Bone gain outstrips bone loss, and bones grow larger. But between the ages of 35 and 40 years, the process reverses, and from that time on, bone loss exceeds bone gain. Bone gain occurs slowly at the outer, or periosteal, surfaces of bones. Bone loss, on the other hand, occurs at the inner, or endosteal, surfaces and occurs at a somewhat faster pace. More bone is lost on the inside than gained on the outside, and inevitably bones become remodeled as the years go by.

Remodeling in compact bone involves the formation of new Haversian systems (osteons). The process begins when osteoclasts in the covering periosteum are activated and erode the outer surface of the bone, forming grooves. Periosteal blood vessels lie in these grooves, which are eventually surrounded by new bone formed as a result of osteoblast activity. As the grooves are transformed into tunnels, additional layers of bone are deposited by osteoblasts in the lining endosteum. With the passage of time, new lamellae are added and osteon formation occurs (Figure 7-12).

Box 7-2 SPORTS AND FITNESS

Exercise and Bone Density

Walking, jogging, and other forms of exercise subject bones to stress. They respond by laying down more collagen fibers and mineral salts in the bone matrix. This, in turn, makes bones stronger. But inactivity and lack of exercise tend to weaken bones because of decreased collagen formation and excessive calcium withdrawal. To prevent these changes, as well as many others, astronauts regularly perform special exercises in space because of the lack of gravity. Regular weight-bearing exercise is also an important part of the prevention and treatment of osteoporosis.

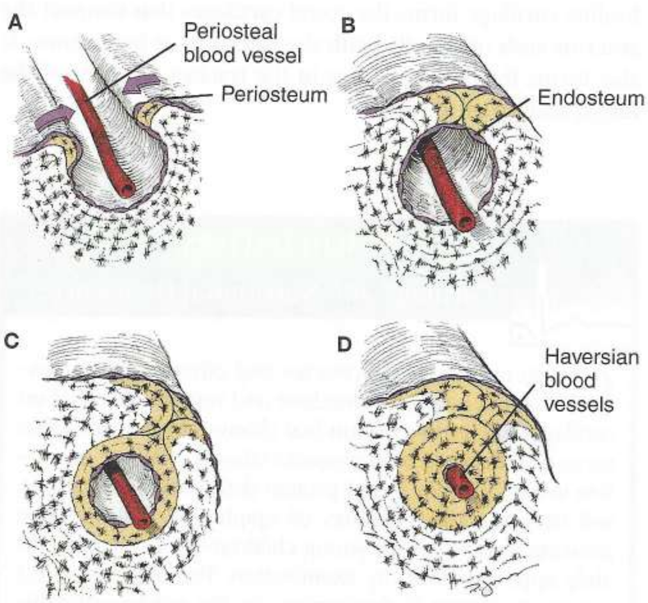


Figure 7-12 New osteon formation. **A,** Erosion of bone surface produces grooves that contain periosteal blood vessels. **B,** New bone is added to the groove edges, forming a tunnel. **C,** The periosteum of the former groove now becomes the endosteum of the tunnel. **D,** Bone deposition fills the tunnel, forming a new osteon.

REPAIR OF BONE FRACTURES

The term *fracture* is defined as a break in the continuity of a bone. Types of bone fractures are discussed in Chapter 8, pp. 248-249. *Fracture healing* is considered the prototype of bone repair. The complex bone tissue repair process that follows a fracture is apparently initiated by bone death or by damage to periosteal and Haversian system blood vessels.

A bone fracture invariably tears and destroys blood vessels that carry nutrients to osteocytes. It is this vascular damage that initiates the repair sequence. Eventually, dead bone is either removed by osteoclastic resorption or serves as a scaffolding or framework for the deposition of a specialized repair tissue called *callus.*

The process of fracture healing is shown in Figure 7-13, *A* to *D.* Vascular damage occurring immediately after a frac-

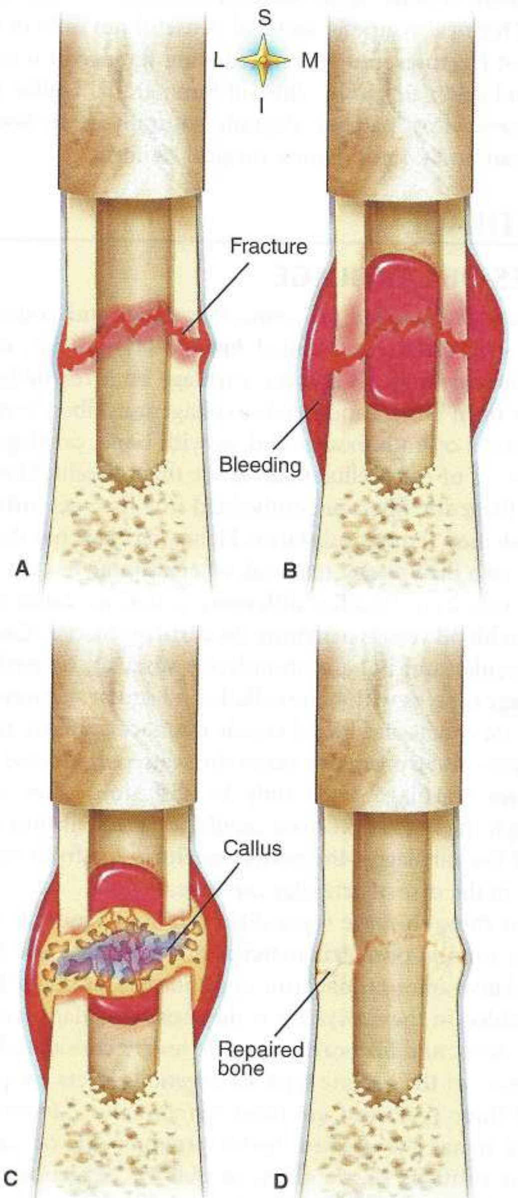


Figure 7-13 Bone fracture and repair. **A,** Fracture of femur. **B,** Formation of fracture hematoma. **C,** Formation of internal and external callus. **D,** Bone remodeling complete.

