

CLASSIFICATION OF JOINTS

Bones are connected at joints (articulations). All bones move at joints. Joints are functionally classified as immovable (synarthroses), partly movable (amphiarthroses), or freely movable (diarthroses). The structural classification of joints is given below.

FIBROUS JOINT

IMMOVABLE_A / PARTLY MOVABLE_{A'}

Fibrous joints (synarthroses) are those in which the articulating bones are connected by fibrous tissue. Sutures of the skull are essentially *immovable fibrous joints*, especially after having ossified with age. Teeth in their sockets are fixed fibrous joints (gomphoses). Syndesmoses are *partly movable fibrous joints*, such as the interosseous ligaments between bones of the forearm or the bones of the leg.

CARTILAGINOUS JOINT

IMMOVABLE_B / PARTLY MOVABLE_{B'}

Cartilaginous joints (synchondroses) are essentially immovable joints seen during growth—e.g., growth (epiphyseal) plates (see Plate 168). Fibrocartilaginous joints (amphiarthroses) are partly movable—e.g., the intervertebral disc. Symphyses also are partly movable fibrocartilaginous joints, as between the pubic bones (symphysis pubis) and the manubrium and body of the sternum (sternal angle).

SYNOVIAL JOINT (FREELY MOVABLE)

ARTICULATING BONES_C

ARTICULAR CARTILAGE_D

SYNOVIAL MEMBRANE_E

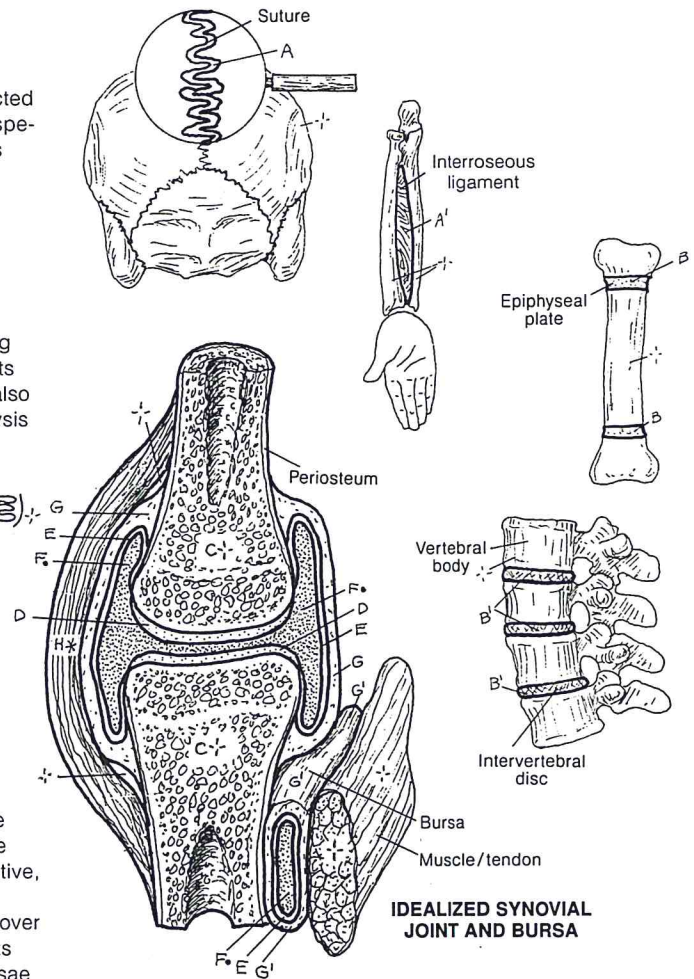
SYNOVIAL CAVITY (FLUID)_F

JOINT CAPSULE_G

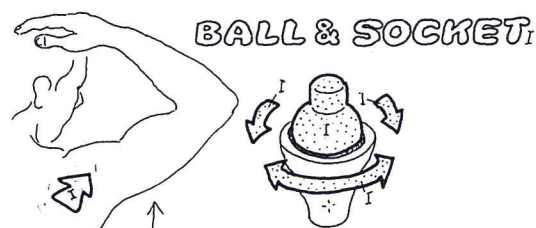
BURSA CAPSULE_{G'}

COLLATERAL LIGAMENT_{H*}

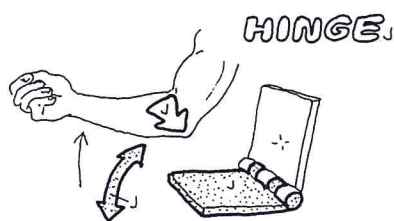
Synovial joints (diarthroses) are freely movable within ligamentous limits and the bony architecture. They are characterized by *articulating bones* whose ends are capped with *articular cartilage* and are enclosed in a ligament-reinforced, sensitive, fibrous (joint) *capsule* lined internally with a vascular *synovial membrane* that secretes a lubricating fluid within the *cavity*. The synovial membrane does not cover articular cartilage. A fibrous tissue-lined synovial sac of fluid (*bursa*) often exists between moving structures outside the joint, as between tendon and bone. Bursae facilitate friction-free movement; friction may induce painful inflammation (bursitis).



