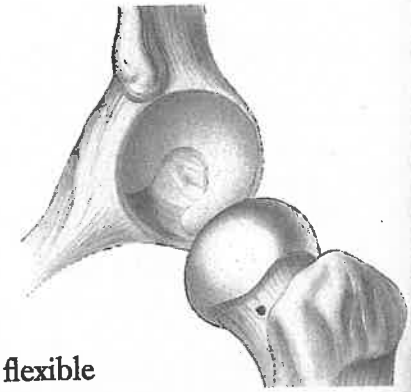
chapter 7

JOINTS



did you know?

For many years, people believed that exercise accelerated joint degeneration, and that people with arthritis should avoid physical activity. Scientists now believe that a sedentary lifestyle leads to loss of strength in muscles, tendons, ligaments, and other joint structures, which makes movement even more painful and difficult. When muscles and joints atrophy, the resulting weakness makes joints less stable, and more vulnerable to injury. Physical activity helps to strengthen joint structures and delay the progress of arthritis. Low- or non-impact activities such as strength training, swimming, and cycling can improve fitness, functional status, and quality of life for people with arthritis.

Focus on Wellness, page 167

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Bones are too rigid to bend without being damaged. Fortunately, flexible connective tissues form joints that hold bones together while in most cases permitting some degree of movement. If you have ever damaged these areas, you know how difficult it is to walk with a cast over your knee or to turn a doorknob with a splint on your finger. A ***joint*** (also called an ***articulation***) is a point of contact between bones, between cartilage and bones, or between teeth and bones. When we say one bone articulates with another bone, we mean that the two bones form a joint. ***Arthrology*** (ar-THROL-ō-jē; *arthr-* = joint; *-logy* = study of) is the scientific study of joints. Many joints of the body permit movement. The study of motion of the human body is called ***kinesiology*** (ki-nē′-sē-OL-ō-jē; *kinesi-* = movement).

looking back to move ahead . . .

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- **Dense Regular Connective Tissue (page 86)**
- **Cartilage (page 89)**
- **Synovial Membranes (page 91)**
- **Divisions of the Skeletal System (page 124)**

JOINTS

OBJECTIVES • Describe how the structure of a joint determines its function.

• Describe the structural and functional classes of joints.

A joint's structure determines its combination of strength and flexibility. At one end of the spectrum are joints that permit no movement and are thus very strong, but inflexible. In contrast, other joints afford fairly free movement and are thus flexible but not as strong. In general, the closer the fit at the point of contact, the stronger the joint. At tightly fitted joints, movement is obviously more restricted. The looser the fit, the greater the movement. However, loosely fitted joints are prone to displacement of the articulating bones from their normal positions (dislocation). Movement at joints is also determined by (1) the shape of the articulating bones, (2) the flexibility (tension or tautness) of the ligaments that bind the bones together, and (3) the tension of associated muscles and tendons. Joint flexibility may also be affected by hormones. For example, toward the end of pregnancy, a hormone called relaxin increases the flexibility of the fibrocartilage of the pubic symphysis and loosens the ligaments between the sacrum and hip bone. These changes enlarge the pelvic outlet, which assists in delivery of the baby.

Joints are classified structurally, based on their anatomical characteristics, and functionally, based on the type of movement they permit.

The structural classification of joints is based on two criteria: (1) the presence or absence of a space between the articulating bones, called a synovial cavity, and (2) the type of connective tissue that holds the bones together. Structurally, joints are classified as one of the following types:

- **Fibrous joints** (FĪ-brus): There is no synovial cavity and the bones are held together by fibrous connective tissue that is rich in collagen fibers.
- **Cartilaginous joints** (kar-ti-LAJ-i-nus): There is no synovial cavity and the bones are held together by cartilage.
- **Synovial joints** (si-NŌ-vē-al): The bones forming the joint have a synovial cavity and are united by the dense irregular connective tissue of an articular capsule, and often by accessory ligaments.

The functional classification of joints relates to the degree of movement they permit. Functionally, joints are classified as one of the following types:

- ***Synarthrosis*** (sin′-ar-THRŌ-sis; *syn-* = together): An immovable joint. The plural is *synarthroses*.
- ***Amphiarthrosis*** (am′-fē-ar-THRŌ-sis; *amphi-* = on both sides): A slightly movable joint. The plural is *amphiarthroses*.
- ***Diarthrosis*** (dī′-ar-THRŌ-sis = movable joint): A freely movable joint. The plural is *diarthroses*. All diarthroses are synovial joints. They have a variety of shapes and permit several different types of movements.

The following sections present the joints of the body according to their structural classification. As we examine the structure of each type of joint, we will also explore its functional attributes.

■ CHECKPOINT

1. What factors determine movement at joints?

FIBROUS JOINTS

OBJECTIVE • Describe the structure and functions of the three types of fibrous joints.

Fibrous joints permit little or no movement. The three types of fibrous joints are (1) sutures, (2) syndesmoses, and (3) gomphoses.

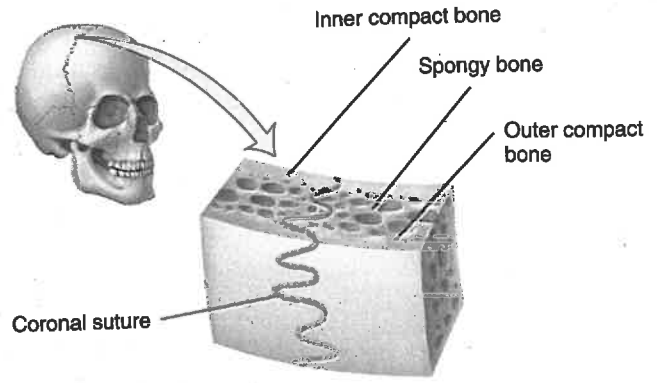
1. A ***suture*** (SOO-cher; *sutur-* = seam) is a fibrous joint composed of a thin layer of dense fibrous connective tissue. Sutures unite the bones of the skull. An example is the coronal suture between the frontal and parietal bones (Figure 7.1a). The irregular, interlocking edges of sutures give them added strength and decrease their chance of fracturing. Because a suture is immovable, it is classified functionally as a synarthrosis.
2. A ***syndesmosis*** (sin′-dez-MŌ-sis; *syndesmo-* = band or ligament) is a fibrous joint in which the distance between the articulating bones and the amount of dense fibrous connective tissue is greater than in a suture (Figure 7.1b). One example of a syndesmosis is the distal articulation between the tibia and fibula where the anterior tibiofibular ligament connects the bones. Because it permits slight movement, a syndesmosis is classified functionally as an amphiarthrosis.
3. A ***gomphosis*** (gom-FŌ-sis; *gompho-* = a bolt or nail; plural is *gomphoses*) is a type of fibrous joint in which a cone-shaped peg fits into a socket. The only gomphoses in the human body are the articulations of the roots of the teeth with the sockets of the alveolar processes of the maxillae and mandible (Figure 7.1c). The dense fibrous connective tissue between the root of a tooth and its socket is the periodontal ligament. A gomphosis is classified functionally as a synarthrosis, an immovable joint.

■ CHECKPOINT

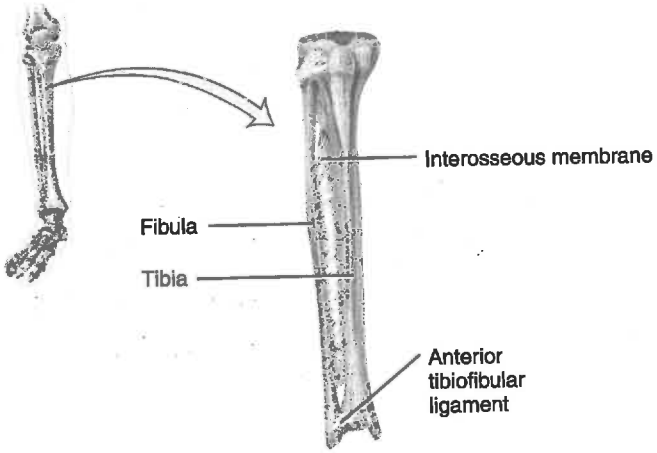
2. Which fibrous joints are synarthroses? Which are amphiarthroses?

Figure 7.1 Fibrous joints.

