Reinforced Binding

Hole's HUMAN ANATOMY & PHYSIOLOGY

Charles J. Welsh
Cynthia Prentice-Craver

Sixteenth Edition

LEARN • PRACTICE • ASSESS

Sample Chapter

Student Edition

Mc Graw Hill

8 Joints of the Skeletal System

THE WHOLE PICTURE

Remember the days when you would skip on the school playground? Believe it or not, skipping is a complicated maneuver and requires physical coordination. The movement is a motion of step, hop, step, hop, where you plant one foot on the ground and hop as the other leg lifts, while the opposite arm to the lifted leg swings forward, and then repeat on the other side. Skipping involves flexion, extension, and plantar flexion, among other movements. We can thank our joints for allowing this kind of locomotion.

Joints, or articulations, are functional junctions between bones. Composed of various connective tissues, joints are found between the bones of your skull, between your vertebrae, and between your ankle and wrist bones, to name a few. Joints allow long bones to grow in length at the growth (epiphyseal) plate. They provide some flexibility between a pregnant woman's pubic bones to accommodate the baby's head upon delivery. Some joints are more complex, such as the knee joint with all of its ligaments and cartilages.

A true appreciation of your joints may not come until an injury occurs, or when you get to an age where joint pain is felt with no obvious cause. Athletes train in an effort to reduce joint (and other) injury. Wear and tear on the joints will occur as a person ages, and may begin early in life, depending on a person's lifestyle, activity, disease, or genetics. As you pursue your daily routine, give some attention to your joints and the movements they allow. Maybe do some skipping!

Two young girls holding hands skipping in a park. Dianne Avery Photography/Moment/Getty Images

LEARNING OUTLINE

After studying this chapter, you should be able to complete the "Learning Outcomes" that follow the major headings throughout the chapter.

UNDERSTANDING WORDS

anul-, ring: *anul*ar ligament—ring-shaped band of connective tissue below the elbow joint that encircles the head of the radius.
arth-, joint: *arth*rology—study of joints and ligaments.
burs-, bag, purse: prepatellar *burs*a—fluid-filled sac between the skin and the patella.
glen-, joint socket: *glen*oid cavity—depression in the scapula that articulates with the head of the humerus.
labr-, lip: glenoidal *labr*um—rim of fibrocartilage attached to the margin of the glenoid cavity.
ov-, egglike: syn*ov*ial fluid—thick fluid in a joint cavity that resembles egg white.
sutur-, sewing: *sutur*e—type of joint in which flat bones are interlocked by a set of tiny bony processes.
syn-, with, together: *syn*chondrosis—type of joint in which the bones are held together by cartilage.
syndesm-, band, ligament: *syndesm*osis—type of joint in which the bones are held together by long fibers of connective tissue.

8.1 | Types of Joints

LEARN

1. Explain how joints may be classified according to the type of tissue that binds the bones together and the degree of movement possible at a joint.
2. Describe how bones of fibrous joints are held together, and name an example of each type of fibrous joint.
3. Describe how bones of cartilaginous joints are held together, and name an example of each type of cartilaginous joint.
4. Describe the general structure of a synovial joint.
5. Distinguish among the six types of synovial joints, and name an example of each type.

Joints, also called *articulations* ("jointed"), are connections between bones. They have many functions that include providing stability by binding parts of the skeletal system, making possible bone growth, permitting parts of the skeleton to change shape during childbirth, and enabling the body to move in response to skeletal muscle contraction. The number of joints changes in the human body from birth until old age. However, typically there are about 230 joints in the average adult.

Joints vary in function and structure. Functionally, joints are classified according to the degree of movement they make possible. Joints can be immovable (synarthrotic), slightly movable (amphiarthrotic), and freely movable (diarthrotic). At some diarthrotic joints, movement can occur over considerable distances, such as flexion and extension of the elbow. In contrast, certain other joints, such as the joint between the sacrum and the ilium, move freely, but only for short distances. Structurally, joints are classified by the type of tissue that binds the bones at each junction. Three general groups are fibrous joints, cartilaginous joints, and synovial joints. The functional and structural classification schemes overlap somewhat. Currently, structural classification by tissue type is most commonly used.

PRACTICE 8.1

Answers to the Practice questions can be found in the eBook.

1. What are the functions of joints?
2. How are joints classified?

Fibrous Joints

Fibrous (fi′brus) **joints** are so named because the dense connective tissue holding them together includes many collagen fibers. These joints are between bones in close contact. The three types of fibrous joints are syndesmoses, sutures, and gomphoses.

Syndesmoses

In a **syndesmosis** (sin″des-mo′sis), the bones are bound by a sheet *(interosseous membrane)* or bundle of dense connective tissue *(interosseous ligament).* This junction is somewhat flexible and may be twisted, so the joint may permit slight movement and thus is amphiarthrotic (am″fe-ar-thro′tik). A syndesmosis lies between

CAREER CORNER
Physical Therapy Assistant

The forty-eight-year-old man joined an over-thirty basketball league, and now he regrets his enthusiasm. He lies on the gym floor, in pain, thanks to an overambitious jump shot. He had felt a sudden twinge in his knee, and now it is red and swelling.

In the emergency department of the nearest hospital, an orthopedist sends the man for an MRI scan, which reveals a small tear in the anterior cruciate ligament (ACL). The patient is willing to give up basketball and doesn't want surgery, so he goes for physical therapy twice a week for a month. A physical therapy assistant leads him through a series of exercises that will restore full mobility.

The therapy, under the supervision of a physical therapist, begins with deep knee bends and progresses to lifting weights, stepping, doing squats, and using a single-leg bicycle that isolates and builds up the injured leg. The physical therapy assistant gives the patient exercises to do daily, at home. The therapy builds the muscles around the knee to compensate for the hurt ACL, restoring full range of motion.

A physical therapy assistant must complete a two-year college program and pass a certification exam. Physical therapy assistants work in hospitals, skilled nursing facilities, private homes, schools, fitness centers, and workplaces.

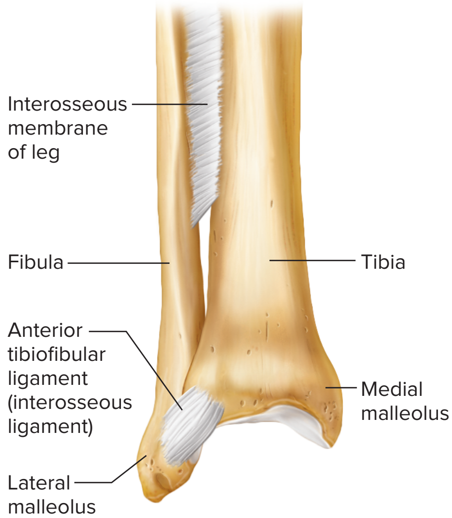


FIGURE 8.1 The articulation between the tibia and fibula is an example of a syndesmosis, seen as an interosseous ligament and an interosseous membrane.

the tibia and fibula at the distal ends as well as between the shafts (diaphyses) of these two bones (fig. 8.1).

Sutures

A **suture** (soo′cher) is found only between flat bones of the skull, where the broad margins of adjacent bones grow together and unite by a thin layer of dense connective tissue called a *sutural ligament.* Recall from chapter 7 (section 7.6, Skull, Infantile Skull) that the infantile skull is incompletely developed, with several of the bones connected by membranous areas called *fontanels* (see fig. 7.32). These areas allow the skull to change shape slightly during childbirth, but as the bones continue to grow, the fontanels close, and sutures replace them. With time, some of the bones at sutures interlock by tiny bony processes. Such a suture is in the adult human skull where the parietal and occipital bones meet to form the lambdoid suture. Sutures are immovable, and therefore they are synarthrotic (sin′ar-thro′tik) joints (figs. 8.2 and 8.3).

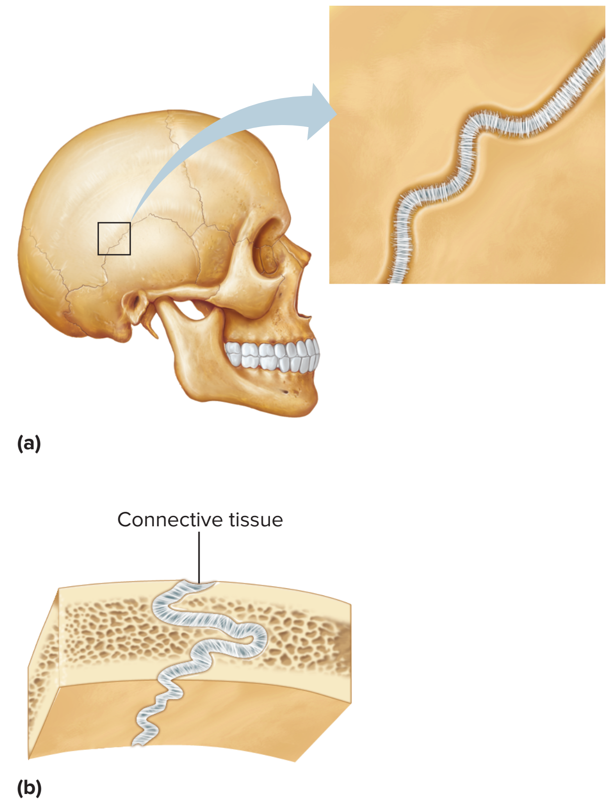


FIGURE 8.2 Fibrous joints. **(a)** The fibrous joints between the bones of the skull are immovable and are called sutures. **(b)** A thin layer of connective tissue connects the bones at the suture.

Gomphoses

A **gomphosis** (gom-fo′sis) is a joint formed by the union of a cone-shaped bony process in a bony socket. The peglike root of a tooth fastened to the maxilla or the mandible by a *periodontal ligament* is such a joint. This ligament surrounds the tooth root and firmly attaches it to the bone with bundles of thick collagen fibers. A gomphosis is a synarthrotic joint (fig. 8.4).

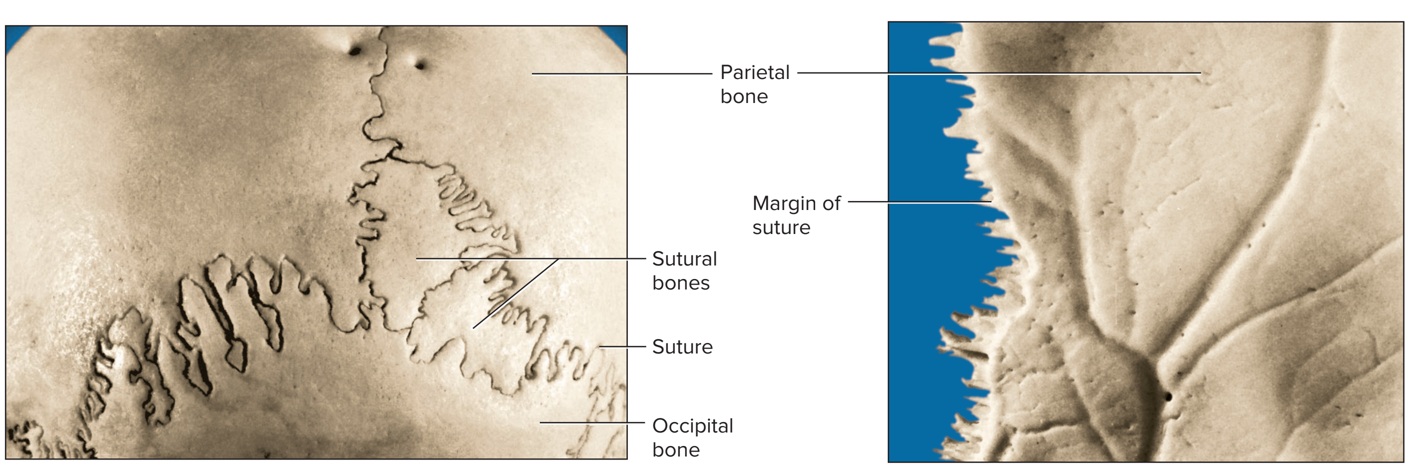


FIGURE 8.3 Cranial sutures. **(a)** Sutures between the parietal and occipital bones of the skull. **(b)** The inner margin of a suture (parietal bone). The grooves on the inside of this parietal bone mark the paths of blood vessels near the brain's surface. Courtesy of John W. Hole, Jr.

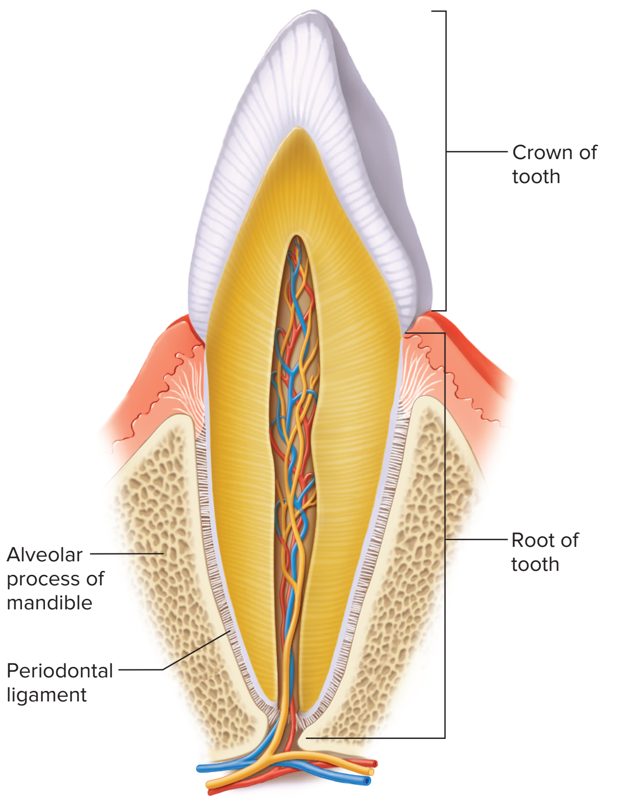


FIGURE 8.4 The articulation between the root of a tooth and the mandible is a gomphosis.