ture results in hemorrhage and the pooling of blood at the point of injury. The resulting blood clot is called a *fracture hematoma* (Figure 7-13, *B*). As the hematoma is resorbed, the formation of specialized callus tissue occurs. It serves to bind the broken ends of the fracture on both the outside surface and along the marrow cavity internally. The rapidly growing callus tissue effectively "collars" the broken ends and stabilizes the fracture so that healing can proceed (Figure 7-13, *C*). If the fracture is properly aligned and immobilized and if complications do not develop, callus tissue will be actively "modeled" and eventually replaced with normal bone as the injury heals completely (Figure 7-13, *D*).

A new synthetic skeletal repair material called *vitos* is now available to facilitate fracture repair. It consists of a calcium spongelike matrix material riddled with microscopic holes. Vitos assists callus tissue in stabilizing the fracture site and in movement of bone repair cells and nutrients into the injured area. This new synthetic material is useful not only in treatment of fractures, but also in reducing the need for expensive and often surgically difficult bone grafts. Unlike metal stabilizers, vitos "patches" degrade naturally in the body after repair and do not require surgical removal.

CARTILAGE

TYPES OF CARTILAGE

Cartilage is classified as connective tissue and consists of three specialized types called ***hyaline*** (HI-ah-lin), ***elastic,*** and ***fibrocartilage.*** As a tissue, cartilage both resembles and differs from bone. Innumerable collagenous fibers reinforce the matrix of both tissues, and, as with bone, cartilage consists more of extracellular substance than of cells. However, in cartilage the fibers are embedded in a firm gel instead of in a calcified cement substance. Hence cartilage has the flexibility of a firm plastic material, whereas bone has the rigidity of cast iron. Another difference is that no canal system and no blood vessels penetrate the cartilage matrix. Cartilage is avascular and bone is abundantly vascular. Nevertheless, cartilage cells, as with bone cells, lie in lacunae. However, because no canals and blood vessels interlace cartilage matrix, nutrients and oxygen can reach the scattered, isolated ***chondrocytes*** (cartilage cells) only by diffusion. They diffuse through the matrix gel from capillaries in the fibrous covering of the cartilage—the **perichondrium**—or from synovial fluid, in the case of articular cartilage.

The three cartilage types differ from one another largely by the amount of matrix material that is present and also by the relative amounts of elastic and collagenous fibers that are embedded in them. *Hyaline* is the most abundant type, and both elastic and fibrocartilage varieties are considered modifications of the hyaline type. Collagenous fibers are present in all three types but are most numerous in *fibrocartilage.* Hence it has the greatest tensile strength. *Elastic* cartilage matrix contains elastic fibers, as well as collagenous fibers, and so has elasticity, as well as firmness.

Cartilage is an excellent skeletal support tissue in the developing embryo. It forms rapidly and yet retains a significant degree of rigidity, or stiffness. A majority of the bones that eventually form the axial and the appendicular skeleton described in Chapter 8 first appear as cartilage models. Skeletal maturation involves replacement of the cartilage models with bone.

After birth there is a decrease in the total amount of cartilage tissue present in the body. However, it continues to play an important role in the growth of long bones until skeletal maturity and is found throughout life as the material that covers the articular surfaces of bones in joints. The three types of cartilage also serve numerous specialized functions throughout the body.

Hyaline Cartilage

Hyaline, in addition to being the most common type of cartilage, serves many specialized functions. It resembles milk glass in appearance (Figure 7-14, *A*). In fact, its name is derived from the Greek word meaning "glassy." Sometimes called *gristle,* it is semitransparent and has a bluish, opalescent cast.

In the embryo hyaline cartilage forms from differentiation of specialized mesenchymal cells that become crowded together in so-called **centers of chondrification.** As the cells enlarge, they secrete matrix material that surrounds the delicate collagen fibrils. Eventually, the continued production of matrix separates and isolates the cells, or ***chondrocytes,*** into compartments, which, as in bone, are called *lacunae.* Like bone, the organic matrix of hyaline cartilage is a mixture of ground substance and collagenous fibers. The ground substance is rich in both chondroitin sulfate and a unique gel-like polysaccharide. Both substances are secreted from chondrocytes in much the same way protein and carbohydrates are secreted from glandular cells.

In addition to covering the articular surfaces of bones, hyaline cartilage forms the costal cartilages that connect the anterior ends of the ribs with the sternum, or breastbone. It also forms the cartilage rings in the trachea, bronchi of the lungs, and tip of the nose.

Box 7-3 HEALTH MATTERS

Cartilage and Nutritional Deficiencies

Certain nutritional deficiencies and other metabolic disturbances have an immediate and very visible effect on cartilage. It is for this reason that changes in cartilage often serve as indicators of inadequate vitamin, mineral, or protein intake. Vitamin A and protein deficiency, for example, will decrease the thickness of epiphyseal plates in the growing long bones of young children–an effect immediately apparent on x-ray examination. The opposite effect occurs in vitamin D deficiencies. As the epiphyseal cartilages increase in thickness but fail to calcify, the growing bones become deformed and bend under weight-bearing. The bent long bones are a sign of **rickets.**

Metabolic Bone Diseases

Metabolic bone diseases are disorders of bone remodeling.

