The need for strength requires bones to be rigid. However, movement would be almost impossible if our skeletons were solid bone. Nature has solved this problem in vertebrates, including humans, by casting the skeleton into many bones and creating joints where they intersect. Joints are custom-formed to serve the functional needs of the limbs that contain them. They are held together by fibrous tissue (capsule and ligaments) and continuously lubricated to offset friction. In this way joints permit motion, which grants us humans a much more complex repertoire of movement than, say, most insects, spiders, and crustaceans, which, like the joints in your fingers, move only in one plane. However, we are not quite as versatile as invertebrates and certain millipedes, which can rotate one skeletal ring upon the next, curving their axis in any direction, even walking with their legs on the ground at a right angle to their coiled position.

The words *articulation* (L. articulatio—the junction between bones) and *joint* (L. junctio—a joining or connection) are used synonymously to refer to those structural arrangements that connect two or more bones. Although most joints permit at least some movement between the bones they connect, this is not essential for a connecting structure to be called a joint. The function of some joints is to allow the joined
structures to grow until they in turn become as solid as the bones they connect.

Where joints are immovable, as in the articulations between the bones of the growing skull, the adjacent margins of the bone are separated merely by a thin layer of fibrous tissue. Where slight movement but great strength is required, the joint surfaces are united by tough elastic fibrocartilages, as in the joints between the vertebral bodies. In freely movable joints, such as the shoulder or knee, the surfaces are completely separated and the bones expanded for greater convenience of mutual connection. They are covered by cartilage and enveloped by fibrous tissue capsules.

ARTICULAR CARTILAGE

Articular cartilage is of a type called hyaline (glasslike) cartilage because thin sections of it are translucent or even transparent to light. In contrast to bone, it is easily cut. It is deformable under pressure, but elastic so that it quickly recovers its shape. These properties are important for its function under conditions of loading (bearing weight). A membrane lines the interior of such joints.
This synovial (Gr. syn.—together; L. ovum—egg) membrane secretes a thick viscous liquid that lubricates the joint. It also regulates protein and electrolyte (ionic or electrically charged molecule) metabolism in the joint and removes waste from the joint.

Joints are strengthened by ligaments, strong fibrous bands that connect the bones that form the joint (Fig 1.1).

DEVELOPMENT

Bone and joint both develop from the middle layer of tissue in the embryo. Circumscribed condensation of cells in this mesoderm (middle skin) become chondrified (turned into cartilage) and finally ossified (turned into bone) to form the bones of the skeleton. The intervening noncondensed portions of tissue develop into joints.

As soon as the joint cavity appears during development, it contains watery fluid. The tissue surrounding the original mesodermal cellular core forms fibrous sheaths for the developing bones, which continue between their ends as the capsules of the joints. Ligaments develop both in these capsules and as derivations from tendons surrounding the joint. After the joint cavity is established during the third month of gestation, the muscles that move the joint begin to contract. This movement enhances nutrition of the articular cartilage and prevents fusion of the apposed joint surfaces. Early restriction of joint motion can result in permanent loss of the joint cavity, whereas later restriction can lead to abnormalities of the soft tissues associated with the joint. Because normal positioning of the fetus in the uterus permits a fair degree of movement of the upper limbs but restricts the legs—which are folded and pressed firmly against the body—the lower limbs are more vulnerable to congenital (found at birth) joint deformity such as clubfoot or congenital hip dislocation. In several of the movable joints, a portion of the mesodermal tissue that originally existed between the ends of the bones persists and forms an articular disc. An example of this is the menisci (cartilages) of the knee joint.

TYPES OF JOINTS

There are various types of joints. The skull type is immovable, the vertebral type is slightly movable, and the limb type is freely
movable. Joints of the skull are temporary until they fuse, those of the vertebrae are secure, and limb type joints or synovial articulations, although freely movable, are insecure. Immovable joints are called synarthroses, slightly movable joints are labeled amphiarthroses, and freely movable joints are called diarthroses.