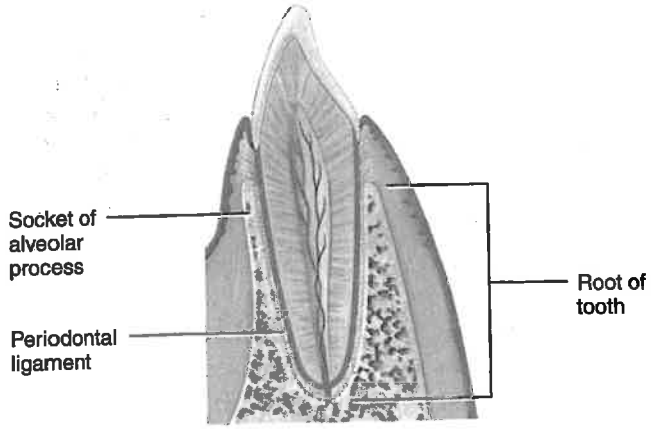
At a fibrous joint, the bones are held together by connective tissue containing many collagen fibers.



(a) Suture between skull bones



(b) Syndesmosis between distal tibia and fibula



(c) Gomphosis between tooth and socket of alveolar process

Functionally, why are sutures classified as synarthroses and syndesmoses classified as amphiarthroses?

CARTILAGINOUS JOINTS

OBJECTIVE • Describe the structure and functions of the two types of cartilaginous joints.

Like a fibrous joint, a ***cartilaginous*** (car-ti-LAJ-i-nus) ***joint*** allows little or no movement. Here the articulating bones are tightly connected by either fibrocartilage or hyaline cartilage. The two types of cartilaginous joints are synchondroses and symphyses.

1. A ***synchondrosis*** (sin′-kon-DRŌ-sis; *chondro-* = cartilage) is a cartilaginous joint in which the connecting material is hyaline cartilage. An example of a synchondrosis is the epiphyseal plate that connects the epiphysis and diaphysis of an elongating bone (Figure 7.2a). Functionally, a synchondrosis is a synarthrosis, an immovable joint. When bone growth stops, bone replaces the hyaline cartilage.
2. A ***symphysis*** (SIM-fi-sis = growing together) is a cartilaginous joint in which the ends of the articulating bones are covered with hyaline cartilage, but the bones are connected by a broad, flat disc of fibrocartilage. The pubic symphysis between the anterior surfaces of the hip bones is one example of a symphysis (Figure 7.2b). This type of joint is also found at the intervertebral joints between bodies of vertebrae. Functionally, a symphysis is an amphiarthrosis, a slightly movable joint.

■ CHECKPOINT

3. Which cartilaginous joints are synarthroses? Which are amphiarthroses?

SYNOVIAL JOINTS

OBJECTIVE • Describe the structure of synovial joints.

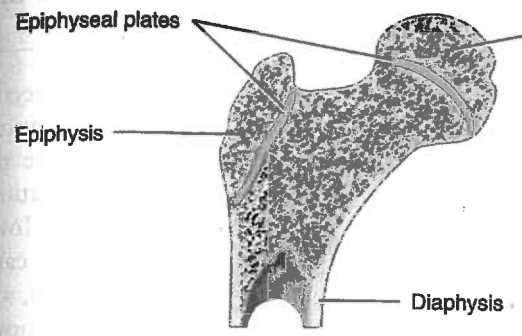
Structure of Synovial Joints

Synovial joints (si-NŌ-vē-al) have certain characteristics that distinguish them from other joints. The unique characteristic of a synovial joint is the presence of a space called a ***synovial (joint) cavity*** between the articulating bones (Figure 7.3). The synovial cavity allows a joint to be freely movable. Hence, all synovial joints are classified functionally as diarthroses. The bones at a synovial joint are covered by ***articular cartilage***, which is hyaline cartilage. Articular cartilage reduces friction between bones in the joint during movement and helps to absorb shock.

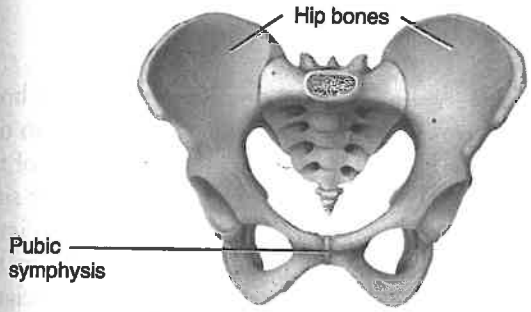
A sleevelike ***articular capsule*** surrounds a synovial joint, encloses the synovial cavity, and unites the articulating bones.

Figure 7.2 Cartilaginous joints.

At a cartilaginous joint, the bones are held firmly together by cartilage.



(a) Synchondrosis



(b) Symphysis

What is the structural difference between a synchondrosis and a symphysis?

The articular capsule is composed of two layers, an outer fibrous capsule and an inner synovial membrane (Figure 7.3). The outer layer, the ***fibrous capsule***, usually consists of dense irregular connective tissue that attaches to the periosteum of the articulating bones. The fibers of some fibrous capsules are arranged in parallel bundles that are highly adapted for resisting strains. Such fiber bundles are called ***ligaments*** (*liga-* = bound or tied) and are one of the main mechanical factors that hold bones close together in a synovial joint. The inner layer of the articular capsule, the ***synovial membrane***, is composed of areolar connective tissue with elastic fibers. At many synovial joints the synovial membrane includes accumulations of adipose tissue, called ***articular fat pads*** (see Figure 7.10c).

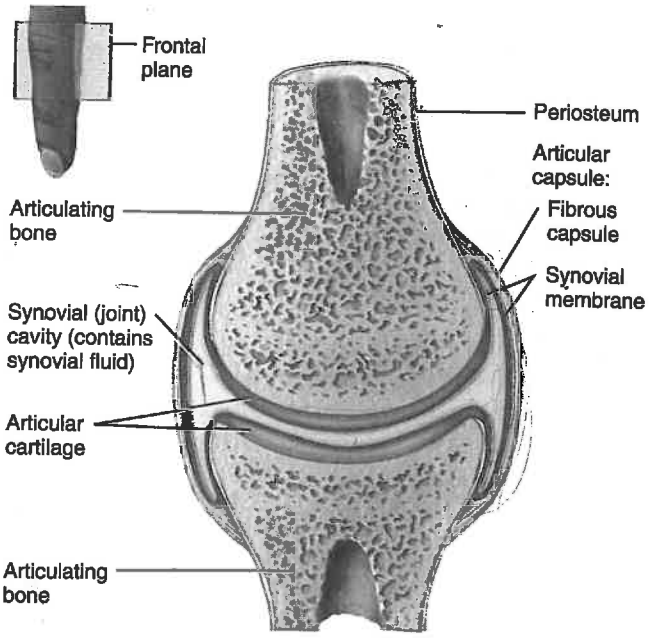
The synovial membrane secretes ***synovial fluid*** (*ovi-* = egg), which forms a thin film over the surfaces within the articular capsule. This viscous, clear or pale yellow fluid was named for its similarity in appearance and consistency to uncooked egg white (albumin). Its several functions include reducing friction by lubricating the joint, and supplying nutrients to and removing metabolic wastes from the chondrocytes within articular cartilage. When a synovial joint is immobile for a time, the fluid is quite viscous (gel-like), but as joint movement increases, the fluid becomes less viscous. One of the benefits of a warm-up before exercise is that it stimulates the production and secretion of synovial fluid. More fluid means less stress on the joint during exercise.

Many synovial joints also contain ***accessory ligaments*** that lie outside and inside the articular capsule. Examples of accessory ligaments outside the articular capsule are the fibular (lateral) and tibial (medial) collateral ligaments of the knee joint (see Figure 7.10d). Examples of accessory ligaments inside the articular capsule are the anterior and posterior cruciate ligaments of the knee joint (see Figure 7.10d).

Inside some synovial joints, such as the knee, are pads of fibrocartilage that lie between the articular surfaces of the bones and are attached to the fibrous capsule. These pads are called ***articular discs*** or ***menisci*** (me-NIS-sī; singular is *meniscus*). Figure 7.10d depicts the lateral and medial menisci in the knee joint. By modifying the shape of the joint surfaces of the articulating bones, articular discs allow two bones of different shapes to fit more tightly. Articular discs also help to maintain the stability of the joint and direct the flow of synovial fluid to the areas of greatest friction.

Figure 7.3 Structure of a typical synovial joint. Note the two layers of the articular capsule: the fibrous capsule and the synovial membrane. Synovial fluid fills the synovial cavity, which is located between the synovial membrane and the hyaline articular cartilage.

