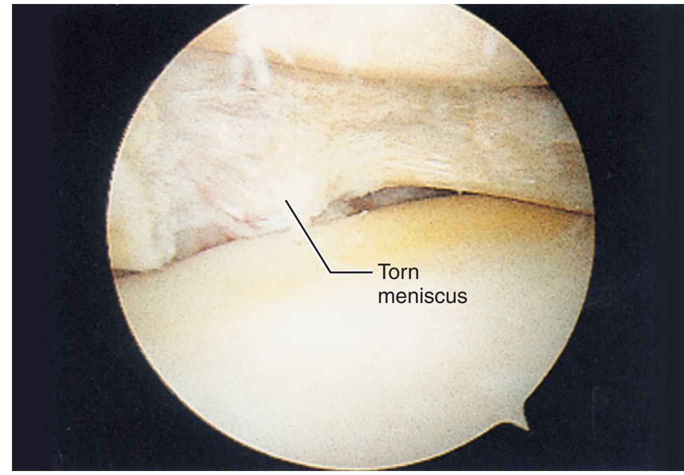


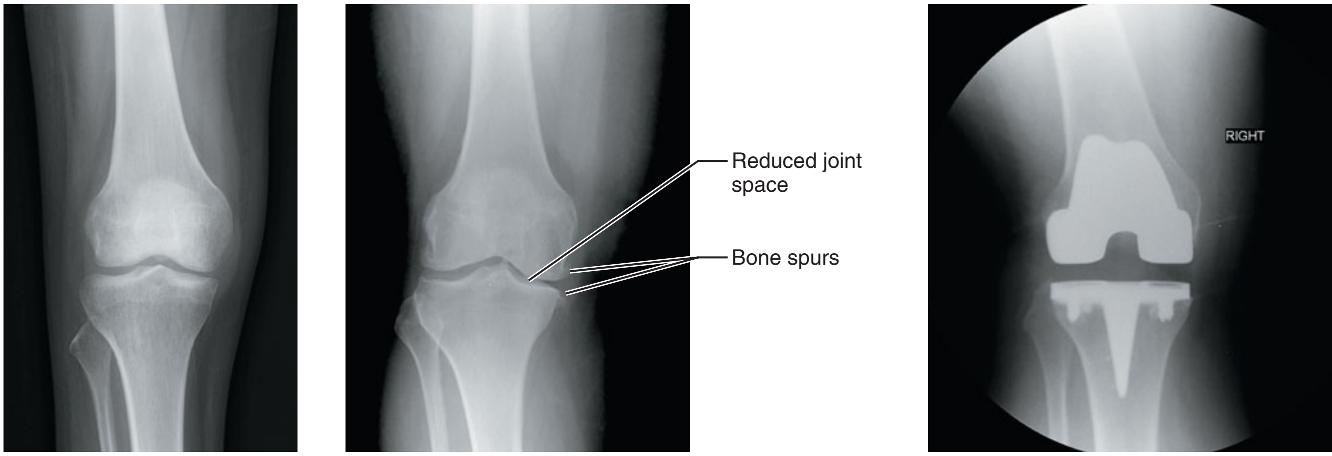
FIGURE 9.19 Arthroscopic photograph of a torn medial meniscus.

Sprains

In a **sprain,** the ligaments reinforcing a joint are stretched or torn. Common sites of sprains are the lumbar region of the spine, the ankle, and the knee. Partly torn ligaments eventually repair themselves, but they heal slowly because ligaments are poorly vascularized. Sprains tend to be painful and immobilizing. Completely ruptured ligaments, by contrast, require prompt surgical repair because inflammation in the joint breaks down the neighboring tissues and turns the injured ligament to "mush." Surgical repair can be a difficult task: A ligament consists of hundreds of fibrous strands, and sewing a ligament back together has been compared to sewing two hairbrushes together. When important ligaments are too severely damaged to be repaired, they must be removed and replaced with grafts or substitute ligaments.