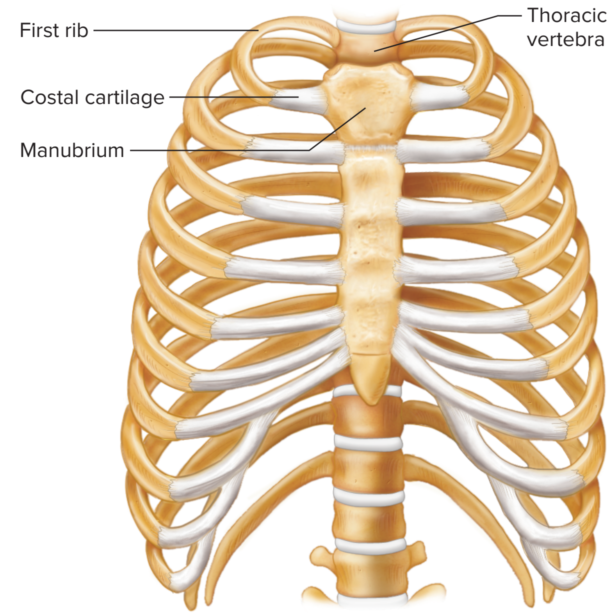


FIGURE 8.5 The articulation between the first rib and the manubrium is a synchondrosis.

PRACTICE FIGURE 8.5

Is the joint between the first rib and the manubrium an example of a fibrous, cartilaginous, or synovial joint?

Answer can be found in Appendix G.

PRACTICE 8.1

3. Describe three types of fibrous joints.
4. What is the function of the fontanels?

Cartilaginous Joints

Hyaline cartilage or fibrocartilage connects the bones of **cartilaginous** (kar″tĭ-laj′ĭnus) **joints.** The two types are synchondroses and symphyses.

Synchondroses

In a **synchondrosis** (sin″kon-dro′sis), bands of hyaline cartilage unite the bones. Many of these joints are temporary structures that disappear during growth. An example of a synchondrosis is that part of an immature long bone where a band of hyaline cartilage (the epiphyseal plate) connects an epiphysis to a diaphysis. This cartilage band participates in bone lengthening and, in time, is replaced with bone. When ossification completes, and the epiphyseal plate becomes an epiphyseal line, usually before the age of twenty-five years, the joint becomes a *synostosis,* a bony joint. The synostosis is synarthrotic (see fig. 7.10).

Another synchondrosis lies between the manubrium and the first rib, directly united by costal cartilage (**fig. 8.5**). This joint is also synarthrotic, but permanent. The joints between the sternum and the costal cartilages of ribs 2 through 10 are synovial.

Symphyses

The articular surfaces of the bones at a **symphysis** (sim′fĭ-sis) are covered by a thin layer of hyaline cartilage, and the bones are connected by a pad of fibrocartilage. Limited movement occurs at such a joint whenever forces compress or deform the fibrocartilage pad. An example of this type of joint is the pubic symphysis between the pubic bones of the pelvis. Certain hormones of pregnancy affect the fibrocartilage pad to allow the maternal pelvic bones to shift slightly at the pubic symphysis, providing more room for the infant to pass through the birth canal (**fig. 8.6*a***).

The joint formed by the bodies of two adjacent vertebrae separated and connected by an intervertebral disc is also a symphysis (**fig. 8.6*b*** and reference plate 11). Each intervertebral disc is composed of a band of fibrocartilage (annulus fibrosus) that surrounds a gelatinous core (nucleus pulposus). The disc absorbs shocks and helps equalize pressure between the vertebrae when the body moves. Because each disc is slightly flexible, the combined movement of many of the joints in the vertebral column allows the back to bend forward or to the side or to twist. The intervertebral discs are amphiarthrotic joints because they allow slight movements.

PRACTICE 8.1

5. Describe two types of cartilaginous joints.
6. What is the function of an intervertebral disc?

Synovial Joints

Most joints of the skeletal system are **synovial** (sĭ-no′ve-al) **joints,** and because they allow free movement, they are diarthrotic (di″ar-thro′tik). These joints are more complex structurally than

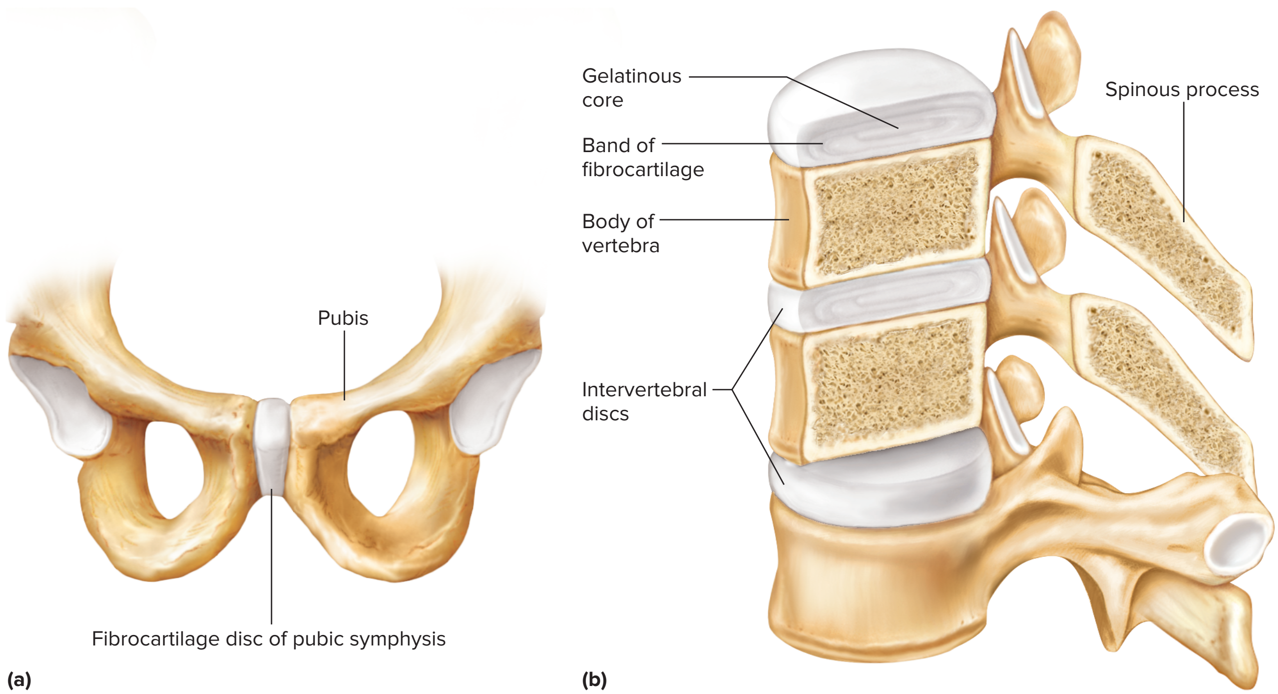


FIGURE 8.6 Fibrocartilage composes **(a)** the pubic symphysis and **(b)** the intervertebral discs of the vertebrae.

fibrous or cartilaginous joints. They consist of articular cartilage; a joint capsule; and a synovial membrane, which secretes synovial fluid.

General Structure of a Synovial Joint

The articular ends of the bones in a synovial joint are covered with a thin layer of hyaline cartilage. This layer, the **articular cartilage,** resists wear and minimizes friction when it is compressed as the joint moves (**fig. 8.7**).

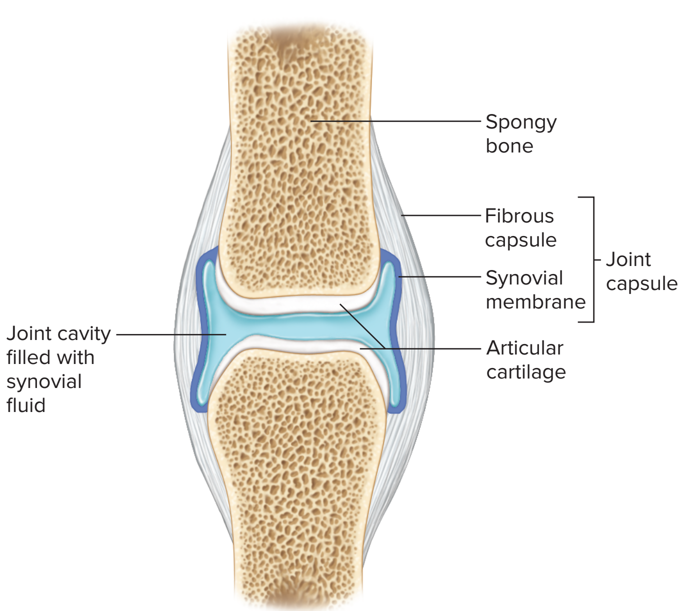


FIGURE 8.7 The generalized structure of a synovial joint.

A tubular **joint capsule** (articular capsule) that has two distinct layers holds together the bones of a synovial joint. The outer layer largely consists of dense connective tissue, whose fibers attach to the periosteum around the circumference of each bone of the joint near its articular end. Thus, the outer fibrous layer of the capsule completely encloses the other parts of the joint. It is, however, flexible enough to permit movement and strong enough to help prevent the bones from being pulled apart.

Bundles of strong, tough collagen fibers called **ligaments** (lig′ah-mentz) reinforce the joint capsule and help bind the articular ends of the bones. Some ligaments appear as thickenings in the fibrous layer of the capsule, whereas others are *accessory structures* located outside the capsule. In either case, these structures help prevent excessive movement at the joint. That is, the ligament is relatively inelastic, and it tightens when the joint is stressed.

The inner layer of the joint capsule consists of a shiny, vascular lining of loose connective tissue called the **synovial membrane.** This membrane, only a few cells thick, covers all of the surfaces within the joint capsule, except the areas the articular cartilage covers. The synovial membrane surrounds a closed sac called the *synovial cavity,* into which the synovial membrane secretes a clear, viscous fluid called **synovial fluid.** In some regions, the surface of the synovial membrane has villi as well as larger folds and projections that extend into the cavity. Besides filling spaces and irregularities of the joint cavity, these extensions increase the surface area of the synovial membrane. The synovial membrane may also store adipose tissue and form movable fatty pads in the joint. This multifunctional membrane also reabsorbs fluid, which is important when a joint cavity is injured or infected. Synovial fluid contains stem cells, which may function in ligament regeneration following injury.

Synovial fluid has a consistency similar to uncooked egg white, and it moistens and lubricates the smooth cartilaginous surfaces of the joint. It also helps supply articular cartilage with nutrients obtained from blood vessels of the synovial membrane. The volume of synovial fluid in a joint cavity is usually just enough to cover the articulating surfaces with a thin film of fluid. The volume of synovial fluid in the cavity of the knee is 0.5 mL or less.

A physician can determine the cause of joint inflammation or degeneration (arthritis) by aspirating a sample of synovial fluid from the affected joint using a procedure called arthrocentesis. Bloody fluid may indicate trauma to the joint. Cloudy, yellowish fluid may indicate rheumatoid arthritis, and crystals in the synovial fluid may signal gout. If the fluid is cloudy but red-tinged and containing pus, a bacterial infection may be present that requires prompt treatment. Normal synovial fluid has 180 or fewer leukocytes (white blood cells) per mL. If the leukocyte count exceeds 2,000, the fluid is infected.

Some synovial joints are partially or completely divided into two compartments by articular discs of fibrocartilage called **menisci** (me-nis′ke) (sing., *meniscus*) between the articular surfaces. Each meniscus attaches to the fibrous layer of the joint capsule peripherally, and its free surface projects into the joint cavity. In the knee joint, crescent-shaped menisci cushion the articulating surfaces and help distribute body weight onto these surfaces **(fig. 8.8)**. Articular discs are also found in the jaw (temporomandibular joint), between the scapula and clavicle (acromioclavicular joint), and in a couple other joints.

Fluid-filled sacs called **bursae** (ber′se) are associated with certain synovial joints. Each bursa has an inner lining of synovial membrane, which may be continuous with the synovial membrane of a nearby joint cavity. These sacs contain synovial fluid and are commonly located between the skin and underlying bony prominences, as in the case of the patella of the knee or the olecranon process of the elbow. Bursae cushion and aid the movement of tendons that glide over bony parts or over other tendons. The names of bursae indicate their locations. Figure 8.8 shows a *suprapatellar bursa,* a *prepatellar bursa,* and an *infrapatellar bursa.*

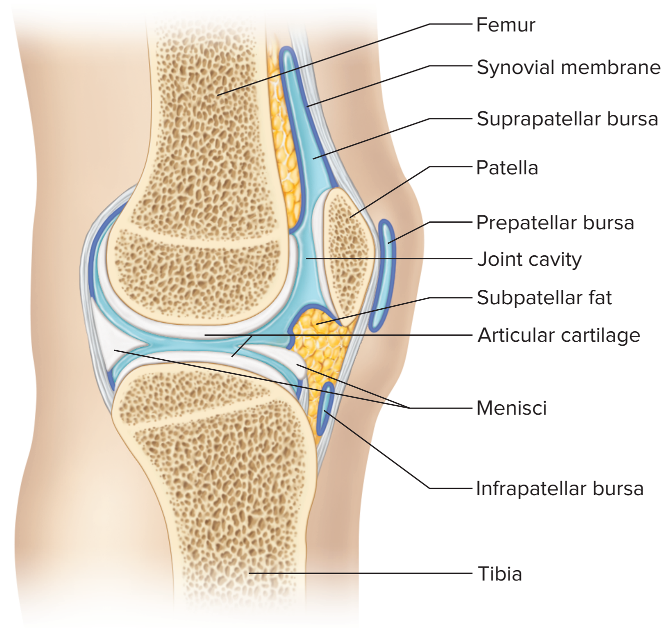


FIGURE 8.8 Menisci separate the articulating surfaces of the femur and tibia. Several bursae are associated with the knee joint. Synovial spaces in this and other line drawings in this chapter are exaggerated. In actuality, articulating cartilages are essentially in contact with one another.

PRACTICE 8.1

7. Describe the structure of a synovial joint.
8. What is the function of the synovial fluid?

The articulating bones of synovial joints have a variety of shapes that allow different types of movement. Based upon their shapes and the movements they permit, these joints can be classified into six major types—ball-and-socket joints, condylar joints, plane joints, hinge joints, pivot joints, and saddle joints.

Ball-and-Socket Joints

A **ball-and-socket joint,** or **spheroidal joint,** consists of a bone with a globular or slightly egg-shaped head that articulates with the cup-shaped cavity of another bone. Such a joint allows a wider range of motion than does any other type, permitting movements in all planes (multiaxial movement), including rotational movement around a central axis. The hip and shoulder have joints of this type **(fig. 8.9*a*)**.