The distinguishing feature of a synovial joint is the synovial (joint) cavity between the articulating bones.



Frontal section

What is the functional classification of synovial joints?

The tearing of articular discs (menisci) in the knee, commonly called **torn cartilage**, occurs often among athletes. Such damaged cartilage will begin to wear and may precipitate arthritis unless it is surgically removed (meniscectomy). Surgical repair of the torn cartilage is required because of the avascular nature of cartilage and may be assisted by **arthroscopy** (ar-THROS-kō-pē; *-scopy* = observation), the visual examination of the interior of a joint, usually the knee, with an *arthroscope*, a lighted, pencil-thin instrument. Arthroscopy is used to determine the nature and extent of damage following knee injury and to monitor the progression of disease and the effects of therapy. In addition, the insertion of surgical instruments through the arthroscope or other incisions enables a physician to remove torn cartilage and repair damaged cruciate ligaments in the knee; to remodel poorly formed cartilage; to obtain tissue samples for analysis; and to perform surgery on other joints, such as the shoulder, elbow, ankle, and wrist.

The various movements of the body create friction between moving parts. Saclike structures called ***bursae*** (BER-sē = purses; singular is *bursa*) are strategically situated to reduce friction in some synovial joints, such as the shoulder and knee joints (see Figure 7.10c). Bursae are not strictly part of synovial joints, but do resemble joint capsules because their walls consist of connective tissue lined by a synovial membrane. They are also filled with a fluid similar to synovial fluid. Bursae are located between the skin and bone in places where skin rubs over bone. They are also found between tendons and bones, muscles and bones, and ligaments and bones. The fluid-filled bursal sacs cushion the movement of one body part over another.

An acute or chronic inflammation of a bursa, for example in the shoulder and knee, is called **bursitis**. The condition may be caused by trauma, by an acute or chronic infection (including syphilis and tuberculosis), or by rheumatoid arthritis (described on page 168). Repeated, excessive exertion of a joint often results in bursitis, with local inflammation and the accumulation of fluid. Symptoms include pain, swelling, tenderness, and limited movement. Treatment may include oral anti-inflammatory agents and injections of cortisol-like steroids.

■ CHECKPOINT

4. How does the structure of synovial joints classify them as diarthroses?
5. What are the functions of articular cartilage, the articular capsule, synovial fluid, articular discs, and bursae?

TYPES OF MOVEMENTS AT SYNOVIAL JOINTS

OBJECTIVE • Describe the types of movements that can occur at synovial joints.

Anatomists, physical therapists, and kinesiologists use specific terminology to designate specific types of movement that can occur at a synovial joint. These precise terms indicate the form of motion, the direction of movement, or the relationship of one body part to another during movement. Movements at synovial joints are grouped into four main categories: (1) gliding, (2) angular movements, (3) rotation, and (4) special movements. The last category includes movements that occur only at certain joints.

Gliding

Gliding is a simple movement in which relatively flat bone surfaces move back-and-forth and side-to-side relative to one another. This can be illustrated between the acromion of the scapula and clavicle by placing your upper limb at your side, rotating it about your head, and lowering it again (see Figure 7.7b). Gliding movements are limited in range due to the loose-fitting structure of the articular capsule and associated ligaments and bones.

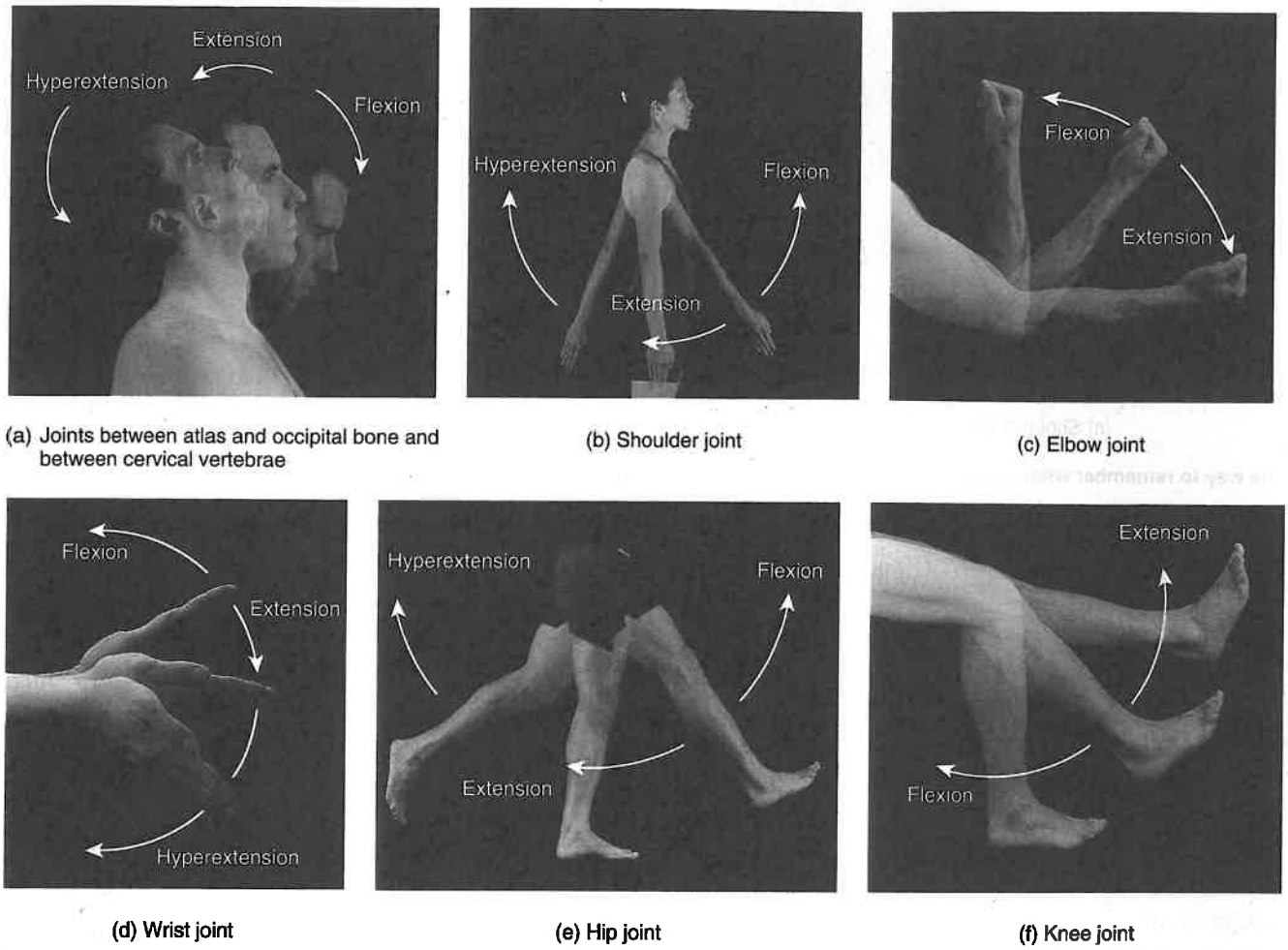
Angular Movements

In ***angular movements***, there is an increase or a decrease in the angle between articulating bones. The principal angular movements are flexion, extension, hyperextension, abduction, adduction, and circumduction and are discussed with respect to the body in the anatomical position. In ***flexion*** (FLEK-shun = to bend), there is a decrease in the angle between articulating bones; in ***extension*** (eks-TEN-shun = to stretch out), there is an increase in the angle between articulating bones, often to restore a part of the body to the anatomical position after it has been flexed (Figure 7.4). Examples of flexion include bending the head toward the chest (Figure 7.4a); moving the humerus forward at the shoulder joint as in swinging the arms forward while walking (Figure 7.4b); moving the forearm toward the arm (Figure 7.4c); moving the palm toward the forearm (Figure 7.4d); moving the femur forward, as in walking (Figure 7.4e); and bending the knee (Figure 7.4f). Extension is simply the reverse of these movements.

Continuation of extension beyond the anatomical position is called ***hyperextension*** (*hyper-* = beyond or excessive). Examples of hyperextension include bending the head backward (Figure 7.4a); moving the humerus backward, as in swinging the arms backward while walking (Figure 7.4b); moving the palm backward at the wrist joint (Figure 7.4d);

Figure 7.4 Angular movements at synovial joints: flexion, extension, and hyperextension.

In angular movements, there is an increase or decrease in the angle between articulating bones.



