

Figure 5.25 Bones of the right hand, anterior view.

When the upper limb is in the anatomical position, the **ulna** is the medial bone (on the little-finger side) of the forearm. On its proximal end are the anterior **coronoid process** and the posterior **olecranon**, which are separated by the **trochlear notch**. Together these two processes grip the trochlea of the humerus in a pliers-like joint.

Hand

The skeleton of the hand consists of the carpals, the metacarpals, and the phalanges (Figure 5.25). The eight **carpal bones**, arranged in two irregular rows of four bones each, form the part of the hand called the **carpus** or, more commonly, the *wrist*. The carpals are bound together by ligaments that restrict movements between them. (In case you need to learn their names, the individual carpal bones are identified in Figure 5.25.)

The palm of the hand consists of the **metacarpals**. The **phalanges** (fah-lan'jēz) are the bones of the fingers. The metacarpals are numbered 1 to 5 from the thumb side of the hand toward the little finger. When the fist is clenched,

the heads of the metacarpals become obvious as the “knuckles.” Each hand contains 14 phalanges. There are three in each finger (proximal, middle, and distal), except in the thumb, which has only two (proximal and distal).

DID YOU GET IT?

21. Contrast the general function of the axial skeleton to that of the appendicular skeleton.
22. What is the single point of attachment of the shoulder girdle to the axial skeleton?
23. What bone forms the skeleton of the arm?
24. Where are the carpals found, and what type (long, short, irregular, or flat) of bone are they?
25. Which bones of the upper limb have a styloid process?

For answers, see Appendix D.

Bones of the Pelvic Girdle

The **pelvic girdle** is formed by two **coxal** (kok'sal) **bones**, or **ossa coxae**, commonly called **hip bones**, and the sacrum (described on p. 156). Together with the coccyx, the pelvic girdle forms the *pelvis* (Figure 5.26). Note that the terms *pelvic girdle* and *bony pelvis* have slightly different meanings (pelvic girdle = 2 coxal bones and sacrum; bony pelvis = 2 coxal bones, sacrum, and coccyx).

The bones of the pelvic girdle are large and heavy, and they are attached securely to the axial skeleton via the sacral attachment to the lowermost lumbar vertebra. The sockets, which receive the thigh bones, are deep and heavily reinforced by ligaments that attach the limbs firmly to the girdle. Bearing weight is the most important function of this girdle, because the total weight of the upper body rests on the pelvis. The reproductive organs, urinary bladder, and part of the large intestine lie within and are protected by the pelvis.

Each hip bone is formed by the fusion of three bones: the *ilium*, *ischium*, and *pubis*. The **ilium** (il'e-um), which connects posteriorly with the sacrum at the **sacroiliac** (sak''ro-il'e-ac) **joint**, is a large, flaring bone that forms most of the hip bone. When you put your hands on your hips, they are resting over the *alae*, or winglike portions, of the ilia. The upper edge of an ala, the **iliac crest**, is an important anatomical landmark that is always kept in mind by those who give intramuscular injections. The iliac crest

Because they relate to muscle activity, we discuss the various types of movements that occur at synovial joints in detail in the next chapter.



HOMEOSTATIC IMBALANCE

Few of us pay attention to our joints unless something goes wrong with them. Joint pain and inflammation may be caused by many things. For example, falling on one's knee can cause a painful **bursitis**, called “water on the knee,” due to inflammation of bursae or synovial membrane. Sprains and dislocations are other types of joint problems that result in swelling and pain. In a **sprain**, the ligaments or tendons reinforcing a joint are damaged by excessive stretching, or they are torn away from the bone. Both tendons and ligaments are cords of dense fibrous connective tissue with a poor blood supply; thus, sprains heal slowly and are extremely painful.

Few inflammatory joint disorders cause more pain and suffering than arthritis. The term **arthritis** (*arth* = joint; *itis* = inflammation) describes over 100 different inflammatory or degenerative diseases that damage the joints. In all its forms, arthritis is the most widespread, crippling disease in the United States. All forms of arthritis have the same initial symptoms: pain, stiffness, and swelling of the joint. Then, depending on the specific form, certain changes in the joint structure occur.

Acute forms of arthritis usually result from bacterial invasion and are treated with antibiotic drugs. The synovial membrane thickens and fluid production decreases, leading to increased friction and pain. Chronic forms of arthritis include osteoarthritis, rheumatoid arthritis, and gouty arthritis, which differ substantially in their later symptoms and consequences. We will focus on these forms here.

Osteoarthritis (OA), the most common form of arthritis, is a chronic degenerative condition that typically affects the aged. Eighty-five percent of people in the United States develop this condition. OA, also called “wear-and-tear arthritis,” affects the articular cartilages. Over the years, the cartilage softens, frays, and eventually breaks down. As the disease progresses, the exposed bone thickens and extra bone tissue, called **bone spurs**, grows around the margins of the eroded cartilage and restricts joint movement. Patients

complain of stiffness on arising that lessens with activity, and the affected joints may make a crunching noise (**crepitus**) when moved. The joints most commonly affected are those of the fingers, the cervical and lumbar joints of the spine, and the large, weight-bearing joints of the lower limbs (knees and hips).