Dislocations

A **dislocation (luxation)** occurs when the bones of a joint are forced out of alignment. This injury is usually accompanied by sprains, inflammation, pain, and difficulty in moving the joint. Dislocations may result from serious falls or blows and are common sports injuries. The jaw, shoulder, finger, and thumb joints are most commonly dislocated. Like fractures, dislocations must be reduced; that is, the bone ends must be returned to their proper positions by a physician. **Subluxation** is a partial or incomplete dislocation of a joint. In a subluxation, the bone ends return to their proper position on their own. A joint that has been dislocated once is susceptible to repeated injury because the initial dislocation stretches the joint capsule and ligaments. After the capsule is loosened, the joint is more likely to dislocate again. Injured ligaments eventually shorten to their original length, but this aspect of healing can take years.



(a) Normal knee **(b) Osteoarthritis** **(c) Total knee replacement**

FIGURE 9.20 Osteoarthritis of the knee.

NURSEMAID'S ELBOW A common injury to the forearm in young children (less than 5 years of age) is subluxation of the proximal radioulnar joint. When the forearm is pulled with the arm outstretched, as in swinging a child by her hands, the head of the radius can be pulled away from the anular ligament (see Figure 9.12b–d), resulting in entrapment of the anular ligament in the humeroradial joint. The immediate pain that occurs upon injury subsides and is followed by a reluctance to use the injured arm. A history of pulling on the forearm is critical for diagnosing this injury accurately. Treatment is a simple reduction that results in immediate return to use of the arm.

Inflammatory and Degenerative Conditions

Inflammatory conditions that affect joints include inflammations of bursae and tendon sheaths and various forms of arthritis.

Bursitis and Tendinitis

Bursitis, inflammation of a bursa, usually results from a physical blow or friction, although it may also be caused by arthritis or bacterial infection. In response, the bursa swells with fluid. Falling on one's knee can cause a painful bursitis of the subcutaneous prepatellar bursa (see Figure 9.15a), known as **housemaid's knee.** Resting and rubbing one's elbows on a desk can lead to **student's elbow,** or **olecranon bursitis,** the swelling of a bursa just deep to the skin of the posterior elbow. Severe cases of bursitis may be treated by injecting inflammation-reducing drugs into the bursa. Excessive fluid accumulation may require fluid removal by needle aspiration.

Tendinitis is inflammation of tendon sheaths. Its causes, symptoms, and treatments mirror those of bursitis.

Arthritis

The term **arthritis** describes over 100 kinds of inflammatory or degenerative diseases that damage the joints. In all its forms, arthritis is the most widespread crippling disease in the United States: One of every seven Americans suffers from its effects. All forms of arthritis have, to a greater or lesser degree, the same initial symptoms: pain, stiffness, and swelling of the joint.

Osteoarthritis (Degenerative Joint Disease) The most common type of arthritis is **osteoarthritis (OA),** a chronic (long-term) degenerative condition that is often called "wear-and-tear arthritis." It is most common in the aged and is probably related to the normal aging process. OA affects women more often than men, but 85% of all Americans develop this condition. OA affects the articular cartilages, causing them to soften, fray, crack, and erode.

The cause of OA is unknown. According to current theory, normal use causes joints to release metalloproteinase enzymes that break down the cartilage matrix (especially the collagen fibrils); meanwhile, the chondrocytes continually repair the damage by secreting more matrix. Whenever the strain on a joint is repeated or excessive, too much of the cartilage-destroying enzyme is thought to be released, causing OA. Because this process occurs most where an uneven orientation of forces causes extensive microdamage, badly aligned or overworked joints are likely to develop OA.

The bone directly below the articular cartilage is also affected, becoming dense and stiff. As the disease progresses, bone spurs tend to grow around the margins of the damaged cartilages, encroaching on the joint cavity and perhaps restricting joint movement **(Figure 9.20)**. Patients complain of stiffness upon waking in the morning, but this decreases within a half hour. However, there is always joint pain during use. The affected joints may make a crunching noise (called *crepitus*) as their roughened surfaces rub together during movement.