Osteoporosis is one of the most common and serious of all bone diseases. It is characterized by excessive loss of calcified matrix, bone mineral, and collagenous fibers that cause a reduction in total bone mass (see p. 191).

Because estrogen and testosterone serve important roles in stimulating osteoblast activity after puberty, decreasing levels of these hormones in the elderly reduce new bone growth and maintenance of existing bone mass. In women decreasing estrogen levels associated with menopause cause accelerated bone resorption. Inadequate intake of calcium or vitamin D, necessary for normal bone mineralization, during a period of years, can also result in decreased bone mass and the development of osteoporosis.

In osteoporosis bones become porous, brittle, and fragile, fracturing easily under stress. As a result, they are often characterized by pathological changes in the mass or chemical composition of skeletal tissue. The result is a dangerous pathological condition resulting in increased susceptibility to "spontaneous fractures" and pathological curvature of the spine. Osteoporosis occurs most frequently in elderly white women. Although requiring specialized equipment, the dual energy x-ray absorptiometry scan (DXA) remains the "method of choice" to measure bone mineral density in the spine and hip. Bone density is expressed in grams per square centimeter and results are available in minutes. Advances in radiographic absorptiometry (RA) are now making this more economical test the choice for determining bone density at the wrist. It is used to determine bone mineral density in growing numbers of osteoporosis patients and in screening programs intended to detect the disease in "at risk" individuals.

Osteomalacia is a metabolic bone disease characterized by inadequate mineralization of bone. A large amount of osteoid (organic bone matrix) does not calcify in patients with this disease. Risk factors for development of osteomalacia include malabsorption problems, vitamin D and calcium deficiencies, chronic renal failure, and inadequate exposure to sunlight. Symptoms, though subtle, may include muscle weakness, fractures, generalized bone pain and tenderness in the extremities, and lower back pain. Treatment includes dietary supplements of vitamin D and calcium. In addition, exposure to sunlight may be instituted to promote vitamin D synthesis in the body.

Paget's disease, also known as *osteitis deformans,* is a disorder affecting older adults. It is characterized by proliferation of osteoclasts and compensatory increased osteoblastic activity. The result is rapid and disorganized bone remodeling. The bones formed are poorly constructed and weakened. It commonly affects the skull, femur, vertebra, and pelvic bones. Clinical manifestations may include bone pain, tenderness, and fractures. However, the majority of patients experience minimal changes and never know they have the disease. No treatment is recommended in the asymptomatic patient.

Osteomyelitis is a bacterial infection of the bone and marrow tissue. Infections of the bone are often more difficult to treat than are soft-tissue infections because of the decreased blood supply and density of the bone. Bacteria, viruses, fungi, and other pathogens may cause osteomyelitis. *Staphylococcus* bacteria are the most common pathogens. Osteomyelitis is associated with extension of another infection (e.g., bacteremia, urinary tract infection, vascular ulcer) or direct bone contamination (e.g., gunshot wound, open fracture). Patients who are elderly, poorly nourished, or diabetic are also at risk. Thrombosis of blood vessels in osteomyelitis often results in ischemia and bone necrosis. As a result, infection can extend under the periosteum and spread to adjacent soft tissues and joints. Signs and symptoms may include an area swollen, warm, tender to touch, and painful. Early recognition of infection and antimicrobial management are required. Sometimes patients may require 6 weeks of antibiotics.

CASE STUDY

Johnny, age 5, was riding his tricycle when he fell and injured one of his long bones. He was taken to the emergency room where an x-ray revealed a fracture through the epiphyseal plate.

1. Which one of the following bones did Johnny most likely fracture?
   - A. Wrist (carpals)
   - B. Tibia
   - C. Clavicle
   - D. Pelvis

2. Why is there a greater significance in this type of fracture in a child Johnny's age compared with an adult?
   - A. Because in the child there is little cartilage located at the epiphyseal plate.
   - B. Because once older than age 12 years there is no need for the epiphyseal plate to adequately control bone growth.
   - C. Because the epiphyseal plate allows the diaphysis of a long bone to increase in length.
   - D. Because the epiphyseal plate controls the zone of hypertrophy and thus bone regeneration in the child.

CHAPTER SUMMARY

TYPES OF BONES

A. Structurally, there are four types of bones (Figure 7-1)
  1. Long bones
  2. Short bones
  3. Flat bones
  4. Irregular bones

B. Bones serve various needs, and their size, shape, and appearance will vary to meet those needs

C. Bones vary in proportion of compact and cancellous (spongy) bone; compact bone is dense and solid in appearance, whereas cancellous bone is characterized by open space partially filled with needle-like structures

D. Parts of a long bone (Figure 7-2)
  1. Diaphysis
     a. Main shaft of long bone
     b. Hollow, cylindrical shape and thick compact bone
     c. Function is to provide strong support without cumbersome weight
  2. Epiphyses
     a. Both ends of a long bone, made of cancellous bone filled with marrow
     b. Bulbous shape
     c. Function is to provide attachments for muscles and give stability to joints
  3. Articular cartilage
     a. Layer of hyaline cartilage that covers the articular surface of epiphyses
     b. Function is to cushion jolts and blows
  4. Periosteum
     a. Dense, white fibrous membrane that covers bone
     b. Attaches tendons firmly to bones
     c. Contains cells that form and destroy bone
     d. Contains blood vessels important in growth and repair
     e. Contains blood vessels that send branches into bone
     f. Essential for bone cell survival and bone formation
  5. Medullary (or marrow) cavity
     a. Tubelike, hollow space in diaphysis
     b. Filled with yellow marrow in adult
  6. Endosteum—thin epithelial membrane that lines medullary cavity