The greatest number of joints in the body are diarthroses. Varieties of these joints have been determined by the kind of motion each allows. Joints permit:

- **gliding movement**
- **flexion**, where the angle between adjoining bones is decreased, as when the forearm is moved forward and upward
- **extension**, where the angle between adjoining bones is increased, as when the forearm is straightened
- **abduction**, when an extremity is moved away from the body or adduction, when an arm or leg is moved toward the body
- **circumduction** (circular movement), best seen in ball-and-socket joints
- **rotation**, where a bone moves around a central axis without undergoing any displacement.

Some examples of hinge joints are the elbow and the knee; ball-and-socket joints, the shoulder and hip; gliding joints, the small bones of the foot and the wrist, the ribs, and the vertebrae. A saddle joint, which permits movement in two directions, unites the thumb with the hand.

**MECHANICS**

Bones in a freely movable joint articulate in pairs, each pair distinguished by its own pair of conarticular surfaces. These surfaces constitute “mating pairs.” Each mating pair consists of a “male” surface and a “female” surface. Following an engineering convention, a joint surface is called male if it is convex and female if it is concave.

In all positions of a diarthrosis—except one—the conarticular surfaces fit imperfectly. Such incongruence is not great and
FIGURE 1-2 Some joint types.

PIVOT
(atlas vertebra)

HINGE
(elbow)

GLIDING
(carpal bones in wrist)

SADDLE
/thumb)

BALL & SOCKET
(shoulder or hip)
is lessened by mutual alteration of the opposed parts of the surfaces. This is a consequence of the plasticity of hyaline cartilage.

The exceptional position is called the close-packed position, in which the entire articulating portion of the female surface is in complete contact with the apposed male surface. Functionally, this changes the joint from a freely movable joint to a “locked” one, and it is the position in which the joint is most stable.

Every joint has its close-packed position. A good example is the wrist when the hand is fully bent backward (dorsiflexed) on the forearm. Another is the knee when the thigh and leg are in the military position of attention.

The close-packed position is not assumed often or constantly because it requires special muscular effort. It is also dangerous because two bones in series are converted temporarily into a functionally single but longer unit that is more likely to be injured by sudden stress. For example, sprain or even fracture of an ankle occurs when that joint, close-packed, is suddenly and violently bent.

**SYNOVIAL JOINTS**

Synovial joints, which allow free movement, must have their surfaces lubricated. The lubricant is called synovial fluid because it has the consistency of egg white. Although synovial fluid is 95 percent water, it enables the cartilaginous joint surfaces to move with less friction than that of ice sliding on ice. Synovial fluid (like printer’s ink and certain gels) has the unusual ability to become thick or thin with change of pressure, a property called thixotropy.

**FAT PADS**

Some of the larger joints contain fat pads. The function of these structures depends on the fact that fat is liquid in the living body and therefore easily deformable. These fat pads contribute to the “internal streamlining” of the joint cavity, preventing eddying (whiplash motion) of the synovial fluid. Their deformability enables them to do this effectively.

In addition, the fat pads keep the synovial fluid sufficiently thin between the neighboring parts of the male and female sur-
faces, with proper elasticity as well as viscosity, to effectively lubricate the joint.

A fat pad can be pinched as a result of an accident. This is very painful because of the large number of pain nerve fibers found in these pads.

All About Joints will describe every major joint in your body from the top of your head to the tips of your toes. We will present the anatomy of each joint and discuss how it works. We will talk about injury and disease, diagnosis, and treatment. When considering joints and their diseases, exercise is important, and we will discuss this in some detail. State-of-the-art research into the newest therapies will be presented. Illustrative case reports will be outlined. At the end of each chapter queries and answers concerning the joint in question will be presented. A glossary, review, and suggestions for further reading are appended at the end of the book.

But before we look at your joints one by one, let’s first talk about the bane of all joints, arthritis.