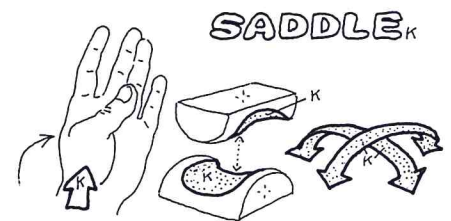
TYPES OF SYNOVIAL JOINTS



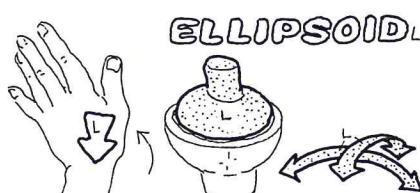
Ball-and-socket joints are best seen at the hip and shoulder. Movements in all direction are permitted—i.e., flexion, extension, adduction, abduction, internal and external rotation, and circumduction.



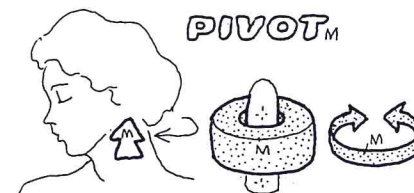
A hinge joint permits movement in only one plane: flexion/extension. The ankle, interphalangeal, and elbow (humeroulnar) joints are hinge joints.



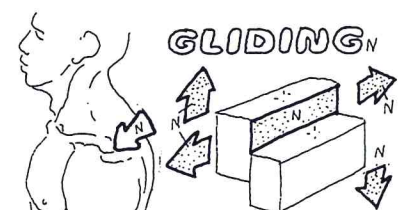
A saddle (sellar) joint—e.g., carpometacarpal joint at the base of the thumb—has two concave articulating surfaces, permitting all motions but rotation.



The ellipsoid (condyloid, condylar) joint is a reduced ball-and-socket configuration in which significant rotation is largely excluded—e.g., the bicondylar knee, temporomandibular, and radiocarpal (wrist) joints.



A pivot joint has a ring of bone around a peg; e.g., the C1 vertebra rotates about the dens of C2, a rounded humeral capitulum on which the radial head pivots (rotates).



Gliding joints (e.g., the facet joints of the vertebrae, the acromio-clavicular, intercarpal, and intertarsal joints) has generally flat articulating surfaces.

TERMS OF MOVEMENTS

CN: Color the arrows pointing to the joints demonstrating the various movements of the body. Inversion (K) and eversion (L) movements occur among bones of the foot, not at the ankle.

EXTENSION_A

DORSIFLEXION_B

FLEXION_C

PLANTAR FLEXION_D

ADDUCTION_E

ABDUCTION_F

CIRCUMDUCTION_G

ROTATION_H

SUPINATION_I

PRONATION_J

INVERSION_K

EVERSION_L

Movements of bones occur at joints. Terms of movement are therefore applicable to joints, not bones (flexion of the humerus would break it!). Ranges of motion are limited by the bony architecture of a joint, related ligaments, and the muscles crossing that joint. It is from the anatomical position that specific directions of movement can be clearly delineated and ranges of motion measured.