(a) Joints between atlas and occipital bone and between cervical vertebrae

(b) Shoulder joint

(c) Elbow joint

(d) Wrist joint

(e) Hip joint

(f) Knee joint

What prevents hyperextension at some synovial joints?

and moving the femur backward, as in walking (Figure 7.4e). Hyperextension of other joints, such as the elbow, interphalangeal joints (fingers and toes), and knee joints, is usually prevented by the arrangement of ligaments and bones.

Abduction (ab-DUK-shun; *ab-* = away; *-duct* = to lead) is the movement of a bone away from the midline, and ***adduction*** (ad-DUK-shun; *ad-* = toward) is the movement of a bone toward the midline. Examples of abduction include lateral movement of the humerus upward (Figure 7.5a), lateral movement of the palm away from the body (Figure 7.5b), and lateral movement of the femur away from the body (Figure 7.5c). Movement in the opposite direction (medially) in each case produces adduction (Figure 7.5).

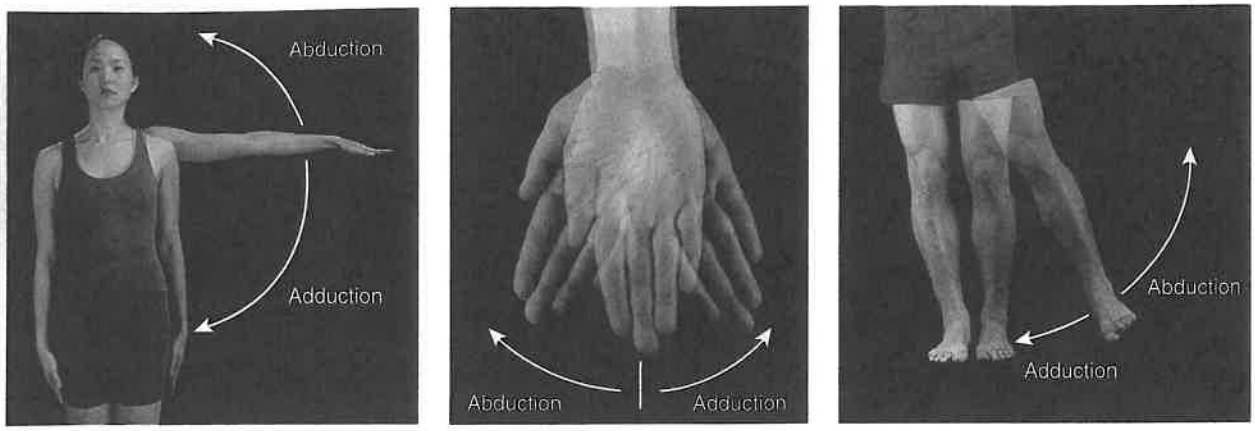
Circumduction (ser-kum-DUK-shun; *circ-* = circle) is movement of the distal end of a part of the body in a circle (Figure 7.6). Examples of joints that allow circumduction include the humerus at the shoulder joint (making a circle with your arm) and the femur at the hip joint (making a circle with your leg). Circumduction is more limited at the hip due to greater tension on the ligaments and muscles.

Rotation

In ***rotation*** (rō-TĀ-shun; *rota-* = to revolve) a bone revolves around its own longitudinal axis. An example is turning the head from side to side, as in signifying "no" (Figure 7.7a on page 163). In the limbs, rotation is defined relative to the midline. If the anterior surface of a bone of the limb is turned toward the midline, the movement is called *medial (internal) rotation*. You can medially rotate the humerus at the shoulder joint as follows: Starting in the anatomical position, flex your elbow and then draw your palm across the chest (Figure 7.7b). If the anterior surface of the

Figure 7.5 Angular movements at synovial joints: abduction and adduction.

Condyloid, saddle, and ball-and-socket joints permit abduction and adduction.



(a) Shoulder joint (b) Wrist joint (c) Hip joint

One way to remember what adduction means is use of the phrase "adding your limb to your trunk." Why is this an effective learning device?

bone of a limb is turned away from the midline, the movement is called *lateral (external) rotation* (see Figure 7.7b).

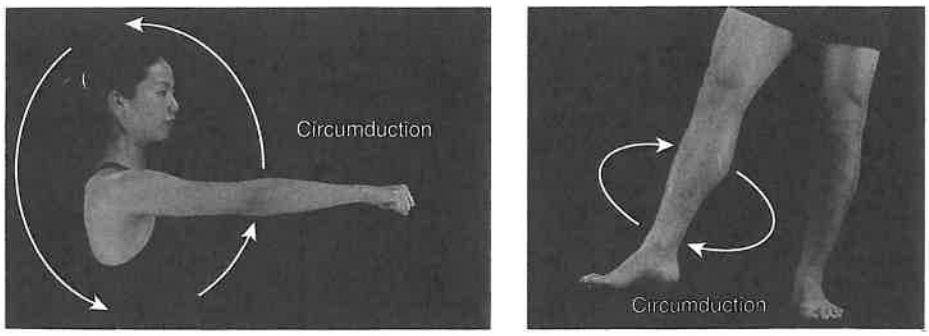
Special Movements

The ***special movements*** that occur only at certain joints include elevation, depression, protraction, retraction, inversion, eversion, dorsiflexion, plantar flexion, supination, and pronation (Figure 7.8).

- ***Elevation*** (el′-e-VĀ-shun = to lift up) is the upward movement of a part of the body, such as closing the mouth to elevate the mandible (Figure 7.8a) or shrugging the shoulders to elevate the scapula.
- ***Depression*** (dē-PRESH-un = to press down) is the downward movement of a part of the body, such as opening the mouth to depress the mandible (Figure 7.8b) or returning shrugged shoulders to the anatomical position to depress the scapula.
- ***Protraction*** (prō-TRAK-shun = to draw forth) is the movement of a part of the body forward. You can protract your mandible by thrusting it outward (Figure 7.8c) or protract your clavicles by crossing your arms.
- ***Retraction*** (rē-TRAK-shun = to draw back) is the movement of a protracted part of the body back to the anatomical position (Figure 7.8d).
- ***Inversion*** (in-VER-zhun = to turn inward) is movement of the soles medially so that they face each other (Figure 7.8e).
- ***Eversion*** (ē-VER-zhun = to turn outward) is movement of the soles laterally so that they face away from each other (Figure 7.8f).

Figure 7.6 Angular movements at synovial joints: circumduction.

Circumduction is the movement of the distal end of a body part in a circle.

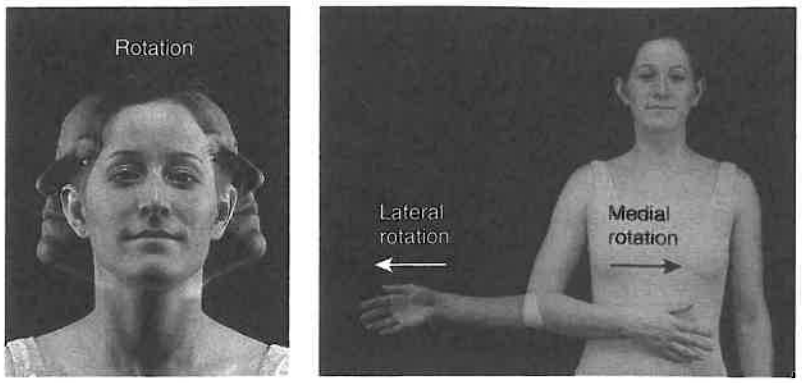


(a) Shoulder joint (b) Hip joint

List two joints where circumduction can occur.

Figure 7.7 Rotation at synovial joints.

In rotation, a bone revolves around its own longitudinal axis.



(a) Atlanto-axial joint (b) Shoulder joint

How do medial and lateral rotation differ?

- ***Dorsiflexion*** (dor′-si-FLEK-shun) is bending of the foot in the direction of the dorsum (superior surface), as when you stand on your heels (Figure 7.8g).
- ***Plantar flexion*** involves bending of the foot in the direction of the plantar surface (Figure 7.8g), as when standing on your toes.
- ***Supination*** (soo′-pi-NĀ-shun) is movement of the forearm so that the palm is turned forward (Figure 7.8h). Supination of the palms is one of the defining features of the anatomical position (see Figure 1.4 on page 11).
- ***Pronation*** (prō-NĀ-shun) is movement of the forearm so that the palm is turned backward (Figure 7.8h).