Condylar Joints

In a **condylar joint,** or **ellipsoidal joint,** the ovoid condyle of one bone fits into the elliptical cavity of another bone, as in the joints between the metacarpals and phalanges **(fig. 8.9*b*)**. This type of joint permits back-and-forth and side-to-side movement in two planes (biaxial movement), but not rotation.

Plane Joints

The articulating surfaces of **plane joints,** or **gliding joints,** are nearly flat or slightly curved. These joints allow sliding or back-and-forth motion and twisting movements (nonaxial movement). Most of the joints in the wrist and ankle, as well as those between the articular processes of vertebrae, belong to this group **(fig. 8.9*c*)**. The sacroiliac joints and the joints formed by ribs 2 through 7 connecting with the sternum are also plane joints.

Hinge Joints

In a **hinge joint,** the convex surface of one bone fits into the concave surface of another, as in the elbow and in the joints between the phalanges **(fig. 8.9*d*)**. Such a joint resembles the hinge of a door in that it permits movement in one plane only (uniaxial movement).

Pivot Joints

In a **pivot joint,** or **trochoid joint,** the cylindrical surface of one bone rotates in a ring formed of bone and a ligament. Movement at such a joint is limited to rotation around a central axis (uniaxial movement). The joint between the proximal ends of the radius and the ulna, where the head of the radius rotates in a ring formed by the radial notch of the ulna and a ligament (anular ligament), is of this

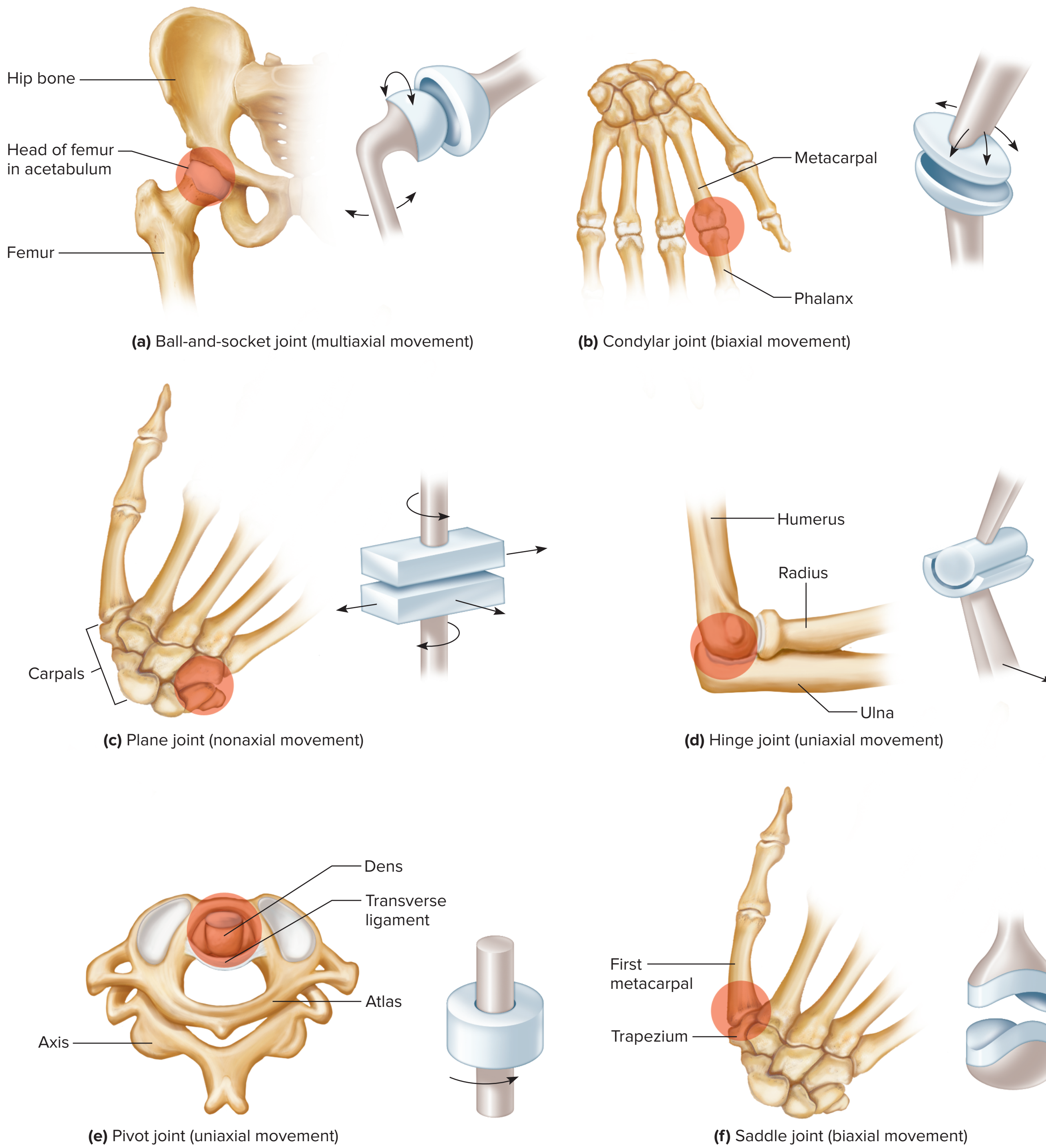


FIGURE 8.9 APR Types and examples of synovial (freely movable) joints (**a–f**).

type. Similarly, a pivot joint functions in the neck as the head turns from side to side. In this case, the ring formed by a ligament (transverse ligament) and the anterior arch of the atlas rotates around the dens of the axis (fig. 8.9*e*).

Saddle Joints

A **saddle joint,** or **sellar joint,** forms between bones whose articulating surfaces have both concave and convex regions. The surface of one bone fits the complementary surface of the other. This physical relationship permits a variety of movements, mainly in two planes (biaxial movement), as in the case of the joint between the carpal (trapezium) and the metacarpal of the thumb (fig. 8.9*f*).

Table 8.1 summarizes the types of joints.

PRACTICE 8.1

9. Name six types of synovial joints.
10. Describe the structure of each type of synovial joint.

TABLE 8.1 Types of Joints

Type of Joint	Description	Possible Movements	Example
Fibrous	Articulating bones fastened together by a thin layer of dense connective tissue containing many collagen fibers		
Syndesmosis (amphiarthrotic)	Bones bound by interosseous ligament	Joint flexible and may be twisted	Tibiofibular articulation
Suture (synarthrotic)	Flat bones united by sutural ligament	None	Parietal bones articulate at sagittal suture of skull
Gomphosis (synarthrotic)	Cone-shaped process fastened in bony socket by periodontal ligament	None	Root of tooth united with mandible
Cartilaginous	Articulating bones connected by hyaline cartilage or fibrocartilage		
Synchondrosis (synarthrotic)	Bones united by bands of hyaline cartilage	None	Joint between the first rib and the manubrium
Symphysis (amphiarthrotic)	Articular surfaces of bones are covered by hyaline cartilage and the bones are connected by a pad of fibrocartilage	Limited movement, as when the back is bent or twisted	Joints between bodies of vertebrae
Synovial (diarthrotic)	Articulating ends of bones surrounded by a joint capsule; articular bone ends covered by hyaline cartilage and separated by synovial fluid		
Ball-and-socket	Ball-shaped head of one bone articulates with cup-shaped socket of another	Movements in all planes (multiaxial), including rotation	Shoulder, hip
Condylar	Oval-shaped condyle of one bone articulates with elliptical cavity of another	Variety of movements in two planes (biaxial), but no rotation	Joints between metacarpals and phalanges
Plane	Articulating surfaces are nearly flat or slightly curved	Sliding or twisting (nonaxial movement)	Joints between various bones of wrist and ankle
Hinge	Convex surface of one bone articulates with concave surface of another	Flexion and extension (uniaxial)	Elbow and joints of phalanges
Pivot	Cylindrical surface of one bone articulates with ring of bone and ligament	Rotation around a central axis (uniaxial)	Joint between proximal ends of radius and ulna
Saddle	Articulating surfaces have both concave and convex regions; surface of one bone fits the complementary surface of another	Variety of movements, mainly in two planes (biaxial)	Joint between carpal and metacarpal of thumb

8.2 | Types of Joint Movements

LEARN

1. Explain how skeletal muscles produce movements at joints.
2. Identify several types of joint movements.

Skeletal muscle action produces movements at synovial joints. Typically, one end of a muscle is attached to a less movable or relatively fixed part on one side of a joint, and the other end of the muscle is fastened to a more movable part on the other side. When the muscle contracts, its fibers pull its movable end (*insertion*) toward its fixed end (*origin*), and a movement occurs at the joint.

The following terms describe movements at joints that occur in different directions and in different planes (figs. 8.10, 8.11, and 8.12):

- **flexion** (flek′shun) Bending parts at a joint so that the angle between them decreases and the parts come closer together (bending the knee).
- **extension** (ek-sten′shun) Moving parts at a joint so that the angle between them increases and the parts move farther apart (straightening the knee).
- **hyperextension** (hi″per-ek-sten′shun) A term sometimes used to describe the extension of the parts at a joint beyond the anatomical position (bending the head back beyond the upright position); often used to describe an abnormal extension beyond the normal range of motion, resulting in injury.
- **dorsiflexion** (dor″si-flek′shun) Movement at the ankle that moves the anterior portion of the foot closer to the shin (rocking back on one's heels).
- **plantar flexion** (plan′tar flek′shun) Movement at the ankle that moves the anterior portion of the foot farther from the shin (walking on one's toes).
- **abduction** (ab-duk′shun) Moving a part away from the midline (lifting the upper limb horizontally to form an angle with the side of the body) or away from the axial line of the limb (spreading the fingers or toes). Abduction of the head and

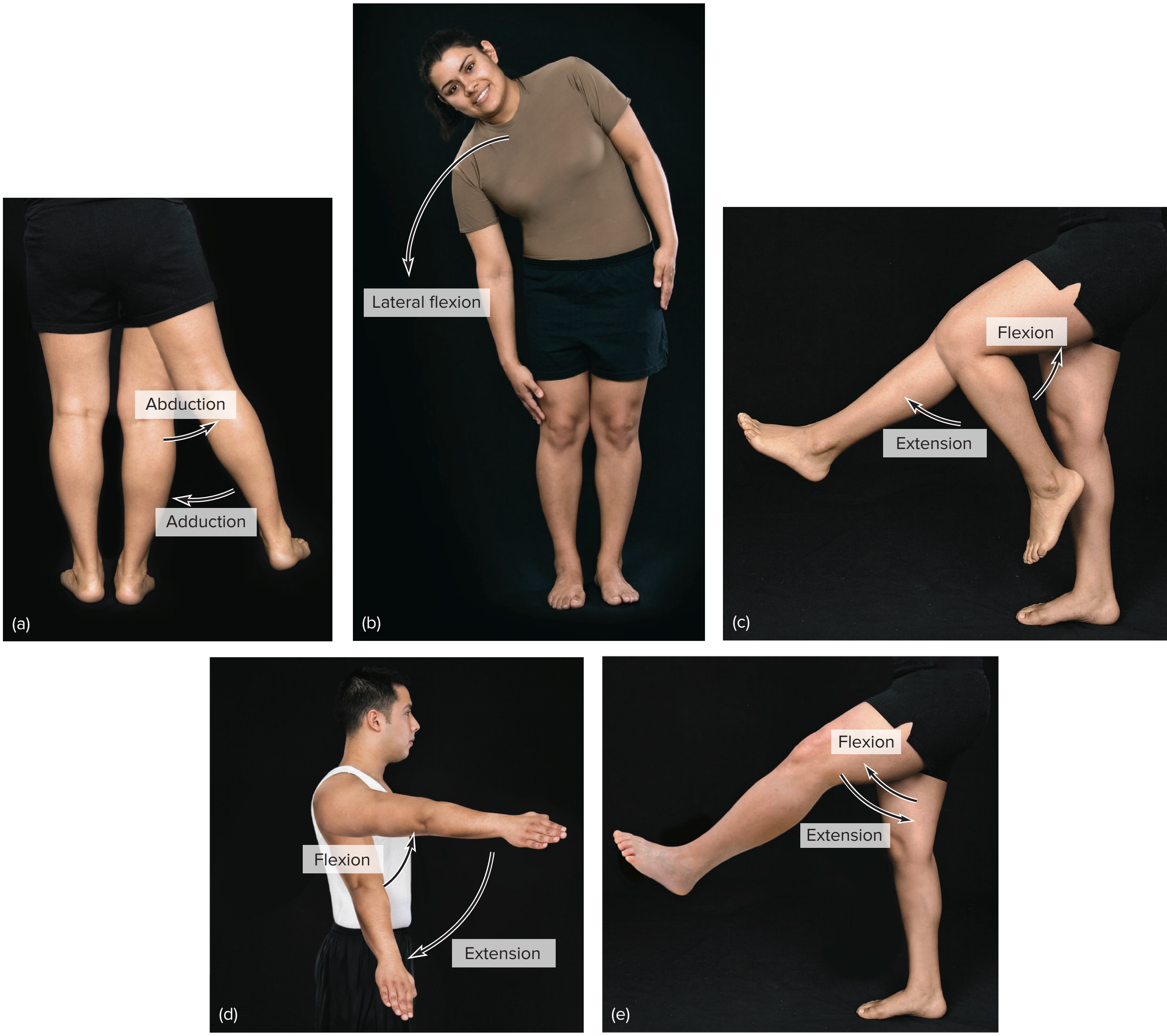


FIGURE 8.10 APR Joint movements illustrating **(a)** abduction and adduction, **(b)** lateral flexion, **(c)** extension and flexion of the knee, **(d)** extension and flexion of the shoulder, and **(e)** extension and flexion of the hip. J&J Photography

neck and bending of the trunk to the side may be termed *lateral flexion.*

- **adduction** (ah-duk′shun) Moving a part toward the midline (returning the upper limb from the horizontal position to the side of the body) or toward the axial line of the limb (moving the fingers or toes closer together).
- **rotation** (ro-ta′shun) Moving a part around an axis (twisting the head from side to side). Medial (internal) rotation is the turning of a limb on its longitudinal axis so its anterior surface moves toward the midline, whereas lateral (external) rotation is the turning of a limb on its longitudinal axis in the opposite direction.
- **circumduction** (ser″kum-duk′shun) Moving a part so that its end follows a circular path (moving the finger in a circular motion without moving the hand).
- **supination** (soo″pĭ-na′shun) Rotation of the forearm so the palm is upward or facing anteriorly (in anatomical position). *Supine* refers to the body lying face up.
- **pronation** (pro-na′shun) Rotation of the forearm so the palm is downward or facing posteriorly (in anatomical position). *Prone* refers to the body lying face down.
- **eversion** (e-ver′zhun) Turning the foot so the plantar surface faces laterally.