The joints most commonly affected in OA are those of the fingers, knuckles, hips, and knees. The nonsynovial joints between the vertebral bodies are also susceptible, especially in the cervical and lumbar regions of the spine.

The course of OA is slow and irreversible. It is not usually crippling, except for some severe cases involving the hip and knee joints. Inflammation may or may not accompany the degeneration of the joints, but it is usually not severe. In many cases the symptoms of OA can be controlled with a pain reliever such as aspirin or acetaminophen plus a program of low-impact exercise. Rubbing a hot-pepper-like substance called capsaicin on the skin over the joint also helps lessen the pain of OA. As more aging individuals are enjoying active lifestyles, joint replacement has become a common treatment for joints severely damaged by arthritis (Figure 9.20c).

Rheumatoid Arthritis Another kind of arthritis, **rheumatoid** (roo′mah-toid) **arthritis (RA)** is a chronic inflammatory disorder. It is a complex disease: Along with pain and swelling of the joints, its manifestations include osteoporosis, muscle weakness, and problems with the heart and blood vessels.

The course of RA is variable: It may develop gradually or in spurts that are years apart, and it is marked by flare-ups and remissions (*rheumat,* from the Greek, means "susceptible to change"). Its onset usually occurs between the ages of 30 and 50, but it may arise at any age. Although not as common as osteoarthritis, RA afflicts millions, about 1% of all people. It affects three times as many women as men and wanes when a woman is pregnant, so apparently it is influenced by female sex hormones. RA tends to affect many joints simultaneously and bilaterally (on both sides of the body), especially the small joints of the fingers, wrists, ankles, and feet.

RA is an **autoimmune disease**—a disorder in which the body's immune system attacks its own tissues. The cause of this reaction is unknown, but RA might follow infection by certain bacteria and viruses that bear surface molecules similar to molecules normally present in the joints. When the body is stimulated to attack the foreign molecules, it inappropriately destroys its own joint tissues as well.

RA begins with an inflammation of the synovial membrane. Capillaries in this membrane leak tissue fluid and white blood cells into the joint cavity. This excess synovial fluid then causes the joint to swell. The chronic inflammation and swelling can deteriorate the connective tissues surrounding the joint. In the hand, the loss of integrity of the joint capsules in the metacarpophalangeal and interphalangeal joints leads to the characteristic deformities due to RA, shown in Figure 9.21. With time, the inflamed synovial membrane thickens into a *pannus* ("rag"), a coat of granulation tissue that clings to the articular cartilages. The pannus erodes the cartilage and, often, the underlying bone. As the cartilage is destroyed, the pannus changes into a fibrous scar tissue that interconnects the bone ends. This scar tissue eventually ossifies, and the bone ends fuse together, immobilizing the joint. This end condition, called **ankylosis** (ang″kĭ-lo′sis; "stiff condition"), often produces bent, deformed fingers.

Most drugs used to treat RA are either anti-inflammatory or antibiotic, or they block the immune response. These must be given for long periods and are only partly successful; there is no cure. Joint prostheses are the last resort for severely crippled patients. Some RA sufferers have over a dozen artificial joints.

FIGURE 9.21 A hand deformed by rheumatoid arthritis. Note the enlarged joints, a product of inflammation of the synovial joints.

Gouty Arthritis (Gout) Ordinarily, people maintain proper blood levels of uric acid, a normal waste product of nucleic acid metabolism, by excreting it in the urine. If the rate of excretion is low, uric acid levels rise abnormally in the blood and body fluids, and the acid precipitates as solid crystals of urate in the synovial membranes. An inflammatory response follows as the body tries to attack and digest the crystals, producing an agonizingly painful attack of **gouty** (gow′te) **arthritis,** or **gout.** The initial attack involves a single joint, usually in the lower limb, often at the base of the big toe. Other attacks usually follow, months to years later. Gout is far more common in men than in women because men naturally have higher levels of uric acid in their blood (perhaps because estrogens increase the rate of its excretion).