Extension of a joint is to generally straighten it. In the anatomical position, most joints are in relaxed extension (neutral). In relation to the anatomical position, movements of extension are directed in the sagittal plane. Extreme, even abnormal extension is called hyperextension. At the ankle and wrist joints, extension is termed dorsiflexion.

Flexion of a joint is to bend it or decrease the angle between the bones of the joint. Movements of flexion are in the sagittal plane. At the ankle joint, flexion is also called plantar flexion.

Adduction of a joint moves a bone toward the midline of the body (or in the case of the fingers or toes, toward the midline of the hand or foot). In relation to the anatomical position, movements of adduction are directed in the coronal plane.

Abduction of a joint moves a bone away from the midline of the body (or hand or foot). Movements of abduction are directed in the coronal plane.

Circumduction is a circular movement, permitted at ball and socket, condylar, and saddle joints, characterized by flexion, abduction, extension, and adduction done in sequence.

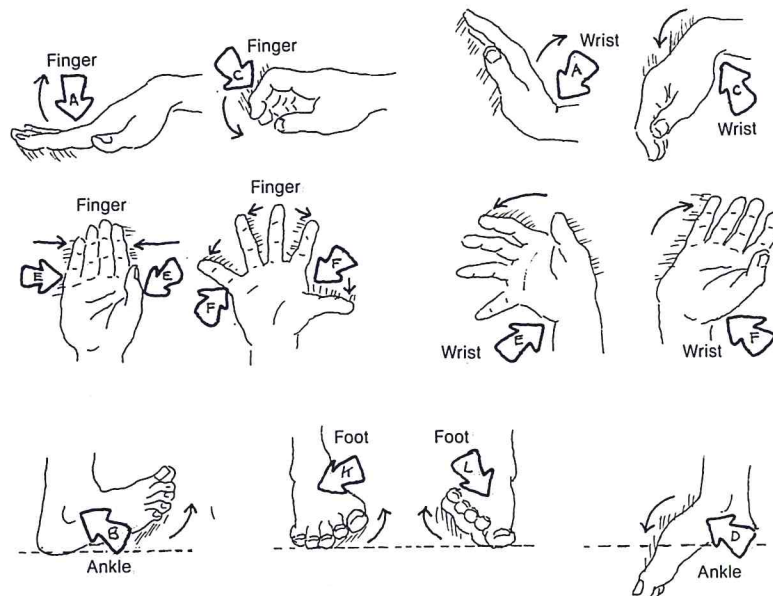
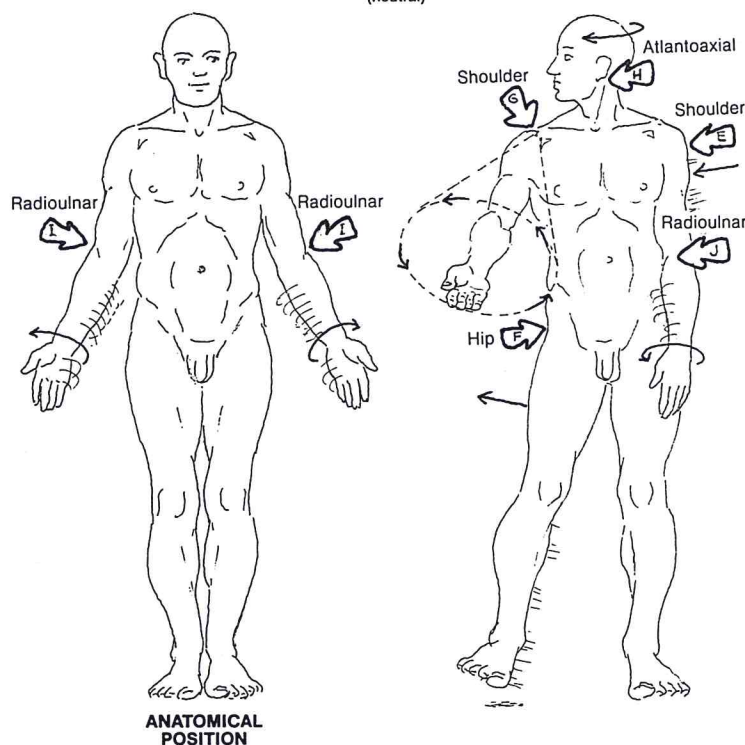
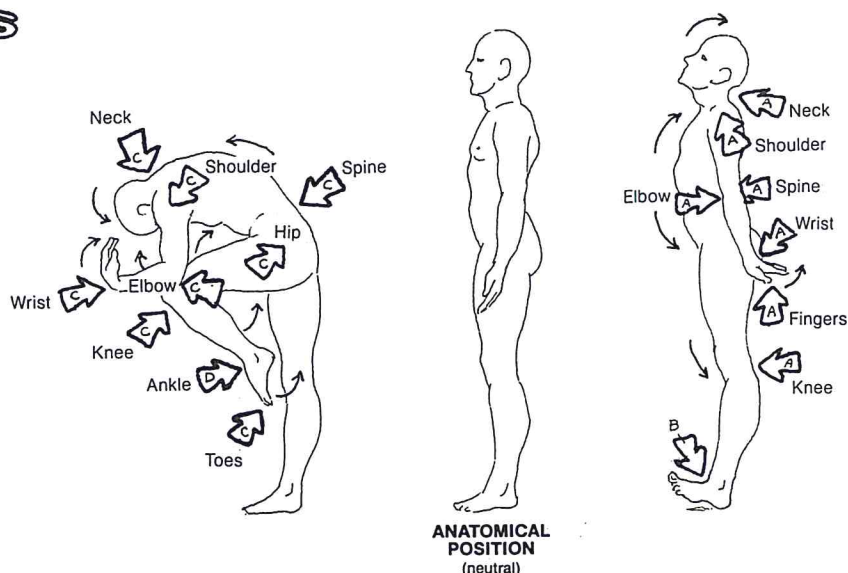
Rotation of a joint is to turn the moving bone about its axis. Rotation toward the body is internal or medial rotation; rotation away from the body is external or lateral rotation.