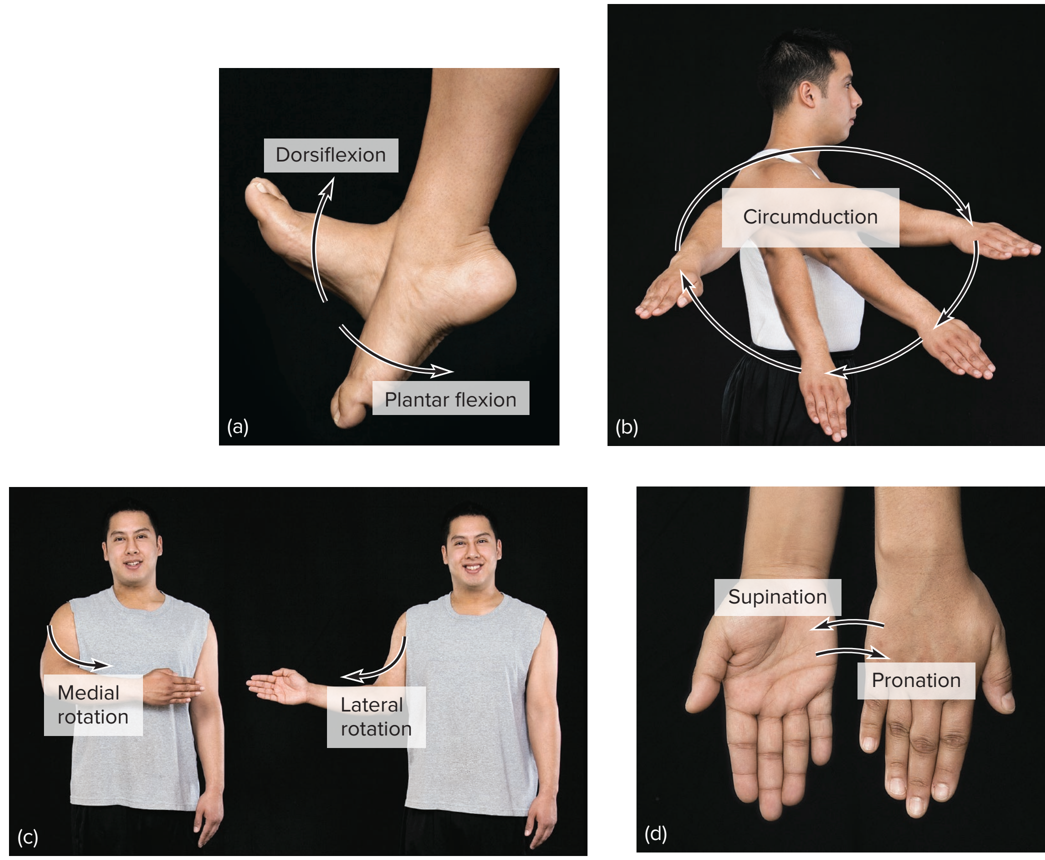


FIGURE 8.11 APR Joint movements illustrating **(a)** dorsiflexion and plantar flexion, **(b)** circumduction (which may occur in either the clockwise or counterclockwise direction), **(c)** medial and lateral rotation, and **(d)** supination and pronation. J&J Photography

PRACTICE FIGURE 8.11

Name the bone that is turning on its longitudinal axis in the illustration of rotation shown in (c).

Answer can be found in Appendix G.

FIGURE 8.12 APR Joint movements illustrating **(a)** inversion and eversion, **(b)** protraction and retraction, and **(c)** elevation and depression. J&J Photography

- **inversion** (in-ver′zhun) Turning the foot so the plantar surface faces medially.
- **protraction** (pro-trak′shun) Moving a part forward (thrusting the head forward).
- **retraction** (rĕ-trak′shun) Moving a part backward (pulling the head backward).
- **elevation** (el-e-vā′shun) Raising a part (shrugging the shoulders).
- **depression** (de-presh′un) Lowering a part (drooping the shoulders).

Description of movements of body parts is complex. At times, it will suffice to include the descriptive term of the movement followed by the part that is moving. For example, the deltoid muscle "abducts arm." Because the action of a muscle is at the insertion, the action of the biceps brachii muscle, for example, is sometimes described as "flexes forearm at the elbow." We have elected to use the more anatomically correct description of the change in geometry at the joint, "flexes elbow," to describe the action of the biceps brachii muscle. **Table 8.2** lists information on several joints.

PRACTICE 8.2

1. Describe how movement occurs at a joint when a muscle contracts.
2. What terms describe movements at synovial joints?

8.3 | Examples of Synovial Joints

LEARN

1. Describe the shoulder joint, and explain how its articulating parts are held together.
2. Describe the elbow, hip, and knee joints, and explain how their articulating parts are held together.

The shoulder, elbow, hip, and knee are large, freely movable joints. Although these joints have much in common, each has a unique structure that makes possible its specific function.

Shoulder Joint

The **shoulder joint** is a ball-and-socket joint that consists of the rounded head of the humerus and the shallow glenoid cavity of the scapula. The coracoid and acromion processes of the scapula protect these parts, and dense connective tissue and muscle hold them together.

The joint capsule of the shoulder is attached along the circumference of the glenoid cavity and the anatomical neck of the humerus. Although it completely envelops the joint, the capsule is very loose, and by itself is unable to keep the bones of the joint in close contact. However, muscles and tendons surround and reinforce the capsule, keeping together the articulating parts of the shoulder **(fig. 8.13)**.

The tendons of several muscles blend with the fibrous layer of the shoulder joint capsule, forming the *rotator cuff,* which reinforces and supports the shoulder joint. Some sports-related movements, such as pitching in baseball or playing tennis, and trauma from falling, can injure the rotator cuff. Repetitive overhead use of the arm in certain activities or jobs, such as painting or carpentry, can also cause injury, which can make activities of daily living difficult. If rest, pain medication, and physical therapy do not help, surgery may be necessary.

The ligaments of the shoulder joint, some of which help prevent displacement of the articulating surfaces, include the following **(fig. 8.14)**:

- The **coracohumeral** (kor″ah-ko-hu′mer-al) **ligament** is composed of a broad band of connective tissue that connects the coracoid process of the scapula to the greater tubercle of the humerus. It strengthens the superior portion of the joint capsule.
- The **glenohumeral** (gle″no-hu′mer-al) **ligaments** include three bands of fibers that appear as thickenings in the ventral wall of the joint capsule. They extend from the edge of the glenoid cavity to the lesser tubercle and the anatomical neck of the humerus.
- The **transverse humeral ligament** consists of a narrow sheet of connective tissue fibers that runs between the lesser and the greater tubercles of the humerus. Together with the intertubercular sulcus of the humerus, the ligament forms a canal (retinaculum) through which the long head of the biceps brachii muscle passes.

The *glenoid labrum* (gle′noid la′brum) is composed of fibrocartilage. It is attached along the margin of the glenoid cavity and forms a rim with a thin, free edge that deepens the cavity.

Several bursae are associated with the shoulder joint. The major ones include the *subscapular bursa* between the joint capsule and the tendon of the subscapularis muscle, the *subdeltoid bursa* between the joint capsule and the deep surface of the deltoid muscle, the *subacromial bursa* between the joint capsule and the undersurface of the acromion process of the scapula, and the *subcoracoid bursa* between the joint capsule and the coracoid process of the scapula (see figs. 8.13 and 8.14). Of these, the subscapular bursa is usually continuous with the synovial cavity of the joint cavity, and although the others do not communicate with the joint cavity, they may be connected to each other.

The shoulder joint is capable of a wide range of movement, due to the looseness of its attachments and the large articular surface of the humerus compared to the shallow depth of the glenoid cavity. These movements include flexion, extension, adduction, abduction, rotation, and circumduction. Motion occurring simultaneously in the joint formed between the scapula and the clavicle may also aid such movements.

Elbow Joint

The **elbow joint** is a complex structure that includes two articulations—a hinge joint between the trochlea of the humerus and the trochlear notch of the ulna and a plane joint between the

TABLE 8.2 Joints of the Body

Joint	Location	Type of Joint	Type of Movement
Skull	Cranial and facial bones	Suture, fibrous	Immovable; synarthrotic
Temporomandibular	Temporal bone, mandible	Modified hinge, synovial	Elevation, depression, protraction, retraction, lateral movement; diarthrotic
Atlantooccipital	Atlas, occipital bone	Condylar, synovial	Flexion, extension; diarthrotic
Atlantoaxial	Atlas, axis	Pivot, synovial	Rotation; diarthrotic
Intervertebral	Between vertebral bodies	Symphysis, cartilaginous	Slight movement; amphiarthrotic
Intervertebral	Between vertebral arches	Plane, synovial	Flexion, extension, lateral flexion, and rotation of the vertebral column; diarthrotic
Sacroiliac	Sacrum and ilium	Plane, synovial	Sliding movement; diarthrotic
Vertebrocostal	Vertebrae and ribs	Plane, synovial	Sliding movement during breathing; diarthrotic
Sternoclavicular	Sternum and clavicle	Plane, synovial	Sliding movement when shrugging shoulders; diarthrotic
Sternocostal	Sternum and rib 1	Synchondrosis, cartilaginous	Immovable; synarthrotic
Sternocostal	Sternum and ribs 2–7	Plane, synovial	Sliding movement during breathing; diarthrotic
Acromioclavicular	Scapula and clavicle	Plane, synovial	Sliding movement, rotation; diarthrotic
Shoulder (glenohumeral)	Humerus and scapula	Ball-and-socket, synovial	Flexion, extension, adduction, abduction, rotation, circumduction; diarthrotic
Elbow (humeroulnar)	Humerus and ulna	Hinge, synovial	Flexion, extension; diarthrotic
Elbow (humeroradial)	Humerus and radius	Plane, synovial	Sliding movement; diarthrotic
Proximal radioulnar	Radius and ulna	Pivot, synovial	Rotation; diarthrotic
Distal radioulnar	Radius and ulna	Pivot, synovial	Pronation, supination; diarthrotic
Wrist (radiocarpal)	Radius and carpals	Condylar, synovial	Flexion, extension, adduction, abduction, circumduction; diarthrotic
Intercarpal	Adjacent carpals	Plane, synovial	Sliding movement, also adduction, abduction, flexion, and extension at the midcarpal joints; diarthrotic
Carpometacarpal	Carpal and metacarpal 1	Saddle, synovial	Flexion, extension, adduction, abduction; diarthrotic
Carpometacarpal	Carpals and metacarpals 2–5	Condylar, synovial	Flexion, extension, adduction, abduction, circumduction; diarthrotic
Metacarpophalangeal	Metacarpal and proximal phalanx	Condylar, synovial	Flexion, extension, adduction, abduction, circumduction; diarthrotic
Interphalangeal	Adjacent phalanges	Hinge, synovial	Flexion, extension; diarthrotic
Pubic symphysis	Pubic bones	Symphysis, cartilaginous	Slight movement; amphiarthrotic
Hip	Hip bone and femur	Ball-and-socket, synovial	Flexion, extension, adduction, abduction, rotation, circumduction; diarthrotic
Knee (tibiofemoral)	Femur and tibia	Modified hinge, synovial	Flexion, extension, slight rotation when flexed; diarthrotic
Knee (femoropatellar)	Femur and patella	Plane, synovial	Sliding movement; diarthrotic
Proximal tibiofibular	Tibia and fibula	Plane, synovial	Sliding movement; diarthrotic
Distal tibiofibular	Tibia and fibula	Syndesmosis, fibrous	Slight rotation during dorsiflexion; amphiarthrotic
Ankle (talocrural)	Talus, tibia, and fibula	Hinge, synovial	Dorsiflexion, plantar flexion, slight circumduction; diarthrotic
Intertarsal	Adjacent tarsals	Plane, synovial	Sliding movement, inversion, eversion; diarthrotic
Tarsometatarsal	Tarsals and metatarsals	Plane, synovial	Sliding movement; diarthrotic
Metatarsophalangeal	Metatarsal and proximal phalanx	Condylar, synovial	Flexion, extension, adduction, abduction; diarthrotic

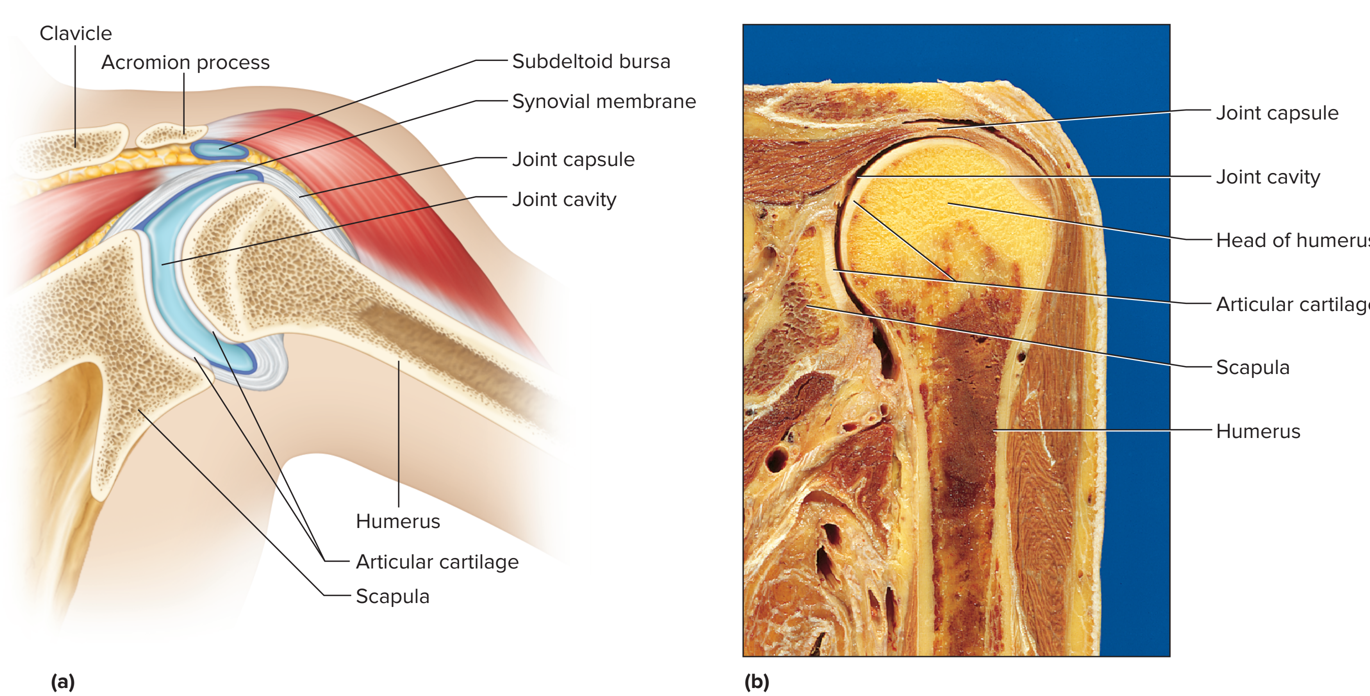


FIGURE 8.13 APR Left shoulder joint. **(a)** The shoulder joint allows movements in all directions. **(b)** Photograph of the shoulder joint.
(b): ©Dr. Ronald Bergman

PRACTICE FIGURE 8.13

The photograph (b) of this figure is of what type of section (sagittal, transverse, or frontal)?