Untreated gout can cause the ends of articulating bones to fuse, immobilizing the joint. Fortunately, effective treatment is available. For acute attacks, nonsteroidal antiinflammatory drugs such as ibuprofen are used. For the long term, urate-lowering drugs and dietary measures (avoidance of alcohol and red meat) are effective.

check your understanding

17. Identify the type of arthritis described in each case: (a) crystallization of uric acid in synovial membranes; (b) erosion of articular cartilage; (c) autoimmune response causing inflammation of the synovial membrane.
18. Why is an injured joint more susceptible to repeat of the injury following a sprain or subluxation?

For answers, see Appendix B.

THE JOINTS THROUGHOUT LIFE

➤ Describe how joints develop and how their function may be affected by aging.

Synovial joints develop from mesenchyme that fills the spaces between the cartilaginous "bone models" in the late embryo. The outer region of this intervening mesenchyme condenses to become the fibrous joint capsule, whereas the inner region hollows to become the joint cavity. By week 8, these joints resemble adult joints in form and arrangement; that is, their synovial membranes are developed, and synovial fluid is being secreted into the joint cavities. These basic structural features are genetically determined, but after birth a joint's size, shape, and flexibility are modified by use. Active joints grow larger and have thicker capsules, ligaments, and bony supports than they would if they were never used.

During youth, many injuries to joints tear or knock the epiphysis off the shaft, a vulnerability that ends after the epiphyseal plates close in early adulthood. From that time on, comparable injuries merely result in sprains.

Osteoarthritis is the most common joint problem associated with advancing age. Just as bones must be stressed to maintain their strength, joints must be exercised to keep their health. Exercise squeezes synovial fluid in and out of articular cartilages, providing the cartilage cells with the nourishment they need. And although exercise cannot prevent osteoarthritis, it strengthens joints and slows degeneration of the articular cartilages. It also strengthens the muscles that stabilize the joints. Overexercising, however, worsens osteoarthritis. Because the buoyancy of water relieves much of the stress on weight-bearing joints, people who exercise in pools often retain good joint function throughout life.

check your understanding

19. By what age of development are synovial joints formed?

For answers, see Appendix B.

RELATED CLINICAL TERMS

ANKYLOSING SPONDYLITIS (ang″kĭ-lo′sing spon″dĭ-li′tis) (*ankyl* = stiff joint; *spondyl* = vertebra) A distinctive kind of rheumatoid arthritis that mainly affects men. It usually begins in the sacroiliac joints and progresses superiorly along the spine. The vertebrae become interconnected by so much fibrous tissue that the spine becomes rigid ("poker back").

ARTHROPLASTY ("joint reforming") Replacing a diseased joint with an artificial joint (see Figure 9.20).

CHONDROMALACIA PATELLAE ("softening of cartilage of the patella") Damage and softening of the articular cartilages on the posterior surface of the patella and the anterior surface of the distal femur. This condition, seen most often in adolescent athletes, produces a sharp pain in the knee when the leg is extended (in climbing stairs, for example). Chondromalacia may result when the quadriceps femoris, the main group of muscles on the anterior thigh, pulls unevenly on the patella, persistently rubbing it against the femur in the knee joint. Chondromalacia can often be corrected by exercises that strengthen weakened parts of the quadriceps muscles.

LYME DISEASE An inflammatory disease that often results in joint pain and arthritis, especially in the knee joint. It is caused by spirochetes, bacterial organisms transmitted by the bites of ticks that live on deer and mice. Lyme disease is also characterized by a skin rash and flulike symptoms. It is treatable with antibiotics, especially if detected early.

PATELLOFEMORAL PAIN SYNDROME Persistent pain in the region behind the patella; results from rubbing pressure between the femoral condyles and the patella, as may occur with overuse of the quadriceps femoris muscles or an abnormally shaped patella. Is distinguished from chondromalacia patellae (see above) by usual absence of damage to the cartilage and generally younger age at onset. Treatment is exercise that strengthens the different quadriceps muscles evenly and gradually.