The course of osteoarthritis is usually slow and irreversible, but it is rarely crippling. In most cases, its symptoms are controllable with a mild analgesic such as aspirin, moderate activity to maintain joint mobility, and rest when the joint becomes very painful. Some people with OA claim that rubbing capsaicin (a hot pepper extract) on the skin over painful joints provides relief. Others swear to the pain-reducing ability of glucosamine sulfate, a nutritional supplement.

Rheumatoid (roo'mah-toid) arthritis (RA) is a chronic inflammatory disorder. Its onset is insidious and usually occurs between the ages of 40 and 50, but it may occur at any age. It affects three times as many women as men. Many joints, particularly those of the fingers, wrists, ankles, and feet, are affected at the same time and usually in a symmetrical manner. For example, if the right elbow is affected, most likely the left elbow will be affected also. The course of RA varies and is marked by remissions and flare-ups (*rheumat* = susceptible to change or flux).

RA is an autoimmune disease—a disorder in which the body's immune system attempts to destroy its own tissues. The initial trigger for this reaction is unknown, but some suspect that it results from certain bacterial or viral infections.

RA begins with inflammation of the synovial membranes. The membranes thicken and the joints swell as synovial fluid accumulates. Inflammatory cells (white blood cells and others) enter the joint cavity from the blood and release a deluge of inflammatory chemicals that destroy body tissues when released inappropriately as in RA. In time the inflamed synovial membrane thickens into a **pannus** (“rag”), an abnormal tissue that clings to and erodes articular cartilages. As the cartilage is destroyed, scar tissue forms and connects the bone ends. The scar tissue eventually ossifies, and the bone ends become firmly fused (**ankylosis**) and often deformed (**Figure 5.33**). Not all cases of RA progress to the severely crippling ankylosis stage, but all cases involve restricted joint movement and extreme pain.



Figure 5.33 X-ray image of a hand deformed by rheumatoid arthritis.

Current therapy for RA involves many different kinds of drugs. Some, like methotrexate, are immunosuppressants. Others, like etanercept (Enbrel), neutralize the inflammatory chemicals in the joint space and (hopefully) prevent joint deformity. However, drug therapy often begins with aspirin, which in large doses is an effective anti-inflammatory agent. Exercise is recommended to maintain as much joint mobility as possible. Cold packs are used to relieve the swelling and pain, and heat helps to relieve morning stiffness. Replacement joints or bone removal are the last resort for severely crippled RA patients.

Gouty (gow'te) **arthritis**, or **gout**, is a disease in which uric acid (a normal waste product of nucleic acid metabolism) accumulates in the blood and may be deposited as needle-shaped crystals in the soft tissues of joints. This leads to an agonizingly painful attack that typically affects a single joint, often in the great toe. Gout is most common in men and rarely appears before the age of thirty. It tends to run in families, so genetic factors are definitely implicated.

Untreated gout can be very destructive; the bone ends fuse, and the joint becomes immobilized. Fortunately, several drugs (colchicine, ibuprofen, and others) are successful in preventing acute gout attacks. Patients are advised to lose weight if obese, to avoid foods such as liver, kidneys, and sardines, which are high in nucleic acids, and to avoid alcohol, which inhibits excretion of uric acid by the kidneys. ▀

DID YOU GET IT ?

31. What are the functions of joints?
32. What is the major difference between a fibrous joint and a cartilaginous joint?
33. Where is synovial membrane found, and what is its role?
34. What two joints of the body are ball-and-socket joints? What is the best example of a saddle joint?

For answers, see Appendix D.

Developmental Aspects of the Skeleton

- ✓ Identify some of the causes of bone and joint problems throughout life.

As we described earlier, the first “long bones” in the very young fetus are formed of hyaline cartilage, and the earliest “flat bones” of the skull are actually fibrous membranes. As the fetus develops and grows, both the flat and the long bone models are converted to bone (**Figure 5.34**). At birth, some fontanelles still remain in the skull to allow for brain growth, but these areas are usually fully ossified by 2 years of age. By the end of adolescence, the epiphyseal plates of long bones that provide for longitudinal growth in childhood have become fully ossified, and long-bone growth ends.

The skeleton changes throughout life, but the changes in childhood are most dramatic. At birth, the baby's cranium is huge relative to its face (**Figure 5.35a**). The rapid growth of the cranium before and after birth is related to the growth of the brain. By 2 years, the skull is three-quarters of its adult size; and, by 8 to 9 years, the skull is almost of adult size and proportions. However, between the ages of 6 and 11, the head appears to enlarge substantially as the face literally grows out from the skull. The jaws increase in size, and the cheekbones and nose become more prominent as respiratory passages expand and the permanent teeth develop.