Answer can be found in Appendix G.

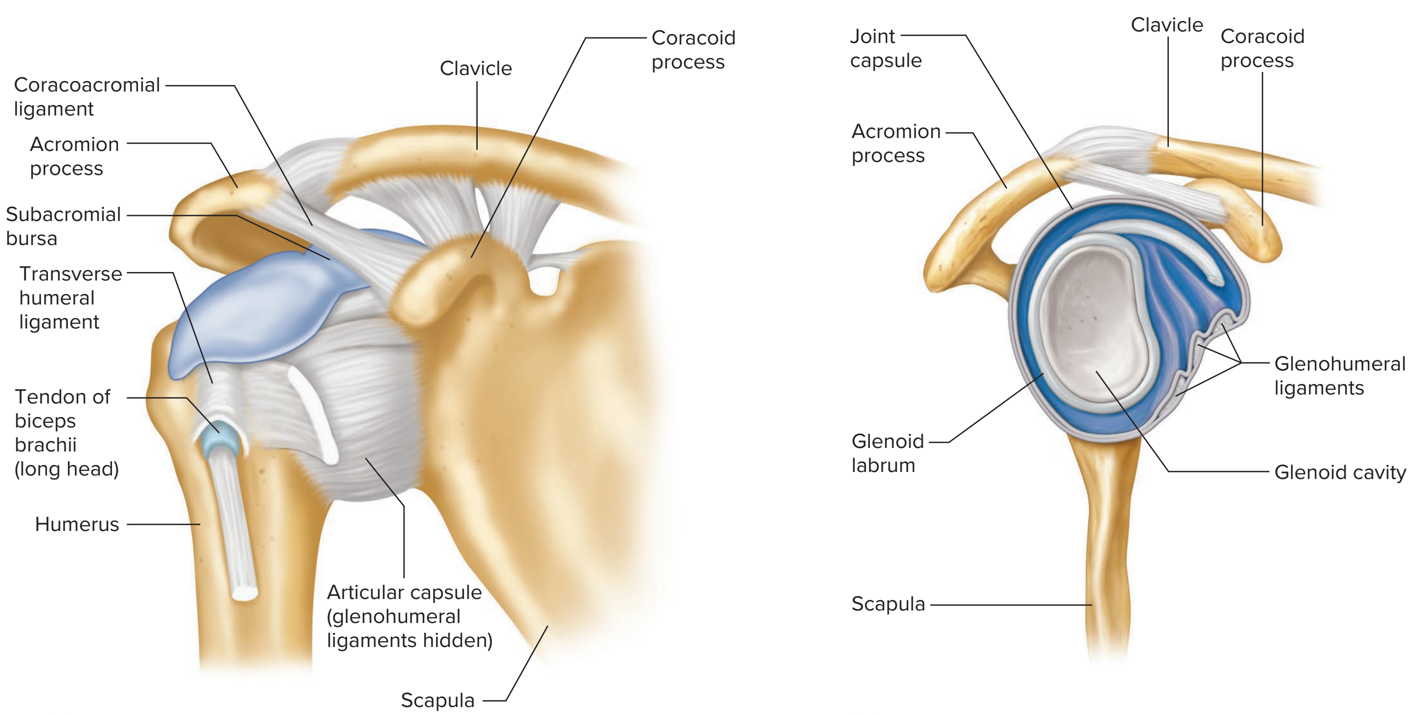


FIGURE 8.14 Ligaments associated with the right shoulder joint. **(a)** Ligaments hold together the articulating surfaces of the shoulder (frontal view). **(b)** The glenoid labrum is composed of fibrocartilage (lateral view of the shoulder joint with the humerus removed).

capitulum of the humerus and a shallow depression (fovea) on the head of the radius. A joint capsule completely encloses and holds together these unions **(fig. 8.15)**. Ulnar and radial collateral ligaments thicken the two joints, and fibers from a muscle (brachialis) in the arm reinforce its anterior surface. These major ligaments of the elbow joint are described as follows:

- The **ulnar collateral ligament,** a thick band of dense connective tissue, is located in the medial wall of the capsule. The anterior portion of this ligament connects the medial epicondyle of the humerus to the medial margin of the coronoid process of the ulna. Its posterior part is attached to the medial epicondyle of the humerus and to the olecranon process of the ulna **(fig. 8.16*a*)**.
- The **radial collateral ligament,** which strengthens the lateral wall of the joint capsule, is a fibrous band extending between the lateral epicondyle of the humerus and the *anular ligament of the radius* (see figs. 8.15*a* and 8.16). The anular ligament, in turn, attaches to the margin of the trochlear notch of the ulna, and it encircles the head of the radius, keeping the head in contact with the radial notch of the ulna **(fig. 8.16*b*)**. The elbow joint capsule encloses the resulting radioulnar joint so that its function is closely associated with the elbow.

The synovial membrane that forms the inner lining of the elbow capsule projects into the joint cavity between the radius and ulna and partially divides the joint into humerus–ulnar and humerus–radial portions. Also, varying amounts of adipose tissue form fatty pads between the synovial membrane and the fibrous layer of the joint capsule. These pads help protect nonarticular bony areas during joint movements.

The only movements that can occur at the elbow between the humerus and ulna are hinge-type movements—flexion and extension. The head of the radius, however, is free to rotate in the anular ligament. This movement allows pronation and supination of the forearm.

PRACTICE 8.3

1. Which parts help keep together the articulating surfaces of the shoulder joint?
2. What factors allow an especially wide range of motion in the shoulder?
3. Which structures form the hinge joint of the elbow?
4. Which parts of the elbow permit pronation and supination of the forearm?

Hip Joint

The **hip joint** is a ball-and-socket joint that consists of the head of the femur and the cup-shaped acetabulum of the hip bone **(fig. 8.17)**. A ligament (ligamentum capitis) attaches to a pit (fovea capitis) on the head of the femur and to connective tissue in the acetabulum. This attachment, however, seems to have little importance in holding the articulating bones together, but rather carries blood vessels to the head of the femur.

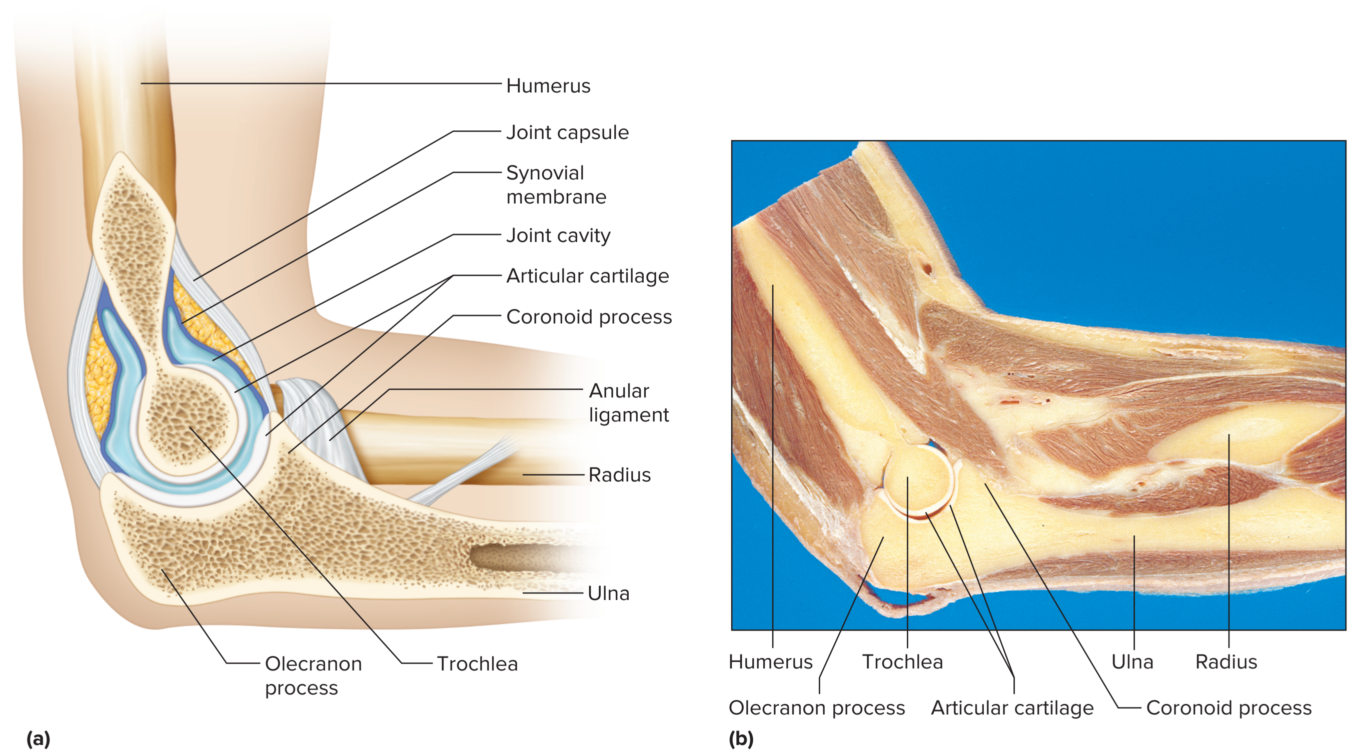


FIGURE 8.15 APR Left elbow joint. **(a)** The elbow joint allows hinge movements, as well as pronation and supination of the hand. **(b)** Photograph of the elbow joint (sagittal section). (b): ©Dr. Ronald Bergman

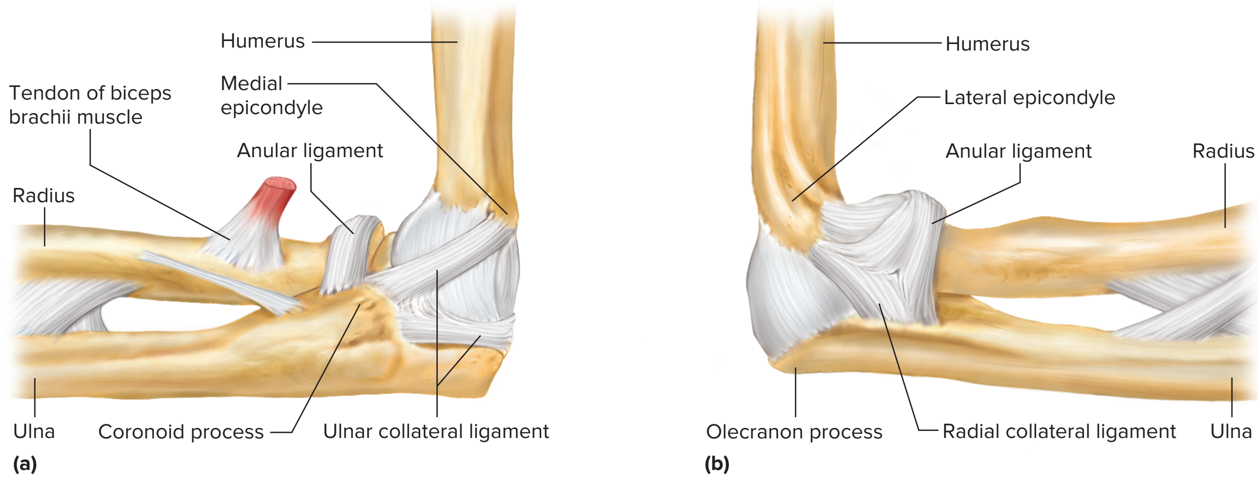


FIGURE 8.16 Ligaments associated with the right elbow joint. **(a)** The ulnar collateral ligament, medial view, and **(b)** the radial collateral ligament strengthen the capsular wall of the elbow joint, lateral view.

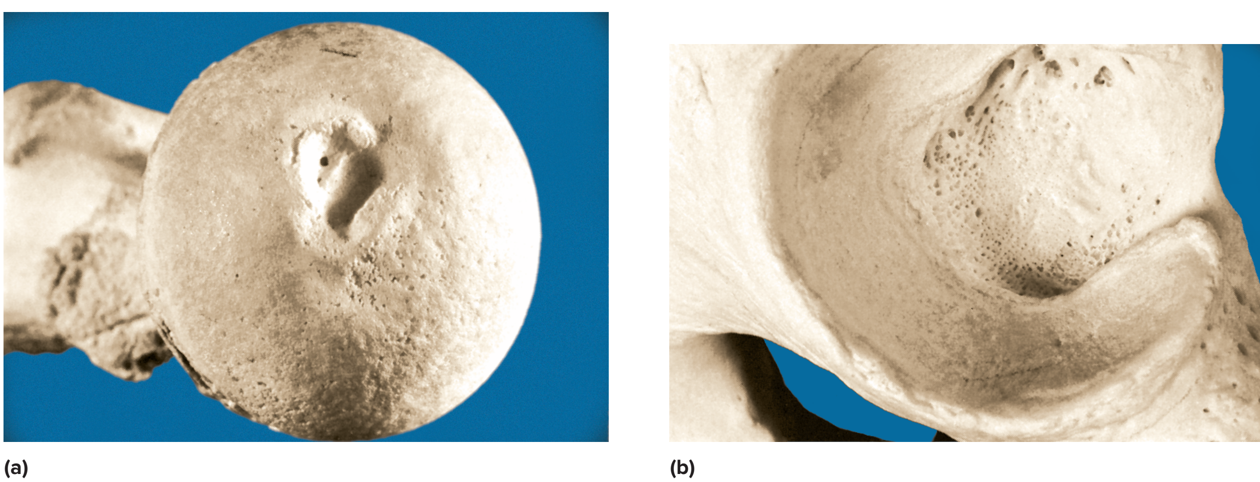


FIGURE 8.17 Hip joint. **(a)** The ball-like head of the femur. **(b)** The acetabulum provides the socket for the head of the femur in the hip joint.
Courtesy of John W. Hole, Jr.