SYNOVITIS Inflammation of the synovial membrane of a joint. Can result from a blow, an infection, or arthritis. Synovitis leads to the production of excess fluid, causing the joints to swell. Such accumulation of fluid in the joint cavity is called *effusion*.

TENOSYNOVITIS (ten′o-sin″o-vi″tis) Painful inflammation of a tendon or its sheath. Occurs most often in the hands, wrists, feet, or ankles as a result of repeated, intense use, and it may be temporarily disabling. The condition is common in pianists and typists. It can also be caused by arthritis and bacterial infection of the tendon sheath. Therapy involves immobilization of the affected body region or surgery to drain an infected tendon sheath.

VALGUS AND VARUS INJURIES *Valgus* means "bent outward, away from the body midline," such as in abduction of the leg at the knee or the forearm at the elbow. *Varus* means "bent inward," such as in adduction of these elements. Because the knee and elbow are not designed for such movements, strong valgus and varus bending injures them.

CHAPTER SUMMARY

You can use the following media study tool for additional help when you review specific key topics in Chapter 9.

PAL = ***Practice Anatomy Lab™***

1. Joints (articulations) are sites where elements of the skeleton meet. They hold bones together and allow various degrees of movement.

Classification of Joints (p. 207)

2. Joints are classified functionally as synarthrotic (no movement), amphiarthrotic (slight movement), or diarthrotic (free movement). They are classified structurally as fibrous, cartilaginous, or synovial.

Fibrous Joints (pp. 207–208)

3. In fibrous joints, the bones are connected by fibrous connective tissue. No joint cavity is present. Nearly all fibrous joints are synarthrotic (immovable).

4. The types of fibrous joints are sutures (between skull bones), syndesmoses ("ligament joints"), and gomphoses (articulation of the teeth with their sockets).

Cartilaginous Joints (pp. 208–209)

5. In cartilaginous joints, the bones are united by cartilage. No joint cavity exists.

6. Synchondroses are immovable joints of hyaline cartilage, such as epiphyseal plates. Symphyses are amphiarthrotic (slightly movable) fibrocartilage joints, such as intervertebral discs and the pubic symphysis.

Synovial Joints (pp. 209–221)

7. Most joints in the body are synovial. Synovial joints are diarthrotic (freely movable).

General Structure of Synovial Joints (pp. 209–221)

8. Synovial joints have a fluid-containing cavity and are covered by an articular capsule. The capsule has an outer fibrous region, often reinforced by ligaments, and an inner synovial membrane that produces synovial fluid. The articulating ends of bone are covered with impact-absorbing articular cartilages. Nerves in the capsule provide a sense of "joint stretch." Some joints contain fibrocartilage discs (menisci), which distribute loads evenly and may allow two movements at one joint.

9. Synovial fluid is mainly a filtrate of the blood, but it also contains molecules that make it a friction-reducing lubricant.

10. Bursae and tendon sheaths are often associated with synovial joints. A bursa is a fibrous sac lined by a synovial membrane and containing synovial fluid. Tendon sheaths, which are similar to bursae, wrap around certain tendons. They act as lubricating devices that allow adjacent structures to move smoothly over one another.

General Function of Synovial Joints (pp. 211–212)

11. Synovial joints reduce friction. The cartilage-covered bone ends glide on a slippery film of synovial fluid squeezed out of the articular cartilages. This mechanism is called weeping lubrication.

Movements Allowed by Synovial Joints (pp. 212–214, 215)

12. Contracting muscles produce three common kinds of bone movements at synovial joints: gliding, angular movements (flexion, extension, abduction, adduction, and circumduction), and rotation.

13. Special movements include elevation and depression, protraction and retraction, supination and pronation of the forearm, opposition of the thumb, inversion and eversion of the foot, and dorsiflexion and plantar flexion of the foot.