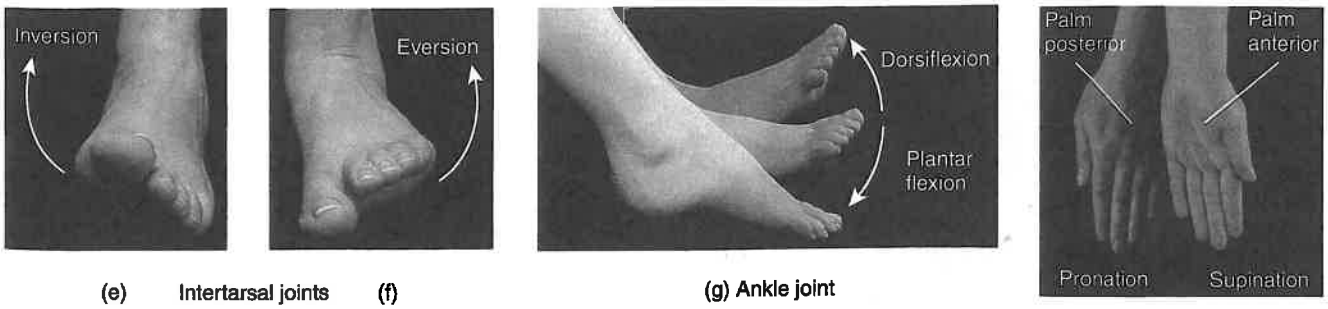
CHECKPOINT

6. Define each of the movements at synovial joints just described and give an example of each.

Figure 7.8 Special movements at synovial joints.

Special movements occur only at certain synovial joints.

(a) Temporomandibular joint (b) (c) Temporomandibular joint (d)



(e) Intertarsal joints (f) (g) Ankle joint (h) Radioulnar joint

What movement of the shoulder girdle is involved in bringing the arms forward until the elbows touch?

TYPES OF SYNOVIAL JOINTS

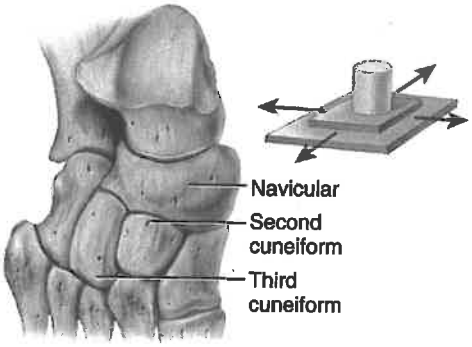
OBJECTIVE • Describe the six subtypes of synovial joints.

Although all synovial joints have a similar structure, the shapes of the articulating surfaces vary and thus various types of movement are possible. Accordingly, synovial joints are divided into six subtypes: planar, hinge, pivot, condyloid, saddle, and ball-and-socket joints.

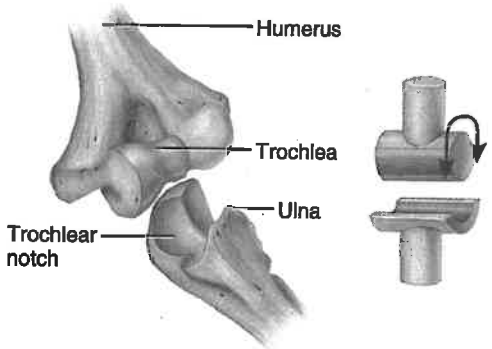
1. The articulating surfaces of bones in ***planar joints*** are flat or slightly curved (Figure 7.9a). Some examples of planar joints are the intercarpal (between carpal bones at the wrist), intertarsal (between tarsal bones at the ankle), sternoclavicular (between the sternum and the clavicle), and acromioclavicular (between the acromion of the scapula and the clavicle) joints. Planar joints primarily permit gliding movements.
2. In ***hinge joints***, the convex surface of one bone fits into the concave surface of another bone (Figure 7.9b).

Figure 7.9 Types of synovial joints. For each subtype, a drawing of the actual joint and a simplified diagram are shown.

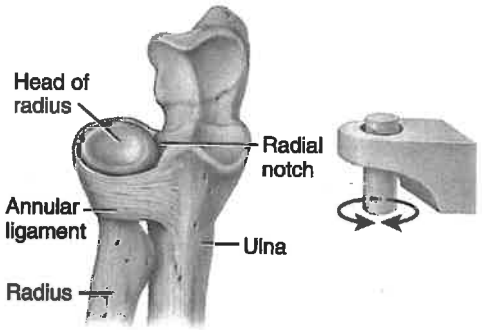
Synovial joints are classified into subtypes on the basis of the shapes of the articulating bone surfaces.



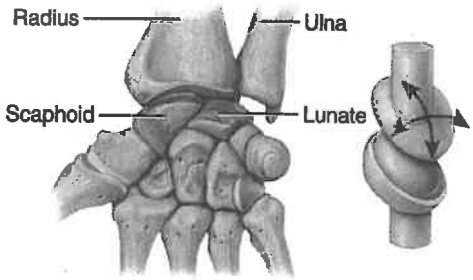
(a) Planar joint between the navicular and second and third cuneiforms of the tarsus in the foot



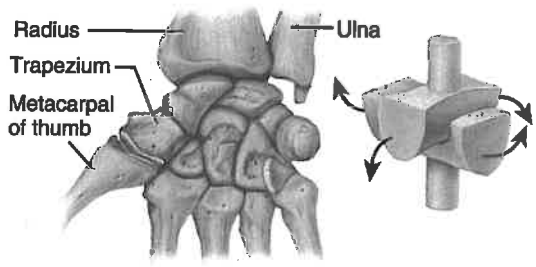
(b) Hinge joint between trochlea of humerus and trochlear notch of ulna at the elbow



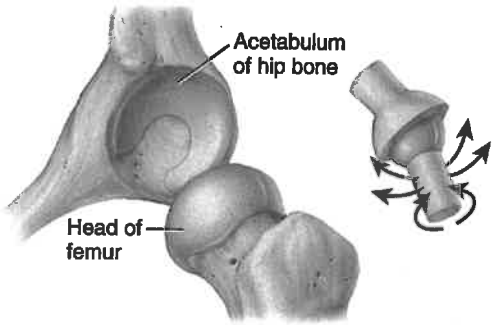
(c) Pivot joint between head of radius and radial notch of ulna



(d) Condyloid joint between radius and scaphoid and lunate bones of the carpus (wrist)



(e) Saddle joint between trapezium of carpus (wrist) and metacarpal of thumb



(f) Ball-and-socket joint between head of the femur and acetabulum of the hip bone

Which joints permit the greatest range of motion?

Examples of hinge joints are the knee, elbow, ankle, and interphalangeal joints (between the phalanges of the fingers and toes). As the name implies, hinge joints produce an angular, opening-and-closing motion like that of a hinged door. Hinge joints permit only flexion and extension.

3. In ***pivot joints***, the rounded or pointed surface of one bone articulates with a ring formed partly by another bone and partly by a ligament (Figure 7.9c). A pivot joint allows rotation around its own longitudinal axis. Examples of pivot joints are the atlantoaxial joint, in which the atlas rotates around the axis and permits you to turn your head from side to side as in signifying "no," and the radioulnar joints that allow you to move your palms forward and backward.
4. In ***condyloid joints*** (KON-di-loyd = knucklelike), the convex oval-shaped projection of one bone fits into the concave oval-shaped depression of another bone (Figure 7.9d). Examples are the wrist and metacarpophalangeal joints (between the metacarpals and phalanges) of the second through fifth digits. A condyloid joint permits flexion, extension, abduction, adduction, and circumduction.
5. In ***saddle joints***, the articular surface of one bone is saddle-shaped, and the articular surface of the other bone fits into the saddle like a rider sitting on a horse (Figure 7.9e). An example of a saddle joint is the carpometacarpal joint between the trapezium of the carpus and metacarpal of the thumb. Saddle joints permit flexion, extension, abduction, adduction, and circumduction.
6. In ***ball-and-socket joints***, the ball-like surface of one bone fits into a cuplike depression of another bone (Figure 7.9f). Ball-and-socket joints permit movement in several directions (flexion, extension, abduction, adduction, circumduction, and rotation); the only examples in the human body are the shoulder and hip joints.

■ **CHECKPOINT**

7. Where in the body can each subtype of synovial joint be found?

DETAILS OF A SYNOVIAL JOINT: THE KNEE JOINT

OBJECTIVE • Describe the principal structures and functions of the knee joint.