Supination is external rotation of the radiohumeral joint. In the foot, supination involves lifting the medial aspect of the foot.

Pronation is internal rotation of the radiohumeral joint. In the foot, pronation involves raising the lateral aspect of the foot.

Inversion turns the sole of the foot inward so that the medial border of the foot is elevated.

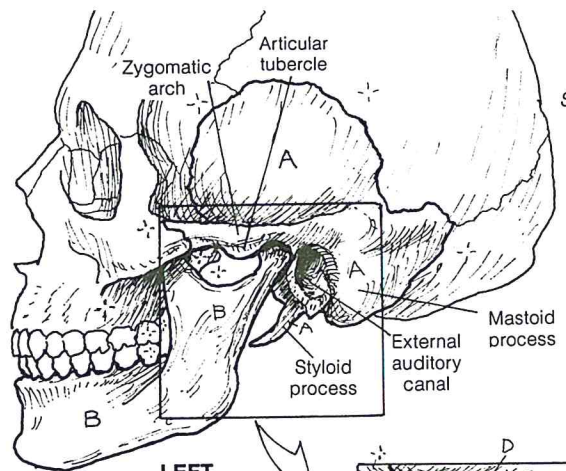
Eversion turns the sole of the foot outward so that its lateral border is elevated.



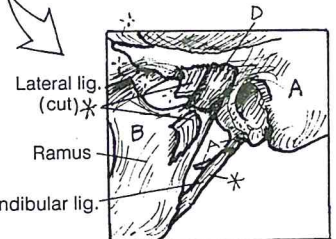
TEMPOROMANDIBULAR JOINT (CRANIOMANDIBULAR)

CN: Read the text before coloring. Use light colors for A and B, light blue for C, and black or a dark color for E. (1) Begin with bones of the TM joint and the corresponding ligaments. (2) In the central illustration of the upward, lateral view of the skull, the articular fossa receives the color of its articular cartilage (C). Also color the cartilage and condyle of the mandible, which is placed here for diagrammatic purposes. (3) Finish with the sagittal views below, which describe the movement of the mandibular condyle within the TM joint.