A horseshoe-shaped ring of fibrocartilage (acetabular labrum) at the rim of the acetabulum deepens the cavity of the acetabulum. It encloses the head of the femur and helps hold it securely in place. In addition, a heavy, cylindrical joint capsule reinforced with still other ligaments surrounds the articulating structures and connects the neck of the femur to the margin of the acetabulum (fig. 8.18).

The major ligaments of the hip joint include the following (fig. 8.19):

- The **iliofemoral** (il″e-o-fem′o-ral) **ligament** consists of a Y-shaped band of strong fibers that connects the anterior inferior iliac spine of the hip bone to a bony line (intertrochanteric line) extending between the greater and lesser trochanters of the femur. The iliofemoral ligament is the strongest ligament in the body.
- The **pubofemoral** (pu″bo-fem′o-ral) **ligament** extends between the superior portion of the pubis and the iliofemoral ligament. Its fibers also blend with the fibers of the joint capsule.
- The **ischiofemoral** (is″ke-o-fem′o-ral) **ligament** consists of a band of strong fibers that originates on the ischium just posterior to the acetabulum and blends with the fibers of the joint capsule.

Muscles surround the joint capsule of the hip. The articulating parts of the hip are held more closely together than those of the shoulder, allowing considerably less freedom of movement. The structure of the hip joint, however, still permits a wide variety of movements, including flexion, extension, adduction, abduction, rotation, and circumduction.

Knee Joint

The **knee joint** is the largest and most complex of the synovial joints. It consists of the medial and lateral condyles at the distal end of the femur and the medial and lateral condyles at the proximal end of the tibia. In addition, the femur articulates anteriorly with the patella. Although the knee articulations between the condyles of the femur and tibia function largely as a modified hinge joint (allowing flexion and extension), they allow some rotation when the knee is flexed. The joint between the femur and patella is a plane joint.

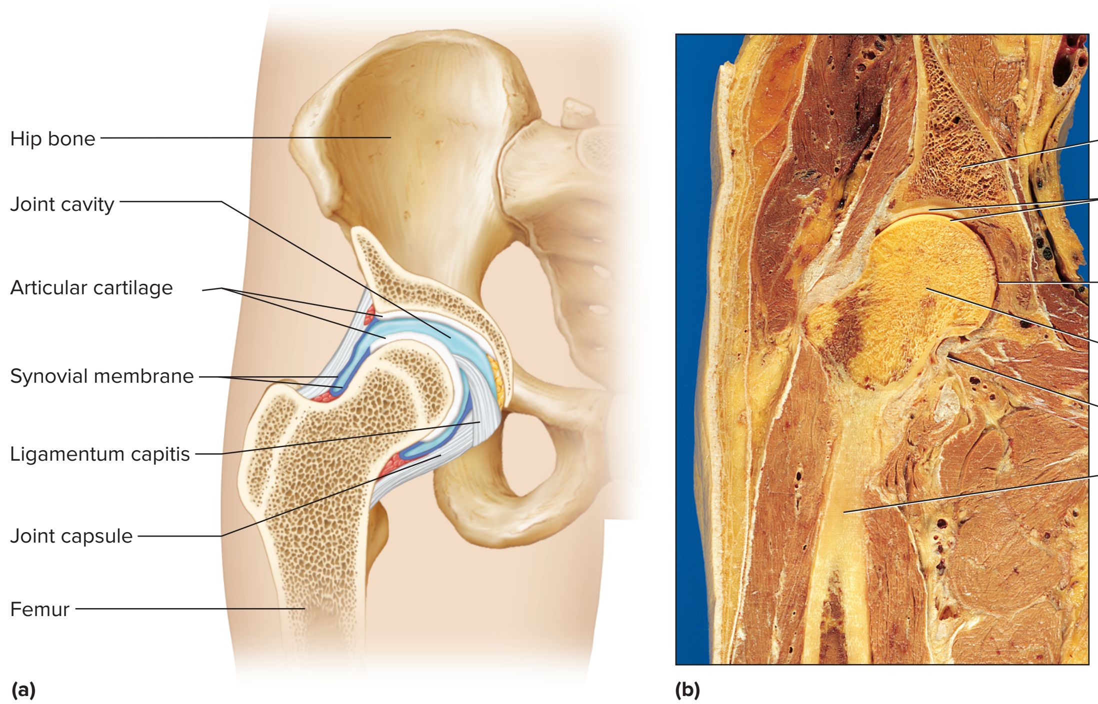


FIGURE 8.18 Right hip joint. **(a)** A ring of cartilage in the acetabulum and a ligament-reinforced joint capsule hold together the hip joint. **(b)** Photograph of the hip joint (frontal section). (b): ©Dr. Ronald Bergman

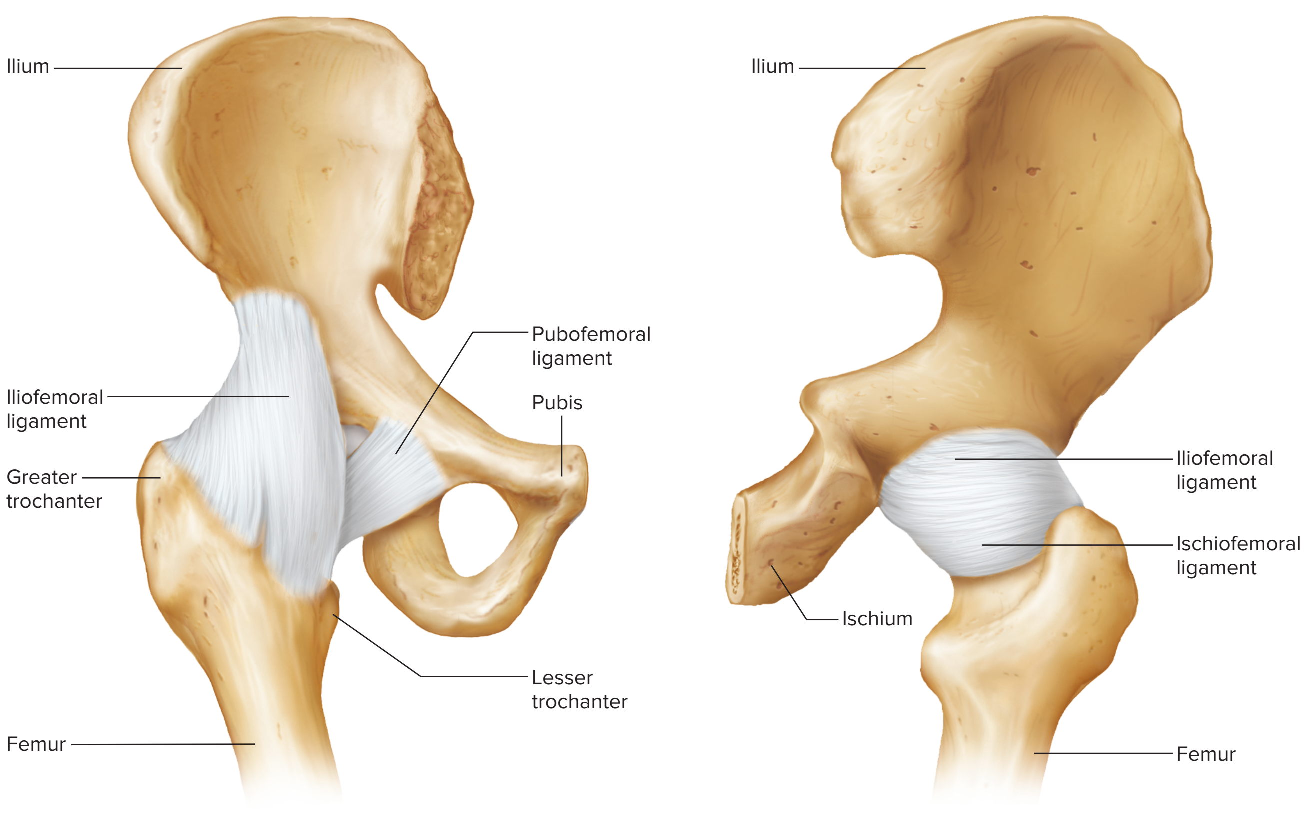


FIGURE 8.19 The major ligaments of the right hip joint. **(a)** Anterior view. **(b)** Posterior view.

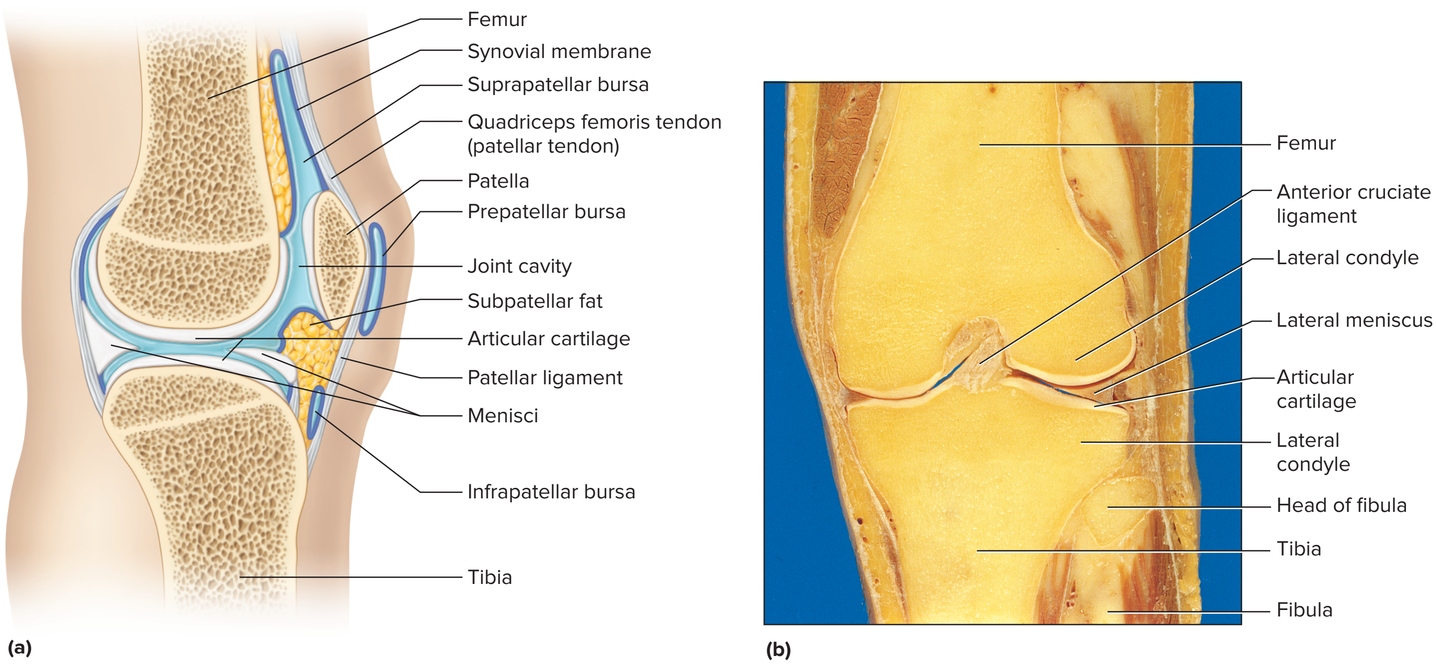


FIGURE 8.20 APR Knee joint. **(a)** The knee joint is the most complex of the synovial joints (sagittal section). **(b)** Photograph of the left knee joint (frontal section). (b): ©Dr. Ronald Bergman

The *joint capsule* of the knee is relatively thin, but ligaments and the tendons of several muscles greatly strengthen it. For example, the fused tendons of several muscles in the thigh cover the capsule anteriorly. Fibers from these tendons descend to the patella, partially enclose it, and continue downward to the tibia. The capsule attaches to the margins of the femoral and tibial condyles as well as between these condyles **(fig. 8.20)**.

The ligaments associated with the joint capsule that help keep the articulating surfaces of the knee joint in contact include the following **(fig. 8.21)**:

- The **patellar** (pah-tel′ar) **ligament** is a continuation of a tendon from a large muscle group in the thigh (quadriceps femoris). It consists of a strong, flat band that extends from the margin of the patella to the tibial tuberosity.
- The **oblique popliteal** (ŏ′blēk pop-lit′e-al) **ligament** connects the lateral condyle of the femur to the margin of the head of the tibia.
- The **arcuate** (ar′ku-āt) **popliteal ligament** appears as a Y-shaped system of fibers that extends from the lateral condyle of the femur to the head of the fibula.
- The **tibial collateral** (tib′e-al kŏ-lat′er-al) **ligament** (medial collateral ligament) is a broad, flat band of tissue that connects the medial condyle of the femur to the medial condyle of the tibia.
- The **fibular** (fib′u-lar) **collateral ligament** (lateral collateral ligament) consists of a strong, round cord located between the lateral condyle of the femur and the head of the fibula.