To give you an idea of the complexity of a synovial joint, we will examine some of the structural features of the knee joint, the largest and most complex joint in the body. Among the main structures of the knee joint are the following (Figure 7.10).

1. The articular capsule is strengthened by muscle tendons surrounding the joint.
2. The ***patellar ligament*** extends from the patella to the tibia and strengthens the anterior surface of the joint.
3. The ***oblique popliteal ligament*** (pop-LIT-ē-al) strengthens the posterior surface of the joint.
4. The ***arcuate popliteal ligament*** strengthens the lower lateral part of the posterior surface of the joint.
5. The ***tibial (medial) collateral ligament*** strengthens the medial aspect of the joint.
6. The ***fibular (lateral) collateral ligament*** strengthens the lateral aspect of the joint.
7. The ***anterior cruciate ligament (ACL)*** extends posteriorly and laterally from the tibia to the femur. The ACL is stretched or torn in about 70% of all serious knee injuries.
8. The ***posterior cruciate ligament (PCL)*** extends anteriorly and medially from the tibia to the femur. The ACL and PCL limit anterior and posterior movement of the femur and maintain the alignment of the femur with the tibia.
9. The menisci, fibrocartilage discs between the tibial and femoral condyles, help compensate for the irregular shapes of the articulating bones. The two menisci of the knee joint are the *medial meniscus*, a semicircular piece of fibrocartilage on the medial aspect of the knee, and the *lateral meniscus*, a nearly circular piece of fibrocartilage on the lateral aspect of the knee.
10. The bursae, saclike structures filled with fluid, help reduce friction.

■ **CHECKPOINT**

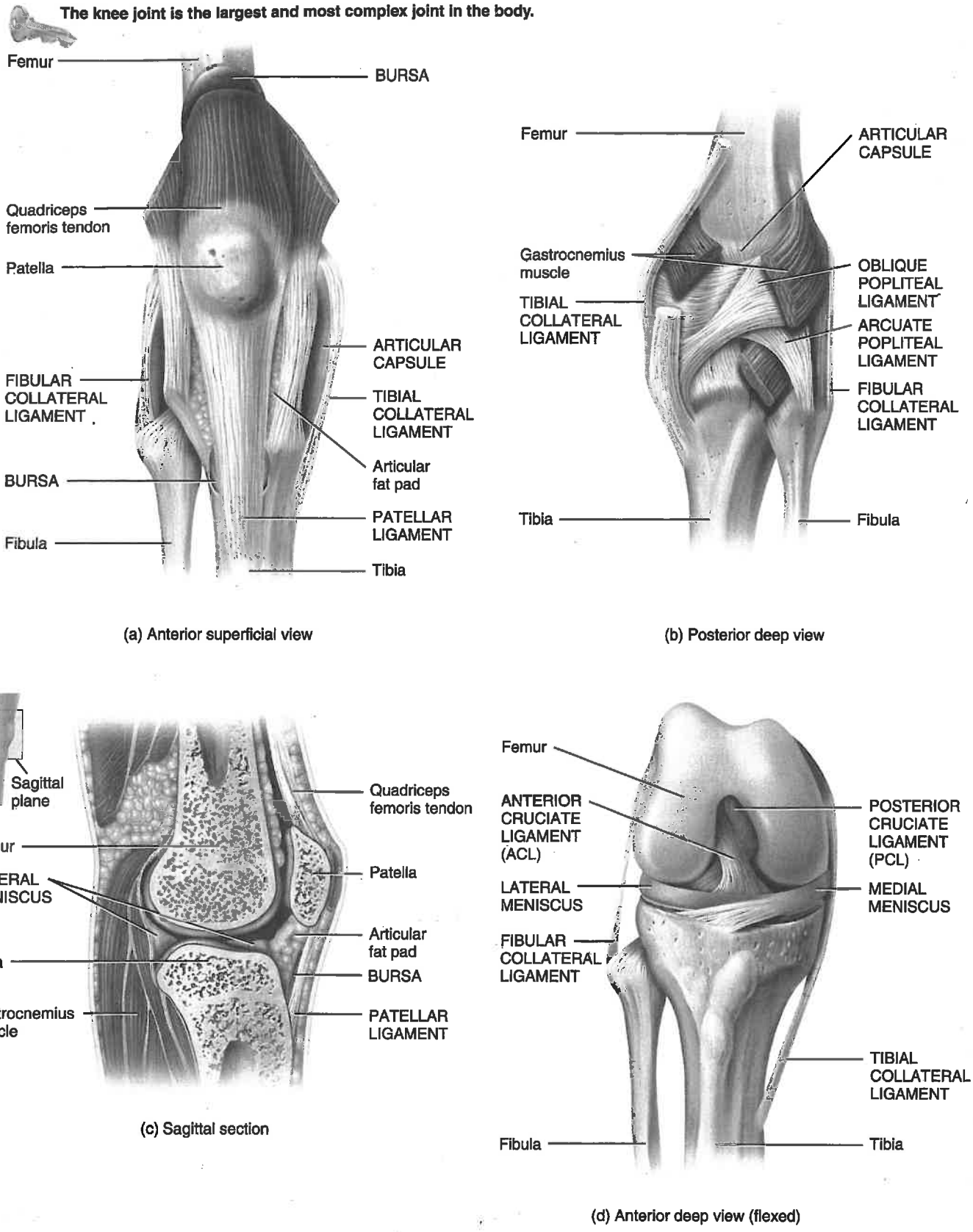
8. Which ligaments strengthen the posterior aspect of the knee joint?

AGING AND JOINTS

OBJECTIVE • Explain the effects of aging on joints.

Aging usually results in decreased production of synovial fluid in joints. In addition, the articular cartilage becomes thinner with age, and ligaments shorten and lose some of their flexibility. The effects of aging on joints are influenced by genetic factors and by wear and tear, and vary considerably from one person to another. Although degenerative changes in joints may begin as early as age 20, most changes do not occur until much later. By age 80, almost everyone de-

Figure 7.10 Structure of the right knee joint.



What structures are damaged in the knee injury called torn cartilage?

Focus on Wellness

Joint Care—Prevent Repetitive Motion Injury

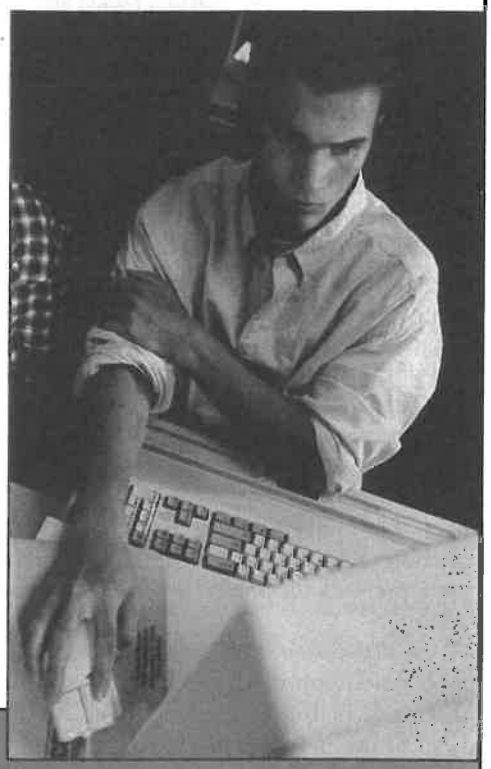
Diarthroses (freely movable joints) allow extensive movement. But the human body is not a machine, and diarthroses were not designed to withstand the repetition of a given motion over and over and over again, all day long. When you repeat the same motion for extended periods of time, you may overstress the joint or joints responsible for that motion and the associated soft-tissue structures, such as the articular capsule, ligaments, bursae, muscles, tendons, and nerves. Repeated episodes of mechanical stress can lead to the development of ***repetitive motion injuries***.

Repeat That?

Repetitive motion injuries are a type of ***cumulative trauma disorder (CTD)***, which is a group of disorders characterized by ongoing damage to soft tissues. Repetitive motion injuries are the most common type of CTD, but CTDs may also involve trauma due to exposure to cold or hot temperatures, certain types of lighting, vibration, and so forth. Repetitive motion injuries are similar in many ways to the ***overuse injuries*** that athletes often experience. Just as tennis players may develop epicondylitis (tennis elbow), so too may construction workers who perform repeated elbow flexion and extension in their work and students who spend hours a day using their computer mouse ("mouse elbow").