Synovial Joints Classified by Shape (pp. 214, 216–219)

14. The shapes of the articular surfaces reflect the kinds of movements allowed at a joint. Joints are classified by shape as plane (nonaxial), hinge or pivot (uniaxial), condyloid or saddle (biaxial), or ball-and-socket (multiaxial) joints.

Factors Influencing the Stability of Synovial Joints (pp. 219–221)

15. Joints are the weakest part of the skeleton. Factors that stabilize joints are the shapes of the articulating surfaces, ligaments, and the tone of muscles whose tendons cross the joint.

Selected Synovial Joints (pp. 221–232)

16. The sternoclavicular joint is a saddle joint between the medial end of the clavicle and the manubrium of the sternum. This joint allows for elevation, depression, protraction, retraction, and slight rotation. It is an extremely stable joint.

17. The temporomandibular joint is a modified hinge joint formed by (1) the head of the mandible and (2) the mandibular fossa and articular tubercle of the temporal bone. This joint allows both a hingelike opening of the mouth and an anterior gliding of the mandible. It often dislocates anteriorly and is frequently the site of stress-induced temporomandibular disorders.

18. The shoulder (glenohumeral) joint is a ball-and-socket joint between the glenoid cavity and the head of the humerus. It is the body's most freely movable joint. Its socket is shallow, and its capsule is lax and reinforced by ligaments superiorly and anteriorly. The tendons of the biceps brachii and the rotator cuff help stabilize the joint. The humerus often dislocates anteriorly, then inferiorly, at the shoulder joint.

19. The elbow is a hinge joint in which the ulna and radius articulate with the humerus. It allows flexion and extension. Its articular surfaces are highly complementary and help stabilize it. Radial and ulnar collateral ligaments prevent side-to-side movement of the forearm.

20. The wrist is composed of a condyloid joint between the distal end of the radius and the proximal carpals (scaphoid, lunate) that allows for flexion, extension, abduction, and adduction of the hand. The intercarpal joint between the proximal row of carpals and the distal row of carpals is a gliding joint allowing sliding movements between the carpals.

21. The hip joint is a ball-and-socket joint between the acetabulum of the hip bone and the head of the femur. It is adapted for weight bearing. Its articular surfaces are deep and secure, and its capsule is strongly reinforced by three ligamentous thickenings.

22. The knee is a complex and shallow joint formed by the articulation of the tibial and femoral condyles (and anteriorly by the patella with the femur). Extension, flexion, and some rotation are allowed. C-shaped menisci occur on the articular surfaces of the tibia. The capsule, which is absent anteriorly, is reinforced elsewhere by several capsular ligaments. For example, the tibial and fibular collateral ligaments help prevent hyperextension, abduction, and adduction of the leg. The intracapsular cruciate ligaments help prevent anterior-posterior displacement of the joint surfaces and

help lock the knee when one stands. The tone of the muscles crossing this joint is important for knee stability. In contact sports, lateral blows are responsible for many knee injuries. In noncontact sports, the anterior cruciate ligament is a frequent site of injury caused by quick stopping and change of direction.

23. The ankle joint is a hinge joint between (1) the distal tibia and fibula and (2) the talus of the foot. Its medial and lateral ligaments allow plantar flexion and dorsiflexion but prevent anterior and posterior displacements of the foot. Inversion and eversion of the foot occur through gliding movements at the intertarsal joints.

PAL **Human Cadaver/Joints**

Disorders of Joints (pp. 233–235)

Joint Injuries (p. 233)

24. Trauma can tear joint cartilages. Sports injuries to the knee menisci are common and can result from twisting forces as well as from direct blows to the knee. Arthroscopic surgery is used to repair knee and other joint injuries.

25. Sprains are the stretching and tearing of joint ligaments. Because ligaments are poorly vascularized, healing is slow.

26. Joint dislocations move the surfaces of articulating bones out of alignment. Such injuries must be reduced.

Inflammatory and Degenerative Conditions (pp. 234–235)

27. Bursitis and tendinitis are inflammation of a bursa and a tendon sheath, respectively.

28. Arthritis is the inflammation or degeneration of joints accompanied by pain, swelling, and stiffness. Arthritis includes many different diseases and affects millions of people.