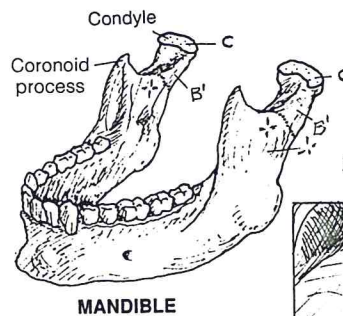
SKULL BONES:-
TEMPORAL BONE A
MANDIBLE B
CONDYLAR PROCESS B'
ARTICULAR CARTILAGE C
JOINT CAPSULE D
SYNOVIAL CAVITY E--
SUP. JOINT SPACE E'
INF. JOINT SPACE E"
ARTICULAR DISC F--
ANT. BAND F'
POST. BAND F"
RETRODISCAL PAD G



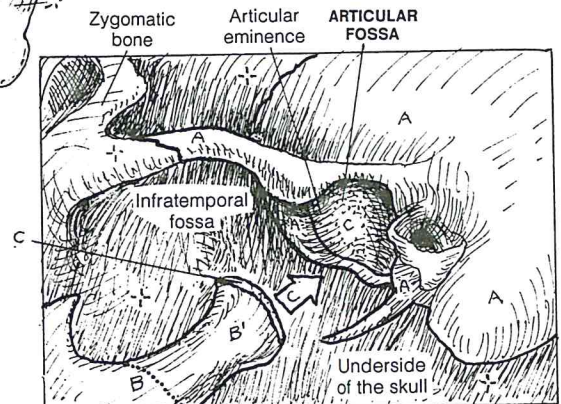
LEFT TM JOINT



LIGAMENTS *



MANDIBLE

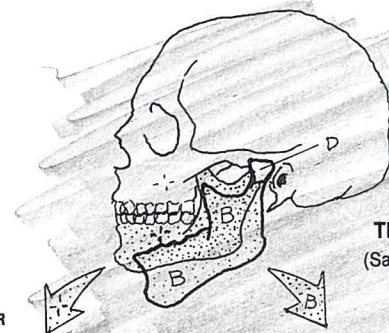


ARTICULAR SURFACE OF ARTICULAR FOSSA
(View of the skull from the side and below)

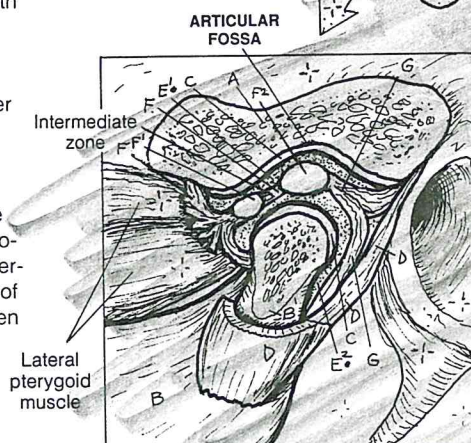
Two temporomandibular joints form the craniomandibular joint, which consists of the heads of the left and right *condylar processes* of the *mandible* articulating with paired articular fossae of the *temporal bones*. Movement or trauma to one of these two temporomandibular joints (TMJ) always involves the contralateral joint. The TMJ is a complex synovial joint, gliding, angling, and rotating during what appears to be simple hinge movements of the lower jaw. Movements of the TMJ can be seen in Plate 47.