Repetitive motions alone may cause repetitive motion injuries. Risk increases when repetitive motions are coupled with poor posture and biomechanics, which put excess strain on joints. Joint stress also increases when a person must apply force with the motion, such as when gripping or lifting heavy objects. The joints at highest risk are those that are the weakest. Wrists, backs, elbows, shoulders, and necks are the most common sites of repetitive motion injury.

Repetitive motion injuries usually develop slowly over a long period of time. They typically begin with mild to moderate discomfort in the affected joints, especially at night. Other symptoms include swelling in the joint, muscle fatigue, numbness, and tingling. Symptoms may come and go at first, but then become constant. Symptoms of more advanced damage include more intense pain, muscle weakness, and nerve problems. If left untreated, repetitive motion injuries can be extremely painful. They also may severely limit a joint's range of motion. Fortunately, because they develop slowly, most repetitive motion injuries are discovered early enough to be successfully treated.



▶ Think It Over . . .

▶ *Carpal tunnel syndrome is a repetitive motion injury in which pressure develops on the median nerve as it passes through the carpal tunnel, a narrow tunnel of bone and ligament at the wrist. Pressure on this nerve causes numbness, tingling, and pain in some or all of the fingers. What kind of workers do you think might be most at risk for the development of carpal tunnel syndrome?*

velops some type of degeneration in the knees, elbows, hips, and shoulders. It is also common for elderly individuals to develop degenerative changes in the vertebral column, resulting in a hunched-over posture and pressure on nerve roots. One type of arthritis, called osteoarthritis, is at least partially age related. Nearly everyone over age 70 has evidence of some osteoarthritic changes. Stretching and aerobic exercises that attempt to maintain full range of motion are helpful in minimizing the effects of aging. They help to maintain the effective functioning of ligaments, tendons, muscles, synovial fluid, and articular cartilage.

■ **CHECKPOINT**

9. Which joints show evidence of degeneration in nearly all individuals as aging progresses?

• • •

Now that you have a basic understanding of bones and joints, we will examine the structure and functions of muscular tissue and muscles. In this way you will understand how bones, joints, and muscles work together to produce various movements.

COMMON DISORDERS

Common Joint Injuries

Rotator cuff injury is a strain or tear in the rotator cuff muscles (see Figure 8.19 on page 205) and is a common injury among baseball pitchers and volleyball players, racket sports players, swimmers, and violinists, due to shoulder movements that involve vigorous circumduction. It also occurs as a result of wear and tear, aging, trauma, poor posture, improper lifting, and repetitive motions in certain jobs, such as placing items on a shelf above your head. Most often, there is tearing of the supraspinatus muscle tendon of the rotator cuff. This tendon is especially predisposed to wear-and-tear because of its location between the head of the humerus and acromion of the scapula, which compresses the tendon during shoulder movements.

A ***separated shoulder*** is an injury of the acromioclavicular joint, the joint formed by the acromion of the scapula and the acromial end of the clavicle. It most often happens with forceful trauma, as may happen when the shoulder strikes the ground in a fall.

Tennis elbow most commonly refers to pain at or near the lateral epicondyle of the humerus, usually caused by an improperly executed backhand. The extensor muscles strain or sprain, resulting in pain. ***Little-league elbow*** typically develops because of a heavy pitching schedule or throwing many curve balls, especially in youngsters. In this injury, the elbow may enlarge, fragment, or separate.

A ***dislocation of the radial head*** is the most common upper limb dislocation in children. In this injury, the head of the radius slides past or ruptures the ligament that forms a collar around the head of the radius at the proximal radioulnar joint. Dislocation is most apt to occur when a strong pull is applied to the forearm while it is extended and supinated, for instance while swinging a child around with outstretched arms.

The knee joint is the joint most vulnerable to damage because it is a mobile, weight-bearing joint and its stability depends almost entirely on its associated ligaments and muscles. Further, there is no correspondence of the articulating bones. A ***swollen knee*** may occur immediately or hours after an injury. The initial swelling is due to escape of blood from damaged blood vessels adjacent to areas involving rupture of the anterior cruciate ligament, damage to synovial membranes, torn menisci, fractures, or collateral ligament sprains. Delayed swelling is due to excessive production of synovial fluid, a condition commonly referred to as "water on the knee." A common type of knee injury in football is ***rupture of the tibial collateral ligaments***, often associated with tearing of the anterior cruciate ligament and medial meniscus (torn cartilage). Usually, a hard blow to the lateral side of the knee while the foot is fixed on the ground causes the damage. A ***dislocated knee*** refers to the displacement of the tibia relative to the femur. The most common type is dislocation anteriorly, resulting from hyperextension of the knee. A frequent consequence of a dislocated knee is damage to the popliteal artery.

Rheumatism and Arthritis

Rheumatism (ROO-ma-tizm) is any painful disorder of the supporting structures of the body—bones, ligaments, tendons, or muscles—that is not caused by infection or injury. ***Arthritis*** is a form of rheumatism in which the joints are swollen, stiff, and painful. It afflicts about 45 million people in the United States, and is the leading cause of physical disability among adults over age 65.

Rheumatoid arthritis (RA) is an autoimmune disease in which the immune system of the body attacks its own tissues—in this case, its own cartilage and joint linings. The primary symptom of RA is inflammation of the synovial membrane. RA is characterized by inflammation of the joint, which causes redness, warmth, swelling, pain, and loss of function.

Osteoarthritis (os′-tē-ō-ar-THRĪ-tis) is a degenerative joint disease in which joint cartilage is gradually lost. It results from a combination of aging, irritation of the joints, muscle weakness, and wear and abrasion. Commonly known as "wear-and-tear" arthritis, osteoarthritis is the most common type of arthritis. A major distinction between osteoarthritis and rheumatoid arthritis is that osteoarthritis strikes the larger joints (knees, hips) first, and rheumatoid arthritis first strikes smaller joints such as those in the fingers. A relatively new treatment for osteoarthritis of some joints is called *viscosupplementation*, in which hyaluronic acid is injected into a joint to improve lubrication. Results are usually as good as those involving corticosteroids.

In ***gouty arthritis*** (GOW-tē), sodium urate crystals are deposited in the soft tissues of the joints. The crystals irritate and erode the cartilage, causing inflammation, swelling, and acute pain. If the disorder is not treated, the ends of the articulating bones fuse, and the joint becomes immovable.

Joints that have been severely damaged by diseases such as arthritis, or by injury, may be replaced surgically with artifical joints in a procedure referred to as ***arthroplasty*** (AR-thrō-plas′-tē; *arthr-* = joint; *-plasty* = plastic repair of). Although most joints in the body can undergo arthroplasty, the ones most commonly replaced are the hips, knees, and shoulders. During the procedure, the ends of the damaged bones are removed and the metal, ceramic, or plastic components are fixed in place. The goals of arthroplasty are to relieve pain and increase range of motion.

Sprain and Strain

A ***sprain*** is the forcible wrenching or twisting of a joint that stretches or tears its ligaments but does not dislocate the bones. It occurs when the ligaments are stressed beyond their normal capacity. Sprains also may damage surrounding blood vessels, muscles, tendons, or nerves. Severe sprains may be so painful that the joint cannot be moved. There is considerable swelling, which results from hemorrhage of ruptured blood vessels. The ankle joint is most often sprained; the lower back is another frequent location for sprains. A ***strain*** is a stretched or partially torn muscle. It often occurs when a muscle contracts suddenly and powerfully—for example, in sprinters when they accelerate quickly.

MEDICAL TERMINOLOGY AND CONDITIONS

Arthralgia (ar-THRAL-jē-a; *arthr-* = joint; *-algia* = pain) Pain in a joint.

Bursectomy (bur-SEK-tō-mē; *-ectomy* = to cut out) Removal of a bursa.

Chondritis (kon-DRĪ-tis; *chondro-* = cartilage) Inflammation of cartilage.

Dislocation (*dis-* = apart) or ***luxation*** (luks-A-shun; *lux-* = dislocation) The displacement of a bone from a joint with tearing of ligaments, tendons, and articular capsules. A partial or incomplete dislocation is called a ***subluxation***.