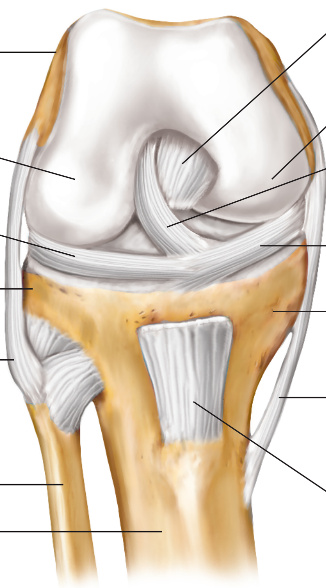
In addition to the ligaments that strengthen the joint capsule, two ligaments in the knee joint, called *cruciate ligaments*, help prevent displacement of the articulating surfaces. These strong bands of fibrous tissue stretch upward and cross between the tibia and the femur. They are named according to their positions of attachment to the tibia as follows:

- The **anterior cruciate** (kroo′she-āt) **ligament** originates from the anterior intercondylar area of the tibia and extends to the lateral condyle of the femur.
- The **posterior cruciate ligament** connects the posterior intercondylar area of the tibia to the medial condyle of the femur.

Two fibrocartilaginous *menisci* separate the articulating surfaces of the femur and tibia and help align them. Each meniscus is roughly C-shaped, with a thick rim and a thinner center, and attaches to the head of the tibia. The medial and lateral menisci form depressions that fit the corresponding condyles of the femur (fig. 8.21).

Tearing or displacing a meniscus is a common knee injury, usually resulting from forcefully twisting the knee when the leg is flexed **(fig. 8.22)**. Because the meniscus is composed of fibrocartilage, which lacks a direct blood supply, this type of injury heals slowly. Also, a torn and displaced portion of cartilage jammed between the articulating surfaces impedes movement of the joint. Following such a knee injury, the synovial membrane may become inflamed (acute synovitis) and secrete excess fluid, distending the joint capsule so that the knee swells above and on the sides of the patella.

Several bursae are associated with the knee joint. These include a large extension of the knee joint cavity called the *suprapatellar bursa,* located between the anterior surface of the distal end of the femur and the muscle group (quadriceps femoris) above it; a large *prepatellar bursa* between the patella and the skin; and a smaller *infrapatellar bursa* between the proximal end of the tibia and the patellar ligament (see fig. 8.8). Clinical Application 8.1 discusses some common joint disorders.



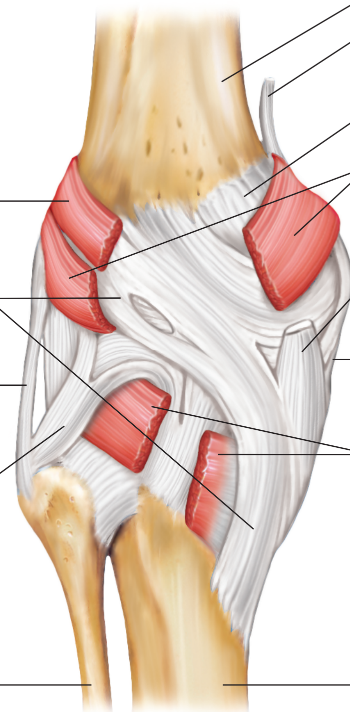


FIGURE 8.21 Ligaments within the knee joint help strengthen it. **(a)** Anterior view of right bent knee (patella removed). **(b)** Posterior view of left knee.

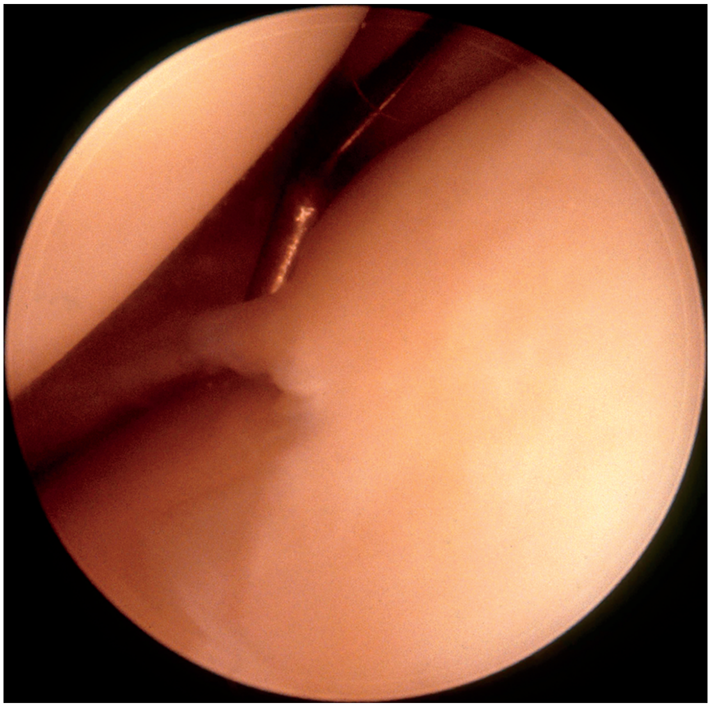


FIGURE 8.22 Arthroscopic view of a torn meniscus in the knee and arthroscopic scissors. Fibrocartilage does not heal well, so in some cases of torn meniscus the only treatment option is to cut out the damaged portion. Alexander Tsiaras/Science Source

PRACTICE 8.3

5. Which structures help keep the articulating surfaces of the hip together?
6. What types of movement does the hip joint permit?
7. What types of joints are found in the knee?
8. What structures help hold together the articulating surfaces of the knee?

8.4 | Life-Span Changes

LEARN

1. Describe life-span changes in joints.

Joint stiffness is an early sign of aging. By the fourth decade, a person may notice that the first steps each morning become difficult. Changes in collagen structure lie behind the increasing stiffness **(fig. 8.23)**. Range of motion may diminish. However, joints age slowly, and exercise can lessen or forestall stiffness.

The fibrous joints are the first to change, as the four types of fontanels close the bony plates of the skull at two, three, twelve, and eighteen to twenty-four months of age. Other fibrous joints may accumulate bone matrix over time, bringing bones closer together, even fusing them. Fibrous joints strengthen over a lifetime.

8.1 CLINICAL APPLICATION

Joint Disorders

Joints must support weight, provide a variety of body movements, and are used frequently. Trauma, overuse, infection, a misdirected immune system attack, and degeneration can injure joints.

A procedure called arthroscopy is commonly used to diagnose and treat injuries to the shoulder, elbow, and knee. An arthroscope is a thin, tubular instrument about 25 cm long containing optical fibers that transmit an image. The surgeon inserts the device through a small incision in the joint capsule, which is first filled with saline to provide a good view. Arthroscopy is much less invasive than conventional surgery. Some runners have undergone uncomplicated arthroscopy and raced several weeks later.

Arthroscopy can also help rapidly diagnose infection. Guided by an arthroscope, the surgeon samples a small piece of the synovial membrane and extracts and examines DNA for bacterial sequences, such as from the bacterium that causes Lyme disease (*Borrelia burgdorferi*). Sampling the synovial membrane can provide valuable information, because a variety of bacteria can infect joints, and choosing the appropriate antibiotic, based on knowing the type of bacterium, is crucial for fast and complete recovery. Following is a list of some common joint problems.

Dislocations

The shoulder joint is somewhat weak because the bones are mainly held together by supporting muscles rather than by bony structures and strong ligaments. Consequently, the articulating surfaces may become displaced or dislocated. Such a dislocation can occur with a forceful impact, as when a person falls on an outstretched arm. This movement may press the head of the humerus against the lower part of the joint capsule where its wall is thin and poorly supported by ligaments. Dislocations most commonly affect joints of the shoulders, knees, fingers, and jaw.

Sprains and Torn Ligaments

Sprains result from overstretching the connective tissues, including cartilage, ligaments, and tendons associated with a joint, but they do not dislocate the articular bones. Usually forceful wrenching or twisting sprains a wrist or ankle. For example, inverting an ankle too far can sprain it by stretching the ligaments on its lateral side.

A sprained joint is painful and swollen, restricting movement. Immediate treatment of a sprain is rest; more serious cases require medical attention. However, immobilization of a joint, even for a brief period, causes bone resorption and weakens ligaments. Exercise may strengthen a joint.

A ligament may fray or tear following a twist, such as to a knee or ankle; an overextension; from lifting a heavy object; or from a fall or sudden cessation of movement. Following the injury, inflammation causes pain, heat, and swelling. The affected joint may feel loose, and may not be able to support weight. The ligament may emit a popping sound as the injury occurs. The anterior cruciate ligament (ACL) is particularly vulnerable in very active individuals, including gymnasts, skiers, and people who play soccer, basketball, or football.

Immediate treatment for a torn ligament is rest, ice, compression, and elevation (also known as RICE). A physician might advise anti-inflammatory medications and exercises that strengthen surrounding structures. Many ligament tears heal on their own, over time. However, a surgical procedure that reconstructs the damaged ligament using tendons from elsewhere in the body may be necessary for severe tears.

Bursitis

Overuse of a joint or stress on a bursa may cause *bursitis,* an inflammation of a bursa. The bursa between the heel bone (calcaneus) and the Achilles tendon may become inflamed as a result of a sudden increase in physical activity using the feet. Bursitis is treated with rest. Medical attention may be necessary.

Arthritis

Arthritis causes inflamed, swollen, stiffened, and painful joints. More than a hundred different types of arthritis affect over 50 million adults in the United States; however, it is estimated that more than one in four adults have arthritis, although it may not be officially diagnosed. Arthritis can also be part of other syndromes **(table 8A)**. The common types of arthritis are osteoarthritis, rheumatoid arthritis (RA), Lyme arthritis, and gout.

Osteoarthritis

Osteoarthritis, a degenerative disorder, is the most common type of arthritis **(fig. 8A)**. Although osteoarthritis can occur in the young, it becomes more common as people age, which is why its prevalence is expected to greatly increase with the aging population. An inherited form of osteoarthritis may appear as early as one's thirties. A person may first become aware of osteoarthritis when a blow to the affected joint produces intense pain. Gradually the area of the affected joint deforms. Arthritic fingers become gnarled, or a knee may bulge.

In osteoarthritis, articular cartilage softens and disintegrates gradually, roughening the articular surfaces. Joints become painful, with restricted movement. For example, arthritic fingers may lock into place while a person is playing the guitar or tying a shoelace. Osteoarthritis most often affects joints used the most, such as those of the fingers, hips, knees, and lower vertebral column.

If a person with osteoarthritis is overweight or obese, the first treatment is usually an exercise and dietary program to lose weight. Nonsteroidal anti-inflammatory drugs (NSAIDs) have been used for many years to control osteoarthritis symptoms. NSAIDs called COX-2 inhibitors relieve inflammation without the gastrointestinal side effects of older drugs, but they are prescribed only to people who do not have risk factors for cardiovascular disease, to which some of these drugs are linked.

Rheumatoid Arthritis (RA)

Rheumatoid arthritis, an autoimmune disorder (a condition in which the immune system attacks the body's healthy tissues), is painful and debilitating. The synovial membrane of a joint

—Continued next page

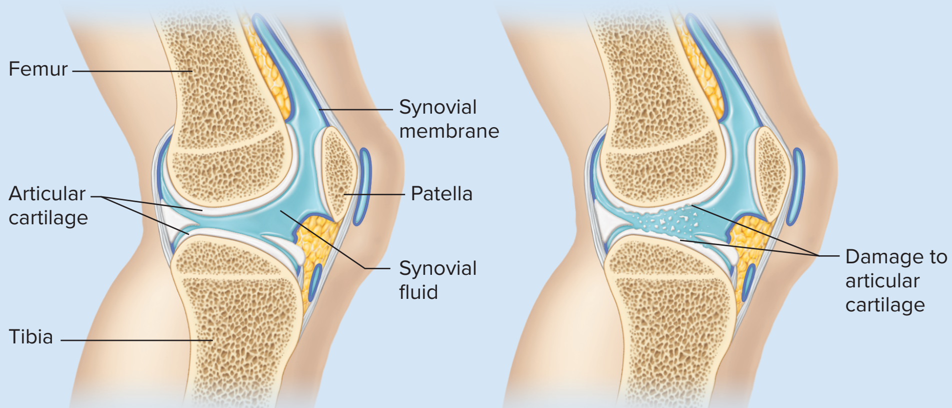


FIGURE 8A In osteoarthritis, an inherited defect in collagen, trauma, or prolonged wear and tear destroys joints. The **(a)** normal knee as compared to the **(b)** osteoarthritic knee, in which articular cartilage is breaking down.

TABLE 8A Different Types of Arthritis

Some More-Common Forms of Arthritis	
Type	**Prevalence in the United States**
Osteoarthritis	30.8 million
Rheumatoid arthritis	1.5 million
Some Less-Common Forms of Arthritis	
Type	**Prevalence in the United States**
Gout	8.3 million (73% male)
Juvenile rheumatoid arthritis	294,000

becomes inflamed and thickens, forming a mass called a pannus. Then, the articular cartilage is damaged, and fibrous tissue infiltrates, interfering with joint movements. In time, the joint may ossify, fusing the articulating bones (bony ankylosis) **(fig. 8B)**. Joints severely damaged by RA may be surgically replaced.

RA may affect many joints or only a few. It is usually a systemic illness, accompanied by fatigue, muscular atrophy, anemia, and osteoporosis, as well as changes in the skin, eyes, lungs, blood vessels, and heart. RA usually affects adults, with women being affected two to three times more than men, but there is a juvenile form.

Lyme Arthritis

Lyme disease, a bacterial infection passed in a tick bite, causes intermittent arthritis of several joints, usually weeks after the initial symptoms of rash, fatigue, and flulike aches and pains. Lyme arthritis was first observed by a resident of Lyme, Connecticut, who noticed that many of her young neighbors had what appeared to be the very rare juvenile form of rheumatoid arthritis. She contacted Yale University rheumatologist Allen Steere, who traced the illness to bacteria-bearing ticks. Antibiotic treatment that begins as soon as the early symptoms are recognized may prevent Lyme arthritis.

Other types of bacteria that cause arthritis include common *Staphylococcus* and *Streptococcus* species, *Neisseria gonorrhoeae* (which causes the sexually transmitted infection gonorrhea), and *Mycobacterium* (which causes tuberculosis). Arthritis may also be associated with AIDS, because the immune system breakdown raises the risk of infection by bacteria that can cause arthritis.