The so-called primary curvatures of the vertebral column are present at birth and are convex posteriorly, so an infant's spine is arched, like that of a four-legged animal. The secondary curvatures are convex anteriorly and are associated with a child's later development. They result from reshaping of

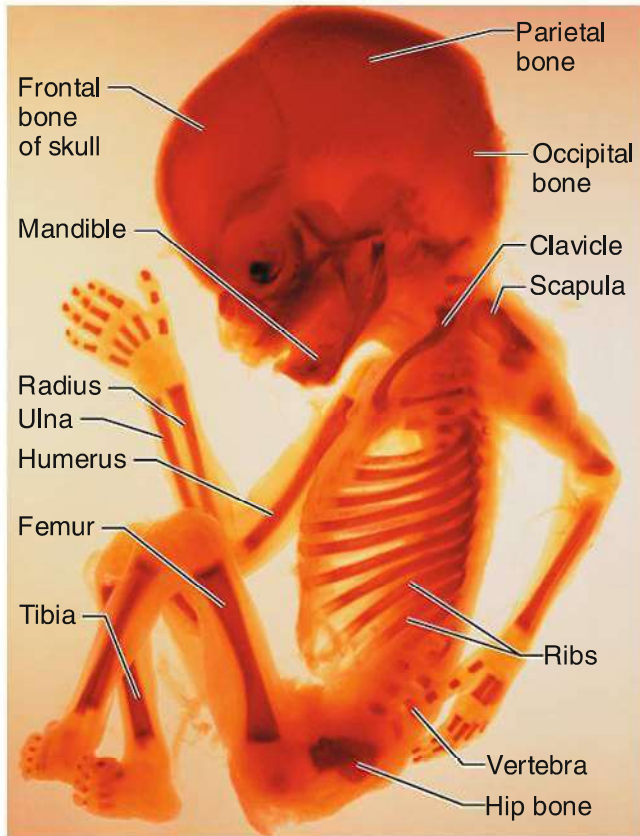
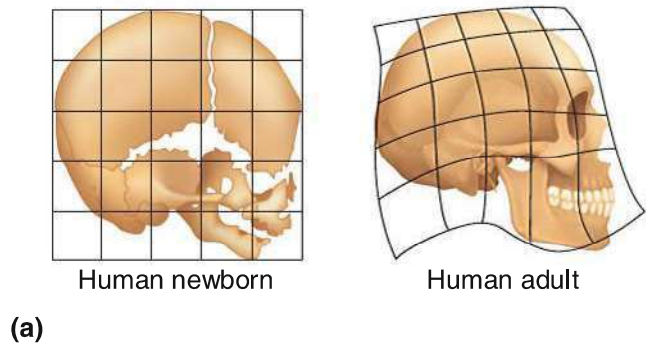


Figure 5.34 Ossification centers in the skeleton of a 12-week-old fetus are indicated by the darker areas. Lighter regions are still fibrous or cartilaginous.

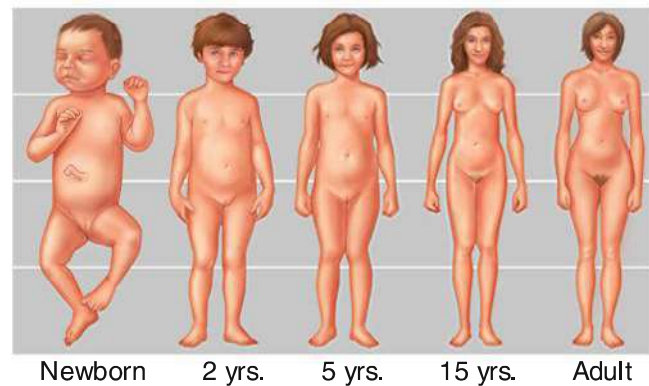
the intervertebral discs rather than from modifications of the bony vertebrae and produce the S-shaped spine typical of the adult.

Most cases of abnormal spinal curvatures, such as scoliosis and lordosis (see Figure 5.18), are congenital, but some can result from injuries. The abnormal curvatures are usually treated by surgery, braces, or casts when diagnosed. Generally speaking, young, healthy people have no skeletal problems, assuming that their diet is nutritious and they stay reasonably active.

During youth, growth of the skeleton not only increases overall body height and size but also changes body proportions (Figure 5.35b). At birth, the head and trunk are approximately $1\frac{1}{2}$ times as long as the lower limbs. The lower limbs grow more rapidly than the trunk from this time on, and by the age of 10, the head and trunk are approximately the same height as the lower



(a)



(b)

Figure 5.35 Differences in the growth rates for some parts of the body compared to others determine body proportions. (a) Differential growth transforms the rounded, foreshortened skull of a newborn to the sloping skull of an adult.

(b) During growth of a human, the arms and legs grow faster than the head and trunk, as shown in this conceptualization of different-aged individuals all drawn at the same height.

limbs and change little thereafter. During puberty, the female pelvis broadens in preparation for childbearing, and the entire male skeleton becomes more robust. Once adult height is reached, a healthy skeleton changes very little until late middle age. In old age, losses in bone mass become obvious.

It cannot be emphasized too strongly that bones have to be physically stressed to remain healthy. When we remain active physically and muscles and gravity pull on the skeleton, the bones respond by becoming stronger. By contrast, if we are totally inactive, they become thin and fragile. **Osteoporosis** is a bone-thinning disease that afflicts half of women over 65 and some 20 percent