E. Short, flat, and irregular bones
  1. Inner portion is cancellous bone covered on the outside with compact bone
  2. Spaces inside cancellous bone of a few irregular and flat bones are filled with red marrow

BONE TISSUE

A. Most distinctive form of connective tissue

B. Extracellular components are hard and calcified

C. Rigidity of bone allows it to serve its supportive and protective functions

D. Tensile strength nearly equal to cast iron at less than one third the weight

E. Composition of bone matrix
  1. Inorganic salts
     a. Hydroxyapatite—highly specialized chemical crystals of calcium and phosphate contribute to bone hardness
     b. Slender needle-like crystals are oriented to most effectively resist stress and mechanical deformation
     c. Magnesium and sodium are also found in bone
  2. Measuring bone mineral density
  3. Organic matrix
     a. Composite of collagenous fibers and an amorphous mixture of protein and polysaccharides called *ground substance*
     b. Ground substance is secreted by connective tissue cells
     c. Adds to overall strength of bone and gives some degree of resilience to the bone

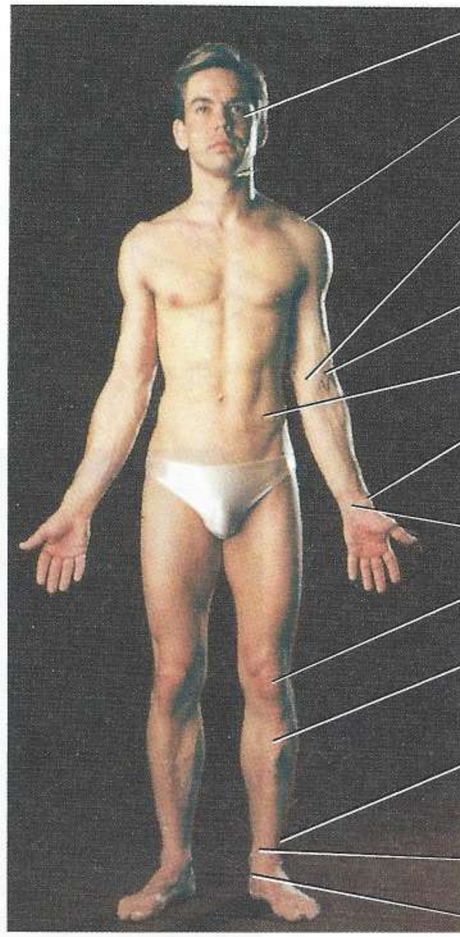
Box 8-4 FYI

Palpable Bony Landmarks

Health professionals often identify externally palpable bony landmarks when dealing with the sick and injured. **Palpable** bony landmarks are bones that can be touched and identified through the skin. They serve as reference points in identifying other body structures.

There are externally palpable bony landmarks throughout the body. Many skull bones, such as the zygomatic bone, can be palpated. The medial and lateral epicondyles of the humerus, the olecranon process of the ulna, and the styloid process of the ulna and the radius at the wrist can be palpated on the upper extremity. The highest corner of the shoulder is the acromion process of the scapula.

When you put your hands on your hips, you can feel the superior edge of the ilium, called the *iliac crest.* The anterior end of the crest, called the *anterior superior iliac spine,* is a prominent landmark used often as a clinical reference. The sacral promontory is a prominent anteriorly projecting ridge or border on the superior aspect of the sacrum. It often serves as a palpable reference point when measuring the pelvis during obstetrical examinations. The medial malleolus of the tibia and the lateral malleolus of the fibula are prominent at the ankle. The calcaneus or heel bone is easily palpated on the posterior aspect of the foot. On the anterior aspect of the lower extremity, examples of palpable bony landmarks include the patella, or kneecap; the anterior border of the tibia, or shin bone; and the metatarsals and phalanges of the toes. Try to identify as many of the externally palpable bones of the skeleton as possible on your own body. Using these as points of reference will make it easier for you to visualize the placement of other bones that cannot be touched or palpated through the skin.



LOWER EXTREMITY

Bones of the hip, thigh, lower leg, ankle, and foot constitute the lower extremity (Table 8-8). Strong ligaments bind each **coxal bone** (*os coxae,* or *innominate bone*) to the sacrum posteriorly and to each other anteriorly to form the ***pelvic girdle*** (Figures 8-21 and 8-26), a stable, circular base that supports the trunk and attaches the lower extremities to it. In early life, each coxal bone is made up of three separate bones. Later, they fuse into a single, massive irregular bone that is broader than any other bone in the body. The largest and uppermost of the three bones is the **ilium;** the strongest and lowermost, the **ischium;** and the anteriorly placed **pubis.** Numerous markings are present on the three bones (see Table 8-8 and Figures 8-21 and 8-22).