29. Osteoarthritis is a degenerative condition that first involves the articular cartilages. It follows wear or excessive loading, and is common in older people. Weight-bearing joints are most often affected.

30. Rheumatoid arthritis, the most crippling kind of arthritis, is an autoimmune disease involving severe inflammation of the joints, starting with the synovial membranes.

31. Gout is joint inflammation caused by a deposition of urate salts in the synovial membranes.

The Joints Throughout Life (p. 236)

32. Joints develop from mesenchyme between the cartilaginous “bone models” in the embryo.

33. Joints usually function well until late middle age, when osteoarthritis almost always appears.

REVIEW QUESTIONS

Multiple Choice/Matching Questions

For answers, see Appendix B.

1. Match the joint types in the key to the descriptions that apply to them (More than one joint type might apply.)

Key: (a) fibrous joints
(b) cartilaginous joints
(c) synovial joints

____ (1) have no joint cavity

____ (2) types are sutures and syndesmoses

____ (3) dense connective tissue fills the space between the bones

____ (4) almost all joints of the skull

____ (5) types are synchondroses and symphyses

____ (6) all are diarthroses

____ (7) the most common type of joint in the body

____ (8) nearly all are synarthrotic

____ (9) shoulder, hip, knee, and elbow joints

2. Synovial joints have (a) articular cartilage, (b) a joint cavity, (c) a lubricant, (d) an articular capsule, (e) all of these.

3. In general, the most important factor(s) determining the stability of synovial joints is (a) interlocking shapes of the articular surfaces, (b) reinforcing ligaments, (c) ligaments and muscle tone, (d) synovial fluid, which acts like glue, (e) the body’s wrapping of skin, which holds the limbs together.

4. Characteristics of a symphysis include (a) presence of fibrocartilage, (b) ability to resist large compression and tension stresses, (c) presence of a joint cavity, (d) very high mobility, (e) both a and b.

5. Synovial joints are most richly innervated by nerve fibers that (a) monitor how much the capsule is stretched, (b) supply the articular cartilages, (c) cause the joint to move, (d) monitor pain when the capsule is injured.

6. Match the parts of a synovial joint listed in the key to their functions below. (More than one part may apply.)

Key: (a) articular cartilage (b) ligaments and fibrous capsule
(c) synovial fluid (d) muscle tendon

____ (1) keeps bone ends from crushing when compressed; resilient

____ (2) resists tension placed on joints

____ (3) lubricant that minimizes friction and abrasion of joint surfaces

____ (4) keeps joints from overheating

____ (5) helps prevent dislocation

7. Indicate the joint (or joints) from the list in column B that contains the structure listed in column A.

Column A	Column B
____ **(1)** medial meniscus	**(a)** sternoclavicular joint
____ **(2)** anular ligament	**(b)** temporomandibular joint
____ **(3)** saddle joint	**(c)** wrist joint
____ **(4)** articular disc	**(d)** shoulder joint
____ **(5)** rotator cuff	**(e)** elbow joint
____ **(6)** anterior cruciate ligament	**(f)** hip joint
____ **(7)** deltoid ligament	**(g)** knee joint
____ **(8)** ulnar collateral ligament	**(h)** ankle joint
____ **(9)** fibular collateral ligament	

8. Classify each of the synovial joints listed as one of the following: (a) plane joint, (b) hinge joint, (c) pivot joint, (d) condyloid joint, (e) saddle joint, (f) ball-and-socket joint.