Synovitis (sin′-ō-VĪ-tis) Inflammation of a synovial membrane in a joint

STUDY OUTLINE

Joints (p. 157)

1. A joint (articulation) is a point of contact between two bones, cartilage and bone, or teeth and bone.
2. A joint's structure determines its combination of strength and flexibility.
3. Structural classification is based on the presence or absence of a synovial cavity and the type of connecting tissue. Structurally, joints are classified as fibrous, cartilaginous, or synovial.
4. Functional classification of joints is based on the degree of movement permitted. Joints may be synarthroses (immovable), amphiarthroses (slightly movable), or diarthroses (freely movable).

Fibrous Joints (p. 157)

1. There is no joint cavity and the bones are held together by fibrous connective tissue in fibrous joints.
2. These joints include immovable sutures (found between skull bones), slightly movable syndesmoses (such as the distal joint between the tibia and fibula), and immovable gomphoses (roots of teeth in alveoli of the mandible and maxilla).

Cartilaginous Joints (p. 158)

1. There is no joint cavity and the bones are held together by cartilage in cartilaginous joints.
2. These joints include immovable synchondroses united by hyaline cartilage (epiphyseal plates) and slightly movable symphyses united by fibrocartilage (pubic symphysis).

Synovial Joints (p. 158)

1. A synovial joint contains a synovial cavity. All synovial joints are diarthroses.
2. Other characteristics of a synovial joint are the presence of articular cartilage and an articular capsule, made up of a fibrous capsule and a synovial membrane.
3. The synovial membrane secretes synovial fluid, which forms a thin, viscous film over the surfaces within the articular capsule.
4. Many synovial joints also contain accessory ligaments and articular discs.
5. Bursae are saclike structures, similar in structure to joint capsules, that reduce friction in joints such as the shoulder and knee joints.

Types of Movements at Synovial Joints (p. 160)

1. In a gliding movement, the nearly flat surfaces of bones move back-and-forth and side-to-side.
2. In angular movements, there is a change in the angle between bones. Examples are flexion–extension, hyperextension, abduction–adduction, and circumduction.
3. In rotation, a bone moves around its own longitudinal axis.
4. Special movements occur at specific synovial joints in the body. Examples are as follows: elevation–depression, protraction–retraction, inversion–eversion, dorsiflexion–plantar flexion, and supination–pronation.

Types of Synovial Joints (p. 164)

1. Types of synovial joints are planar, hinge, pivot, condyloid, saddle, and ball-and-socket.
2. In a planar joint, the articulating surfaces are flat; examples are joints between carpals and tarsals.
3. In a hinge joint, the convex surface of one bone fits into the concave surface of another; examples are the elbow, knee, and ankle joints.
4. In a pivot joint, a round or pointed surface of one bone fits into a ring formed by another bone and a ligament; examples are the atlantoaxial and radioulnar joints.
5. In a condyloid joint, an oval-shaped projection of one bone fits into an oval cavity of another; examples are the wrist joint and metacarpophalangeal joints for the second through fifth digits.
6. In a saddle joint, the articular surface of one bone is shaped like a saddle, and the other bone fits into the "saddle" like a rider on a horse; an example is the carpometacarpal joint between the trapezium and the metacarpal of the thumb.
7. In a ball-and-socket joint, the ball-shaped surface of one bone fits into the cuplike depression of another; examples are the shoulder and hip joints.

Details of a Synovial Joint: The Knee Joint (p. 165)

1. The knee joint is a diarthrosis that illustrates the complexity of this type of joint.
2. It contains an articular capsule, several ligaments within and around the outside of the joint, menisci, and bursae.

Aging and Joints (p. 165)

1. With aging, a decrease in synovial fluid, thinning of articular cartilage, and decreased flexibility of ligaments occur.
2. Most individuals experience some degeneration in the knees, elbows, hips, and shoulders due to the aging process.

SELF-QUIZ

1. A joint that has a _____ fit offers a great amount of movement and is _____ likely to become dislocated.
   a. tight, less b. tight, more c. loose, less
   d. loose, more e. flexible, less

2. An example of a fibrous joint in which the bones are immovable is a
   a. suture b. syndesmosis c. synovial d. symphysis
   e. synchondrosis

3. Pulling out a tooth would disarticulate which type of joint?
   a. symphysis b. synovial c. gomphosis
   d. cartilaginous e. suture

4. Which of the following is NOT a function of synovial fluid?
   a. It acts as a lubricant.
   b. It helps strengthen the joint.
   c. It removes microbes and debris from the joint.
   d. It provides nutrients to the tissues around the joints.
   e. It removes metabolic wastes.

5. Articular cartilage and bursae would most likely be found in which of the following?
   a. a gomphosis b. a suture c. the pubic symphysis
   d. the knee e. a synchondrosis

6. Which of the following structures provides flexibility to a joint while also preventing dislocation?
   a. bursae b. articular cartilage c. synovial fluid
   d. muscles e. articular capsule

7. The joints between the vertebrae and the joint between the hip bones are examples of which joint type?
   a. synovial b. symphysis c. fibrous
   d. synchondrosis e. suture

8. Match the following:

   ____ a. the joint between the atlas and axis
   ____ b. allows gliding movements
   ____ c. the joint between the carpal and metacarpal of the thumb
   ____ d. hip joint
   ____ e. knee joint

   A. planar joint
   B. hinge joint
   C. ball-and-socket joint
   D. pivot joint
   E. saddle joint

9. Which of the following diarthrotic joints allows for the greatest degree of movement?
   a. ball-and-socket b. hinge c. condyloid
   d. pivot e. saddle

10. Moving the femur forward when walking is an example of
    a. abduction b. circumduction c. flexion
    d. gliding e. inversion

11. When a gymnast performs the "splits," the primary movement at the hip joint is
    a. rotation b. adduction c. extension d. gliding
    e. abduction

12. In the anatomical position, the palms are
    a. supinated b. flexed c. inverted d. pronated
    e. protracted

13. A fluid-filled sac found between skin and bone that helps reduce friction between the skin and bone is a
    a. meniscus b. bursa c. ligament
    d. articular capsule e. synovial membrane

14. Nodding your head "yes" in response to a question involves
    a. abduction and adduction b. circumduction
    c. extension and hyperextension d. rotation
    e. flexion and extension

15. Match the following:

    ____ a. movement of a bone around its own axis
    ____ b. movement away from the midline of the body
    ____ c. turning the palm so it faces forward
    ____ d. downward movement of a body part
    ____ e. movement toward the midline of the body
    ____ f. movement of the mandible or shoulder backward
    ____ g. turning the palm so it faces backward
    ____ h. upward movement of a body part
    ____ i. movement of the distal end of a body part in a circle
    ____ j. movement beyond the plane of extension

    A. rotation
    B. supination
    C. depression
    D. adduction
    E. retraction
    F. pronation
    G. abduction
    H. hyperextension
    I. circumduction
    J. elevation

CRITICAL THINKING APPLICATIONS

1. After your second A & P exam, you dropped to one knee, tipped your head back, raised one arm over your head, clenched your fist, pumped your arm up and down, and yelled "Yes!" Use the proper terms to describe the movements undertaken by the various joints.
2. Aunt Rosa's hip has been bothering her for years, and now she can hardly walk. Her doctor suggested a hip replacement. "It's one of those synonymous joints," Aunt Rosa explained. What type of joint is the hip joint? What types of movements can it perform?
3. Remember Kate, the volleyball player from Chapter 6? Her cast finally came off today. The orthopedist tested her knee's range of motion and declared that the ACL appeared to be intact. What is the ACL? How does the ACL contribute to the knee joint's stability?
4. Drew got slammed by a wave while bodysurfing. Now his arm feels useless, he's got an odd bump on his shoulder, and his shoulder really hurts! What happened to Drew's shoulder?

ANSWERS TO FIGURE QUESTIONS

7.1 Sutures are synarthroses because they are immovable; syndesmoses are classified as amphiarthroses because they are slightly movable.

7.2 Hyaline cartilage holds a synchondrosis together, and fibrocartilage holds a symphysis together.

7.3 Synovial joints are diarthroses, freely movable joints.

7.4 The arrangement of ligaments and bones prevents hyperextension at some synovial joints.

7.5 When you adduct your arm or leg, you bring it closer to the midline of the body, thus "adding" it to the trunk.

7.6 Circumduction can occur at the shoulder joint and at the hip joint.

7.7 The anterior surface of a bone or limb rotates toward the midline in medial rotation, and away from the midline in lateral rotation.

7.8 Bringing the arms forward until the elbows touch is an example of protraction.

7.9 Ball-and-socket joints permit the greatest range of movement.

7.10 In torn cartilage injuries of the knee, the menisci are damaged.