The TMJ is encapsulated within a fibrous (joint) capsule, the only true ligament of the joint. The *articular disc* (meniscus) is a fibrocartilaginous, oval plate between the cartilage-lined articular fossa and the articular cartilage of the condylar process. It divides the *synovial cavity* into superior and inferior *joint spaces*. The disc incorporates two avascular *bands* whose long axes lie in the coronal plane. Here we see them in cross section. These bands are connected by an intermediate zone of fibrous tissue. The disc is well connected, anteriorly to the lateral pterygoid muscle, posteriorly to the vascular, elastic *retrodisical pad* in the bilaminar region from which it gets its nutrition, and medially/laterally to the condylar process. When the mouth is closed, the head of the condylar process abuts the larger, posterior band. As the mouth opens, the condylar head rotates forward and downward to abut the anterior band at full opening (35–50 mm between upper and lower incisors). During mouth opening, the meniscus itself is stretched as it is pulled forward with the condylar head.

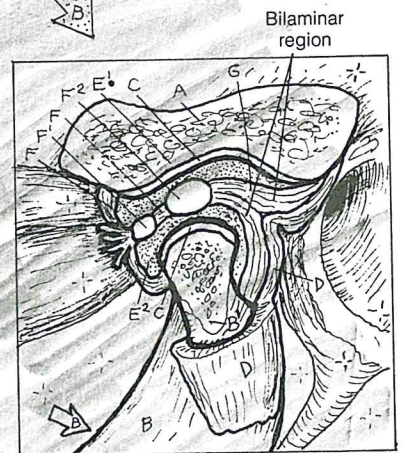
The articular disc of the TMJ may fray or become dislocated or detached with aging, abuse (trauma), or misuse (clenching, grinding of teeth). This condition may be associated with bitemporal headaches (temporalis muscle over-use), clicking during jaw movement, and reduced range of motion. The disc may also be structurally incomplete (even perforated) from birth.



TM JOINT
(Sagittal view)



MOUTH CLOSED

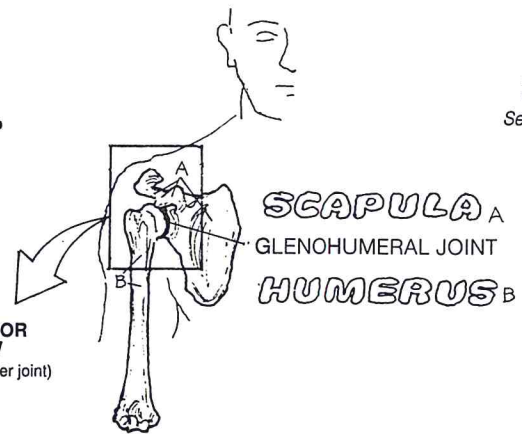


MOUTH OPEN

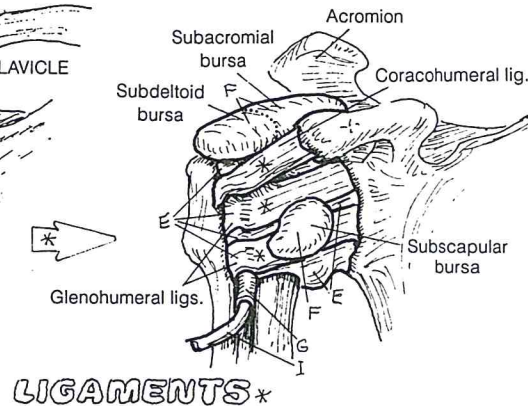
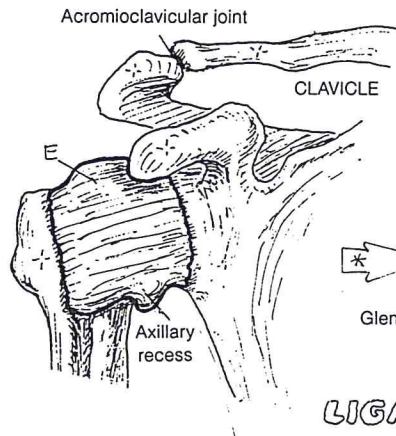
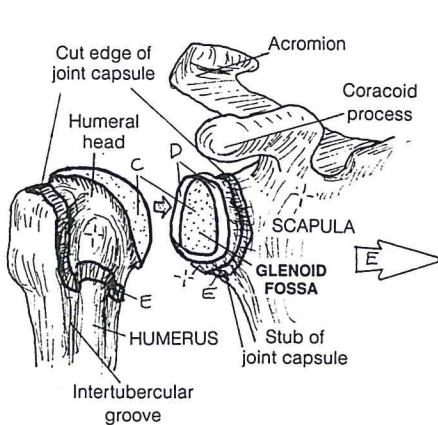
GLENOHUMERAL (SHOULDER) JOINT