—— (1) proximal radioulnar joint

—— (2) trapezium and metacarpal 1

—— (3) knee (tibiofemoral)

—— (4) metacarpophalangeal joint

—— (5) wrist (radiocarpal) joint

—— (6) atlanto-occipital joint

—— (7) atlantoaxial joint

—— (8) sternocostal joints, ribs 2–7

—— (9) intervertebral joints (between articular processes)

—— (10) acromioclavicular

Short Answer Essay Questions

9. Define joint.
10. Where does synovial fluid come from?
11. Explain weeping lubrication of the synovial joint surfaces.
12. Compare and contrast (1) flexion and extension with (2) adduction and abduction.
13. Name two specific examples of each: hinge joint, plane joint, condyloid joint, ball-and-socket joint.
14. What are the functions of the menisci of the knee? Of the anterior and posterior cruciate ligaments?
15. Why are sprains and injuries to joint cartilages particularly troublesome?
16. Name the most common direction in which each of the following joints tends to dislocate: (a) shoulder, (b) elbow.
17. Examine the thorax using a skeleton or an illustration. Classify the various joints you see as containing either hyaline cartilage, fibrocartilage, or fibrous tissue (fibrous joints).
18. What are the technical names of and movements allowed at the following joints? (a) joints in the toes, (b) wrist joint, (c) jaw joint, (d) joint between sacrum and coxal bones, (e) knuckle joint in the hand.
19. List the functions of the following parts of a synovial joint: (a) fibrous part of the capsule, (b) synovial fluid, (c) articular disc.
20. Compare a bursa and a tendon sheath in terms of their structure, function, and locations.
21. Provide the anatomically proper names of the joints between (a) the scapula and clavicle, (b) the articular processes of successive vertebrae, (c) the ribs and sternum, (d) the ribs and vertebrae, (e) the various tarsal bones.
22. Name the joint that contains the (a) glenoid cavity and labrum; (b) cruciate ligaments and menisci; (c) anular ligament and head of radius; (d) coronoid process, trochlea, and radial collateral ligament; (e) medial and lateral ligaments and talus.

CRITICAL REASONING & CLINICAL APPLICATION QUESTIONS

1. Harry was jogging down the road when he tripped in a pothole. As he fell, his ankle twisted violently to the side. The diagnosis was severe dislocation and spraining of the ankle. The surgeon stated that she would perform a reduction of the dislocation and then attempt to repair the injured ligament using arthroscopy. (a) What kinds of movements can normally occur at the ankle joint? (b) Was the doctor telling Harry that his bones were broken? (c) What is reduction of a joint? (d) Why is it necessary to repair ligaments surgically? (e) How will the use of arthroscopic surgery minimize Harry's recovery time and his suffering?
2. Dan Park, an exhausted anatomy student, was attending a lecture. After 30 minutes he began to doze. He woke up suddenly (the professor's voice was too loud to permit a good nap) and yawned widely. To his great distress, he couldn't close his mouth—his lower jaw was stuck open. What had happened?
3. Mrs. Estevez, who is 37 years old, visited her physician and complained of unbearable pain in several joints of both hands. The joints were very red, swollen, and warm to the touch. When asked if she had ever had such an episode in the past, she said she had had a similar attack 2 years earlier that had disappeared as suddenly as it had come. Her diagnosis was arthritis. (a) What type of arthritis does she have? (b) What is the cause of joint inflammation in this type of arthritis?
4. At work, a box fell from a shelf onto Ming's acromial region. In the emergency room, the physician could feel that the head of her humerus had moved into the axilla. What had happened to Ming?
5. At his ninety-fourth birthday party, Jim was complimented on how good he looked and was asked about his health. He answered, "I feel good, except that some of my joints ache and are stiff, especially my knees and hips and lower back, and especially when I wake up in the morning." A series of X-ray studies and an MRI scan taken a few weeks earlier showed that the articular cartilages of these joints were rough and flaking off and that bone spurs were present at the ends of some of Jim's bones. What is Jim's probable condition?
6. On the evening news, Samantha heard that the deer population in her state had increased greatly in the past few years, and she knew that deer were often seen walking the streets of her suburban community. Suddenly, she exclaimed, "So that's why several children in my son's class got Lyme disease this year!" Explain her reasoning. (See "Related Clinical Terms")
7. How does the structure of the joints in each limb reflect the function of each limb (mobility in the upper limb, stability in the lower limb)?