The pelvis can be divided into two parts by an imaginary plane, called the *pelvic inlet.* The edge of this plane, outlined in Figure 8-21, is called the *pelvic brim,* or *brim of the true pelvis.* The structure above the pelvic inlet, termed the **false pelvis,** is bordered by muscle in the front and bone along the sides and back. The structure below the pelvic inlet, the so-called *true pelvis,* creates the boundary of another imaginary plane, called the *pelvic outlet.* It is through the pelvic outlet that the digestive tract empties. The female reproductive tract also passes through the pelvic outlet; this is a fact of great importance in childbirth. The *pelvic outlet* is just large enough for the passage of a baby during delivery; however, careful positioning of the baby's head is required. Measurements such as those shown in Figure 8-21 are routinely made by obstetricians to ensure successful delivery. Despite its apparent rigidity, the joint between the pubic portions of each coxal bone, the *symphysis pubis,* softens prior to delivery. This allows the pelvic outlet to expand to accommodate the newborn's head as it passes out of the birth canal. The tiny coccyx bone, which protrudes into the pelvic outlet, sometimes breaks when the force of labor contractions pushes the newborn's head against it.

The two thigh bones, or **femurs,** have the distinction of being the longest and heaviest bones in the body. Several prominent markings characterize them. For example, three projections are conspicuous at each epiphysis: the head and

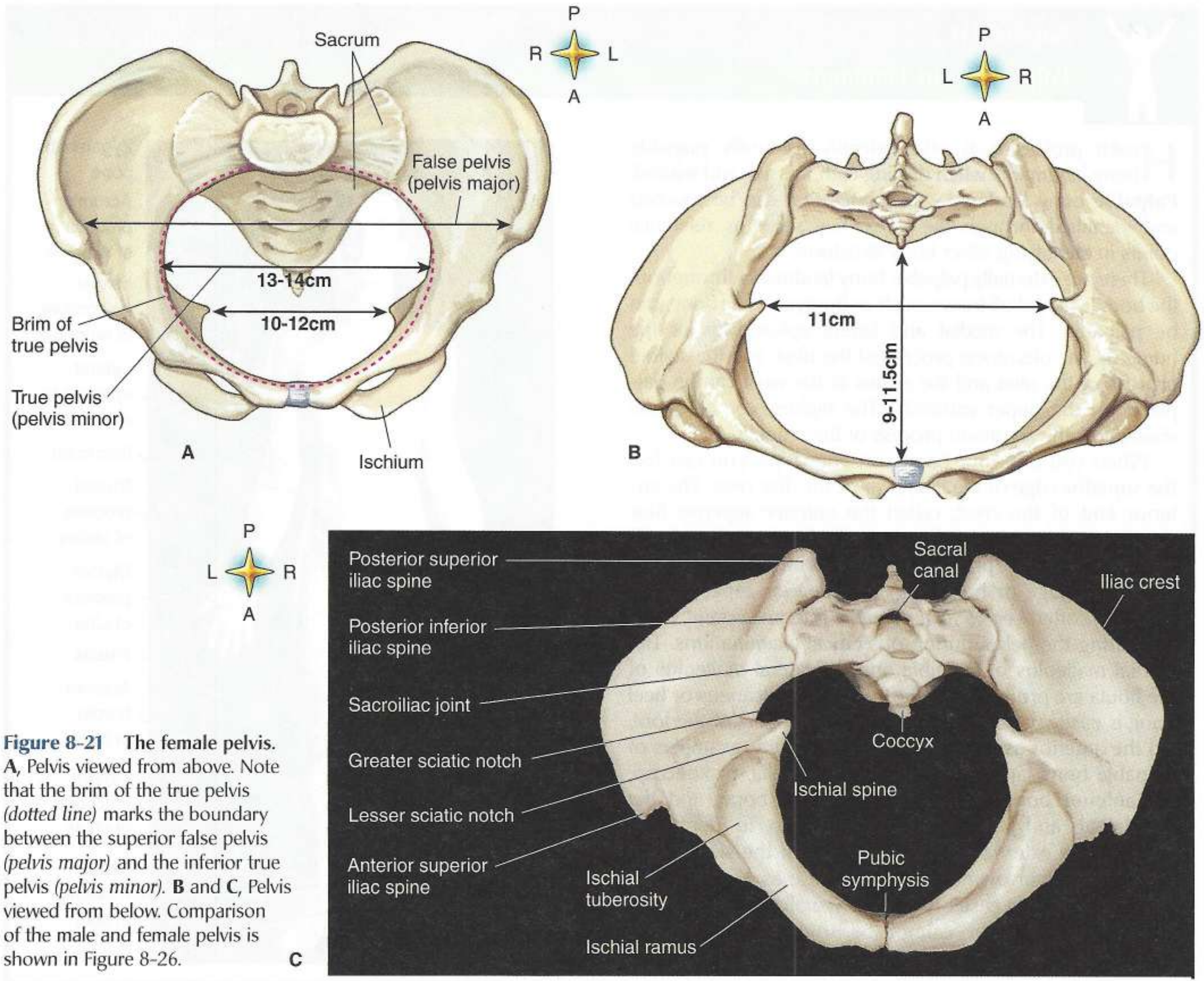


Figure 8-21 The female pelvis. **A**, Pelvis viewed from above. Note that the brim of the true pelvis *(dotted line)* marks the boundary between the superior false pelvis *(pelvis major)* and the inferior true pelvis *(pelvis minor)*. **B** and **C**, Pelvis viewed from below. Comparison of the male and female pelvis is shown in Figure 8-26.