Gout

An inflammatory arthritis that usually affects people over forty years old, gout forms in people who have excessive uric acid in their blood. The uric acid assembles as sharp urate crystals in joints and surrounding tissues, often in the big toe. Uric acid is a breakdown product of purines normally found in body cells. They are also found in higher quantities in certain foods, like steak, seafood, and alcoholic beverages, especially beer. Usually, the kidneys receive uric acid from the blood, and it becomes a constituent of urine. However, an accumulation of uric acid results in an attack of gout, where redness, pain, and swelling in the affected joint make mobility difficult. Risk factors are many, including family history, high blood pressure, certain medications like low-dose aspirin and diuretics, gender (higher percentage in males), and obesity. Lifestyle changes and medications may be prescribed to reduce reoccurrences.

FIGURE 8B Bony ankylosis of the joints of the fingers in a person afflicted with rheumatoid arthritis. chaowalit407/iStock/Getty Images

8.2 CLINICAL APPLICATION

Replacing Joints

Surgeons use synthetic materials to replace joints in cases of joint damage, most commonly from osteoarthritis, but also from rheumatoid arthritis and other causes. Metals such as steel and titanium are used to replace larger joints, whereas flexible silicone polymers are often used to replace smaller joints. Such artificial joints must be durable yet not provoke immune system rejection. They must also allow normal healing to occur and not move surrounding structures out of their normal positions. Ceramic materials are used in about 5% of hip replacements. More than two dozen joint replacement models are in use by more than a million people. Most total joint replacements are of the knee (fig. 8C) and hip, respectively.

A surgeon inserts a joint implant in a procedure called implant resection arthroplasty. The surgeon first removes the surface of the joint bones and excess cartilage. Next, the centers of the tips of abutting bones are hollowed out, and the stems of the implant inserted. The movable part of the implant lies between the bones, aligning them yet allowing them to move. Bone cement fixes the implant in place. Finally, the surgeon repairs the tendons, muscles, and ligaments. A year of physical therapy may be necessary to fully benefit from replacement joints.

Newer joint replacements use materials that resemble natural body chemicals. Hip implants, for example, may bear a coat of hydroxyapatite, which interacts with natural bone. Instead of filling in spaces with bone cement, some investigators are testing a variety of porous coatings that allow bone tissue to grow into the implant area.

Three-dimensional (3D) printing technology is useful in creating a replacement joint that closely matches an individual's anatomy. A biomedical engineer applies the technology to CT or MRI scans to create and customize a 3D model to guide surgeons in performing the replacement. The precision that the technology offers can decrease surgical time, speed recovery, lengthen the lifetime of the part, and increase range of motion.

FIGURE 8C An X ray of a total joint replacement of the knee. Dr. P. Marazzi/Science Photo Library/Getty Images

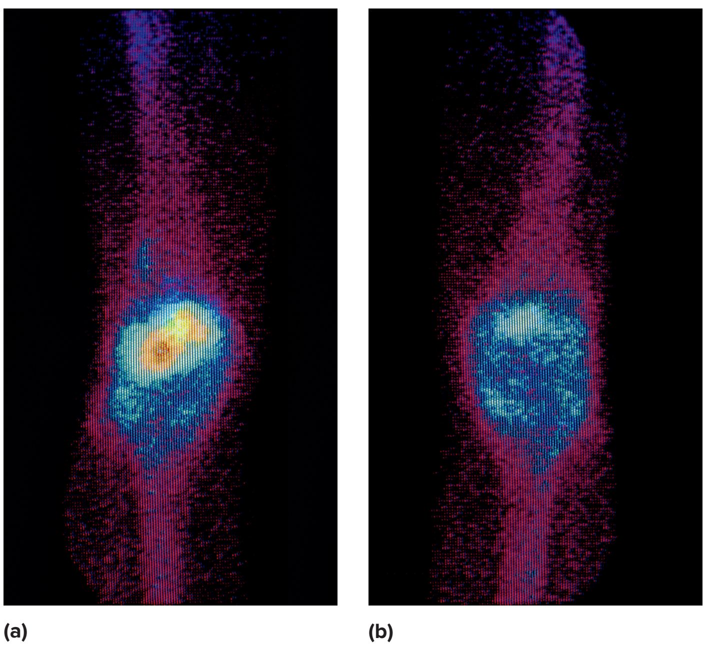


FIGURE 8.23 Nuclear scan of **(a)** a healthy knee and **(b)** an arthritic knee. The different colors in **(b)** indicate changes within the tissues associated with degeneration. Chris Priest/SPL/Science Source

Synchondroses that connect epiphyses to diaphyses in long bones, forming the *epiphyseal (growth) plate*, disappear as the skeleton grows and develops. Another synchondrosis is the joint that links the first rib to the manubrium (sternum). As water content decreases and deposition of calcium salts increases, this cartilage stiffens. Ligaments lose their elasticity as the collagen fibers become more tightly cross-linked. Breathing may become labored, and movement more restrained.

Aging also affects symphysis joints, which consist of a pad of fibrocartilage sandwiched between thin layers of hyaline cartilage. In the intervertebral discs, less water diminishes the flexibility of the vertebral column and impairs the ability of the soft centers of the discs to absorb shocks. The discs may even collapse on themselves slightly, contributing to the loss of height in older people. The stiffening spine gradually restricts the range of motion.

Loss of function in synovial joints begins in the third decade of life, but progresses slowly. Fewer capillaries serving the synovial membrane slows the circulation of synovial fluid, and the membrane may become infiltrated with fibrous material and cartilage. As a result, the joint may lose elasticity, stiffening. More collagen cross-links shorten and stiffen ligaments, affecting the range of motion. This may, in turn, upset balance and retard the ability to respond in a protective way to falling, which may explain why older people are more likely to be injured in falls than younger individuals.

Using joints, through activity and exercise, can keep them functional longer. Disuse hampers the nutrient supply to joints, which hastens stiffening. Paradoxically, this can keep people from exercising, when this is exactly what they should be doing. Damaged joints may need to be replaced (Clinical Application 8.2).

PRACTICE 8.4

1. Describe the loss of function in synovial joints as a progressive process.

ASSESS

CHAPTER ASSESSMENTS

8.1 Types of Joints

1. Describe how joints are classified.
2. A(n) ______________ is a fibrous joint with bones bound by long connective tissue fibers, whereas a(n) ______________ is a fibrous joint where flat bones are united by a thin layer of connective tissue.
3. Describe a gomphosis, and name an example.
4. Compare the structures of a synchondrosis and a symphysis.
5. Explain how the joints between vertebrae permit movement.
6. Draw the general structure of a synovial joint, labeling all the main parts.
7. Describe how a joint capsule may be reinforced.
8. Explain the function of a synovial membrane.
9. Explain the function of synovial fluid.
10. Define *meniscus*.
11. Define *bursa*.
12. Describe the six types of synovial joints, and name an example of each type.
13. Describe the movements permitted by each type of synovial joint.

8.2 Types of Joint Movements

14. Joint movements occur when a muscle contracts and the muscle fibers pull the muscle's more movable end of attachment, the ______________, toward its less movable or relatively fixed end, the ______________ .
15. Match the movements listed on the left with the descriptions listed on the right.

(1) rotation	A. turning the palm upward
(2) supination	B. decreasing the angle between parts
(3) extension	C. moving a part forward
(4) eversion	D. moving a part around an axis
(5) protraction	E. moving a part toward midline
(6) flexion	F. turning the foot so the plantar surface faces laterally
(7) pronation	G. increasing the angle between parts
(8) abduction	H. lowering a part
(9) depression	I. turning the palm downward
(10) adduction	J. moving a part away from midline

8.3 Examples of Synovial Joints

16. Name the parts that comprise the shoulder joint.
17. Name the major ligaments associated with the shoulder joint.
18. Explain why the shoulder joint permits a wide range of movements.
19. Name the parts that comprise the elbow joint.
20. Name the major ligaments associated with the elbow joint.
21. Describe the movements permitted by the elbow joint.
22. Name the parts that comprise the hip joint.
23. Describe how the articular surfaces of the hip joint are held together.
24. Explain why there is less freedom of movement in the hip joint than in the shoulder joint.
25. Name the parts that comprise the knee joint.
26. Describe the major ligaments associated with the knee joint.
27. Explain the function of the menisci of the knee.
28. Describe the locations of the bursae associated with the knee joint.

8.4 Life-Span Changes

29. Describe the process of aging as it contributes to the stiffening of fibrous, cartilaginous, and synovial joints.

ASSESS

INTEGRATIVE ASSESSMENTS/CRITICAL THINKING

Outcomes 5.3, 8.1, 8.3, 8.4

1. How would you explain to an athlete why damaged joint ligaments and cartilages are so slow to heal following an injury?

Outcomes 8.1, 8.3, 8.4

2. How would you explain to a person with a dislocated shoulder that the shoulder is likely to become more easily dislocated in the future?

Outcomes 8.1, 8.3

3. Based upon your knowledge of joint structures, which do you think could be more satisfactorily replaced by a prosthetic device—a hip joint or a knee joint? Why?
4. Compared to the shoulder and hip joints, in what ways is the knee joint especially vulnerable to injuries?
5. When a friend tells you she needs to have labrum surgery, to which joint(s) might she be referring? Explain.

Chapter Summary

8.1 Types of Joints

Joints are classified according to structure (the type of tissue that binds the bones) and function (the degree of movement possible).

1. Fibrous joints
   a. Bones at **fibrous joints** are tightly fastened to each other by a layer of dense connective tissue with many collagen fibers.
   b. There are three types of fibrous joints.
      (1) A **syndesmosis** has bones bound by long connective tissue fibers.
      (2) A **suture** is where flat bones are united by a thin layer of connective tissue and are interlocked by a set of bony processes.
      (3) A **gomphosis** is formed by the union of a cone-shaped bony process with a bony socket.
2. Cartilaginous joints
   a. A layer of cartilage holds together bones of **cartilaginous joints.**
   b. There are two types of cartilaginous joints.
      (1) A **synchondrosis** occurs where bones are united by hyaline cartilage that may disappear as a result of bone growth.
      (2) A **symphysis** is found where articular surfaces of the bones are covered by hyaline cartilage and the bones are connected by a pad of fibrocartilage.
3. Synovial joints
   a. **Synovial joints** have a more complex structure than other types of joints.
      (1) **Articular cartilage** covers articular ends of bones in a synovial joint.
      (2) A **joint capsule** strengthened by **ligaments** holds bones together.
      (3) A **synovial membrane** that secretes synovial fluid lines the inner layer of a joint capsule.
      (4) **Synovial fluid** moistens, provides nutrients, and lubricates the articular surfaces.
      (5) **Menisci** divide some synovial joints into compartments.
      (6) Some synovial joints have fluid-filled **bursae.**
         (a) Most bursae are located between the skin and underlying bony prominences.
         (b) Bursae cushion and aid movements of tendons over bony parts.
         (c) Bursae are named according to their locations.
   b. There are six major types of synovial joints.
      (1) In a **ball-and-socket joint,** the globular head of a bone fits into the cup-shaped cavity of another bone.
         (a) These joints permit a wide variety of movements.
         (b) The hip and shoulder are ball-and-socket joints.
      (2) A **condylar joint** consists of an ovoid condyle of one bone fitting into an elliptical cavity of another bone.
         (a) This joint permits movement in two planes.
         (b) The joints between the metacarpals and phalanges are condylar.
      (3) Articular surfaces of **plane joints** are nearly flat.
         (a) These joints permit the articular surfaces to slide back and forth.
         (b) Most of the joints of the wrist and ankle are plane joints.
      (4) In a **hinge joint,** the convex surface of one bone fits into the concave surface of another bone.
         (a) This joint permits movement in one plane only.
         (b) The elbow and the joints of the phalanges are the hinge type.
      (5) In a **pivot joint,** a cylindrical surface of one bone rotates within a ring of bone and ligament.
         (a) This joint permits rotational movement.
         (b) The articulation between the proximal ends of the radius and the ulna is a pivot joint.
      (6) A **saddle joint** forms between bones that have complementary surfaces with both concave and convex regions.
         (a) This joint permits a variety of movements.
         (b) The articulation between the carpal and metacarpal of the thumb is a saddle joint.

8.2 Types of Joint Movements

1. Muscles acting at synovial joints produce movements in different directions and in different planes.
2. Joint movements include **flexion, extension, dorsiflexion, plantar flexion, abduction, adduction, rotation, circumduction, supination, pronation, eversion, inversion, protraction, retraction, elevation,** and **depression.**

8.3 Examples of Synovial Joints

1. **Shoulder joint**
   a. The shoulder joint is a ball-and-socket joint that consists of the head of the humerus and the glenoid cavity of the scapula.
   b. A cylindrical joint capsule envelops the joint.
      (1) The capsule is loose and by itself cannot keep the articular surfaces together.
      (2) It is reinforced by surrounding muscles and tendons.

c. Several ligaments help prevent displacement of the bones.
d. Several bursae are associated with the shoulder joint.
e. Its parts are loosely attached, so the shoulder joint permits a wide range of movements.

2. **Elbow joint**
   a. The elbow has a hinge joint between the humerus and the ulna and a plane joint between the humerus and the radius.
   b. Collateral ligaments reinforce the joint capsule.
   c. A synovial membrane partially divides the joint cavity into two portions.
   d. The joint between the humerus and the ulna permits flexion and extension only.
3. **Hip joint**
   a. The hip joint is a ball-and-socket joint between the femur and the hip bone.
   b. A ring of fibrocartilage deepens the cavity of the acetabulum.
   c. The articular surfaces are held together by a heavy joint capsule reinforced by ligaments.
   d. The hip joint permits a wide variety of movements.
4. **Knee joint**
   a. The knee joint includes a modified hinge joint between the femur and the tibia and a plane joint between the femur and the patella.
   b. Ligaments and tendons strengthen the thin joint capsule.
   c. Several ligaments, some in the joint capsule, bind the articular surfaces of the joint bones.
   d. Two menisci separate the articulating surfaces of the femur and the tibia.
   e. Several bursae are associated with the knee joint.
   f. The knee joint permits flexion and extension; when the knee is flexed, some lower limb rotation is possible.

8.4 Life-Span Changes

1. Joint stiffness is often the earliest sign of aging.
   a. Collagen changes cause the feeling of stiffness.
   b. Regular exercise can lessen the effects.
2. Fibrous joints are the first to begin to change and strengthen over a lifetime.
3. Synchondroses of the long bones disappear with growth and development.
4. Changes in symphysis joints of the vertebral column diminish flexibility and decrease height.
5. Over time, synovial joints lose elasticity.

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