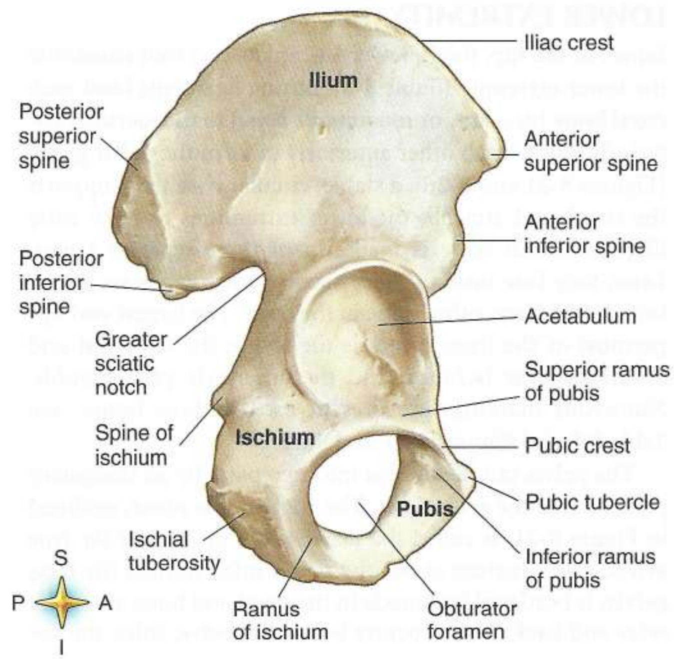


Figure 8-22 Right coxal bone. The right coxal bone is disarticulated from the skeleton and viewed from the side with the bone turned so as to look directly into the acetabulum.

quently in tendons near the distal end (head) of the first metatarsal bone of the big toe (Figure 8-24, *C*).

SKELETAL DIFFERENCES IN MEN AND WOMEN

General and specific differences exist between male and female skeletons. The general difference is one of size and weight, the male skeleton being larger and heavier. The specific differences concern the shape of the pelvic bones and cavity. Whereas the male pelvis is deep and funnel shaped with a narrow subpubic angle (usually less than 90 degrees), the female pelvis, as Figure 8-26 shows, is shallow, broad,

Box 8-5 SPORTS AND FITNESS

Chondromalacia Patellae

Chondromalacia patellae is a degenerative process that results in a softening (degeneration) of the articular surface of the patella. The symptoms associated with chondromalacia of the patella are a common cause of knee pain in many individuals–especially young athletes. The condition is usually caused by an irritation of the patellar groove, with subsequent changes in the cartilage on the underside of the patella. The most common complaint is of pain arising from behind or beneath the kneecap, especially during activities that require flexion of the knee, such as climbing stairs, kneeling, jumping, or running.

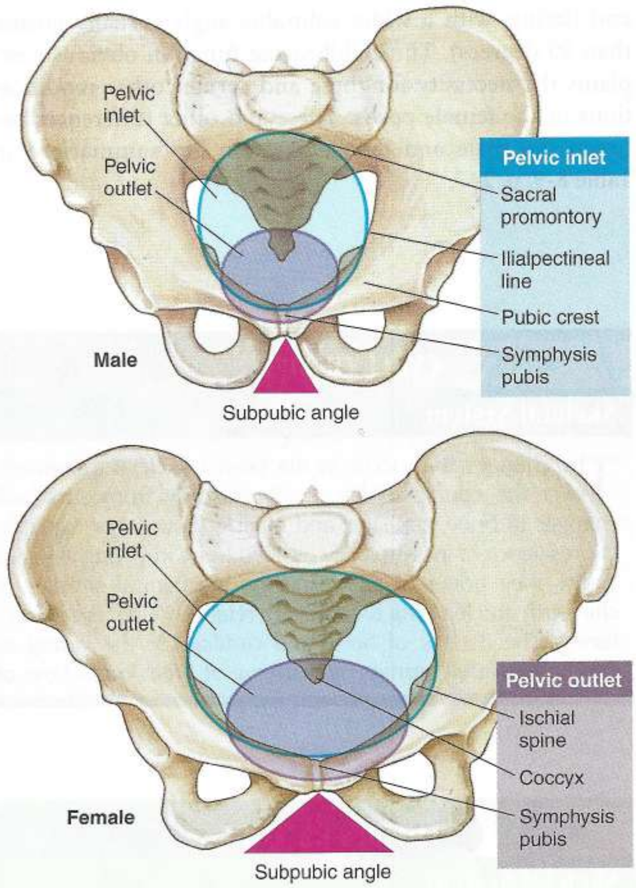


Figure 8-26 Comparison of male and female bony pelvis.

Table 8-9 Comparison of Male and Female Skeletons

Portion of Skeleton	Male	Female
General Form	Bones heavier and thicker	Bones lighter and thinner
	Muscle attachment sites more massive	Muscle attachment sites less distinct
	Joint surfaces relatively large	Joint surfaces relatively small
Skull	Forehead shorter vertically	Forehead more elongated vertically
	Mandible and maxillae relatively larger	Mandible and maxillae relatively smaller
	Facial area more pronounced	Facial area rounder, with less pronounced features
	Processes more prominent	Processes less pronounced
Pelvis		
Pelvic cavity	Narrower in all dimensions	Wider in all dimensions
	Deeper	Shorter and roomier
	Pelvic outlet relatively small	Pelvic outlet relatively large
Sacrum	Long, narrow, with smooth concavity (sacral curvature); sacral promontory more pronounced	Short, wide, flat concavity more pronounced in a posterior direction; sacral promontory less pronounced
Coccyx	Less movable	More movable and follows posterior direction of sacral curvature
Pubic arch	Less than a 90-degree angle	Greater than a 90-degree angle
Symphysis pubis	Relatively deep	Relatively shallow
Ischial spine, ischial tuberosity, and anterior superior iliac spine	Turned more inward	Turned more outward and further apart
Greater sciatic notch	Narrow	Wide

and flaring, with a wider subpubic angle (usually greater than 90 degrees). The childbearing function obviously explains the necessity for these and certain other modifications of the female pelvis. These and other differences between the male and female skeleton are summarized in Table 8-9, p. 247.

Quick Check

1. Which three bones fuse during skeletal development to form the coxal (hip) bone?
2. List the bones of the lower extremity, indicating their positions in the skeleton.
3. What is the functional advantage of foot arches?
4. Name two differences between typical male and female skeletons.

CYCLE OF LIFE

Skeletal System

The changes that occur in the body's skeletal framework over the course of life result primarily from structural changes in bone, cartilage, and muscle tissues. For example, the resilience of incompletely ossified bone in young children allows their bones to withstand the mechanical stresses of childbirth and learning to walk with relatively little risk of fracturing. The density of bone and cartilage in the young to middle-age adult permits the carrying of great loads. Loss of bone density in later adulthood can make a person so prone to fractures that simply walking or lifting with moderate force can cause bones to crack or break. The loss of skeletal tissue density may result in a compression of weight-bearing bones that causes a loss of height and perhaps an inability to maintain a standard posture. Degeneration of skeletal muscle tissue in late adulthood also may contribute to postural changes and loss of height.

THE BIG PICTURE

Skeletal System

The skeletal system is a good example of increasing structural hierarchy or complexity in the body.

Recall from Chapter 1 that "levels of organization" characterize body structure so that all of our anatomical components logically fit together and function effectively (see Figure 1-2 on p. 6). In studying skeletal tissues in Chapter 7, we proceeded from the chemical level of organization (inorganic salts and organic matrix) to a discussion of the specialized skeletal and cartilaginous cells and tissues.

In this chapter, we have grouped skeletal tissues into discrete organs (bones) and then joined groups of individual bones together with varying numbers and kinds of other structures, such as blood vessels and nerves, to form a complex operational unit–the skeletal system. The "Big Picture" becomes more apparent when we integrate the skeletal system with other organ systems, which ultimately allow us to respond in a positive way to disruptions in homeostasis. The skeletal system, for example, plays a key role in purposeful movement, which, in turn, allows us to move away from potentially harmful stimuli. This organ system is much more than an assemblage of individual bones–it is a complex and interdependent functional unit essential for life.

MECHANISMS OF DISEASE

Fractures and Abnormal Spinal Curvatures

Bone Fractures

A *bone fracture* is defined as a partial or complete break in the continuity of a bone that occurs under mechanical stress. The most common cause of a fracture is traumatic injury. Bone cancer or metabolic bone disorders can also cause fractures by weakening a bone to the point that it fractures under very little stress. An *open fracture,* also known as a *compound fracture,* is one in which broken bone projects through surrounding tissue and skin, inviting possibility of infection (Figure 8-27, *A*). A *closed fracture,* also known as a *simple fracture,* does not produce a break in the skin and therefore does not pose an immediate danger of bone infection (Figure 8-27, *B*). As Figure 8-27, *C,* shows, fractures also are classified as "complete" or "incomplete." A *complete fracture* involves a break across the entire section of bone, whereas an *incomplete fracture* involves only a partial break, in which bone fragments are still partially joined.

Fractures are also described anatomically according to the bone involved (e.g., femur) and the region of bone in which the fracture occurs (e.g., distal). There are many different specific types of fractures. For example, a *greenstick fracture* is one in which one side of the bone is bent and the other side is broken. This type of fracture commonly occurs in children because their growing bones are less brittle than in the adult. A *dentate* fracture results in fragmented ends of the bone being jagged and opposing each other, fitting together like teeth on a gear. A *hangman's* fracture is a fracture of the posterior elements of the second vertebral bone of the spine.

Sometimes the angle of the fracture line or crack is used in labeling fracture types (Figure 8-27, *D*). A *linear* fracture involves a fracture line parallel to the bone's long axis. A fracture line at a right angle to the bone's long axis is labeled a *transverse* fracture. *Oblique* fractures occur at slanted, or diagonal, angles to the longitudinal axis of bone.

Clinical signs and symptoms of a fracture are loss of function or false motion, pain, soft tissue edema, and deformity. These vary with the type and location of the fracture. Treatment usually involves *reduction* or realignment of the bone, immobilization, and restoring function through rehabilitation. Repair of bone tissue is discussed in Skeletal Tissues (Chapter 7).

Abnormal Spinal Curvatures

The normal curvature of the spine is convex through the thoracic region and concave through the cervical and lumbar regions (see Figure 8-13). This gives the spine strength to support the weight of the rest of the body and balance necessary to stand and walk. A curved structure has more strength than a straight one of the same size and material. Poor posture or disease may cause the lumbar curve to be abnormally accentuated—a condition known as "sway back," or *lordosis* (Figure 8-28, *A*). This condition is frequently seen during pregnancy as the woman adjusts to changes in her center of gravity. It may also be idiopathic, secondary to traumatic injury, or a degenerative process

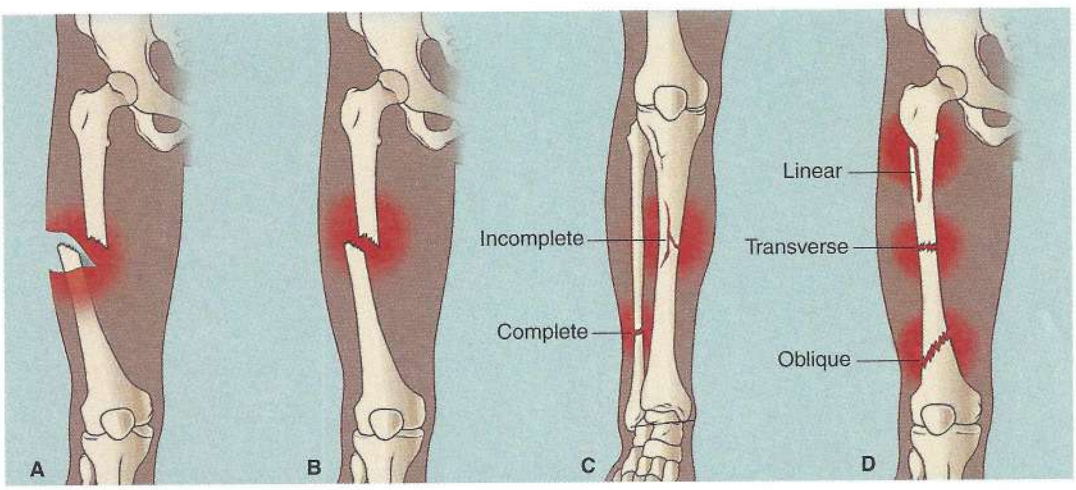


Figure 8-27 **Bone fractures. A,** Open. **B,** Closed. **C,** Incomplete and complete. **D,** Linear, transverse, and oblique.

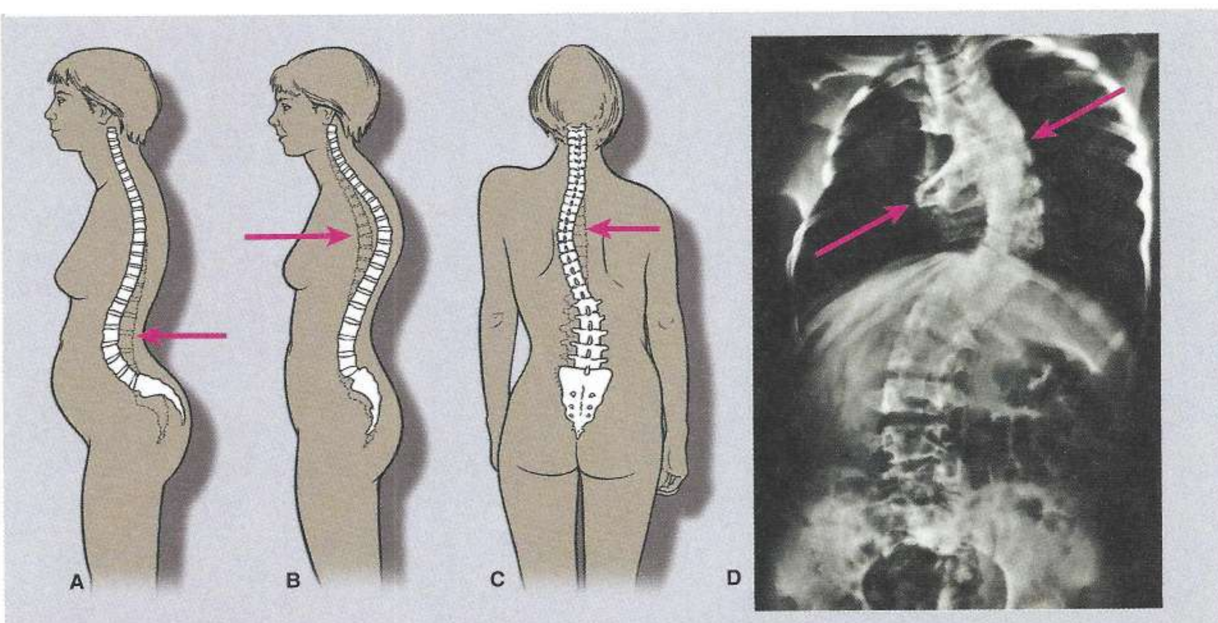


Figure 8-28 **Abnormal spine curvatures. A,** Lordosis. **B,** Kyphosis. **C,** Scoliosis. **D,** X-ray film of scoliosis curvature.

of the vertebral bodies. *Kyphosis,* or "hunchback," is an abnormally increased roundness in the thoracic curvature (Figure 8-28, *B*). It is frequently seen in elderly people with osteoporosis or chronic arthritis, those with neuromuscular diseases, or compression fractures of the thoracic vertebrae. In a condition called *Scheuermann's disease*, kyphosis can develop in children at puberty. Abnormal side-to-side curvature is called *scoliosis* (Figure 8-28, *C*). This too may be idiopathic or a result of damage to the supporting muscles along the spine. It is a relatively common condition that appears before adolescence.

All three abnormal curvatures can interfere with normal breathing, posture, and other vital functions. The degree of curvature and resulting deformity of the vertebral column determine the various treatments instituted. The traditional treatment for scoliosis is the use of a supportive brace, called the *Milwaukee brace*, that is worn on the upper body 23 hours per day for up to several years. A newer approach to straighten abnormal curvature is transcutaneous stimulation. In this method, muscles on one side of the vertebral column are electrically stimulated to contract and pull the vertebrae into a more normal position. If these methods fail, surgical intervention is used in which pieces of bone from elsewhere in the skeleton, or metal rods, are grafted to the deformed vertebrae to hold them in proper alignment. If treated early enough, kyphosis resulting from poor posture can be corrected with special exercises and instructions for appropriate posture. Kyphosis resulting from pathological causes may also require special braces or surgical intervention.