CN: Use the same color that the scapula (A) and humerus (B) received on the preceding plate. Use light blue for (C). (1) The scapula (A) and humerus (B) are only to be colored in the upper right corner. (2) Color all ligaments gray. Because the glenohumeral ligaments are thickenings of the joint capsule (E), they are colored both gray and the color assigned to E. (3) The subdeltoid bursa and the subacromial bursa (F) are one continuous structure. (4) In the coronal section, part of the synovial membrane (G) has been removed to reveal the biceps brachii tendon where it attaches to the supraglenoid tubercle of the scapula.

ANTERIOR VIEW
(Right shoulder joint)



SCAPULA A
GLENOHUMERAL JOINT
HUMERUS B



LIGAMENTS *

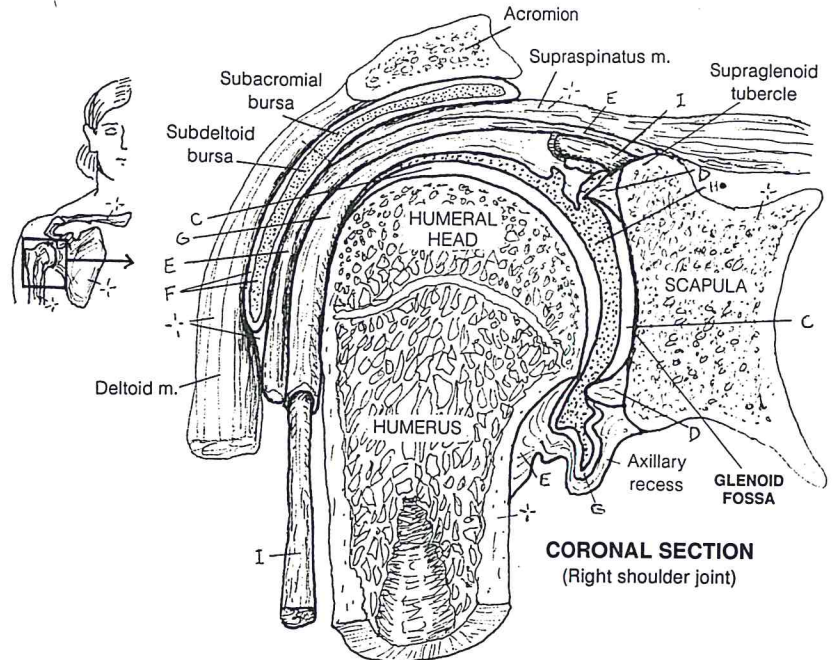
ARTICULAR CARTILAGE C
GLENOID LABRUM D
JOINT CAPSULE E
BURSA F
SYNOVIAL MEMBRANE G
SYNOVIAL CAVITY H
TENDON OF BICEPS BRACHII M, I

The glenohumeral (shoulder) joint is a synovial, ball-and-socket-type, multi-axial articulation between the glenoid fossa of the scapula and the head of the humerus. The shallow fossa is deepened by the labrum around its rim. The fossa and the humeral head are covered with a thin layer of articular (hyaline) cartilage. The connecting ends of the bones are encapsulated with a fibrous joint capsule lined internally with a synovial membrane and containing a small amount of synovial fluid. Usually isolated from the joint capsule and its cavity are numerous fibrous sacs of synovial fluid (bursae) intervening between muscle tendons crossing bones, tendons, and muscles. One of these, the subacromial bursa, has great clinical significance (see Plate 55).

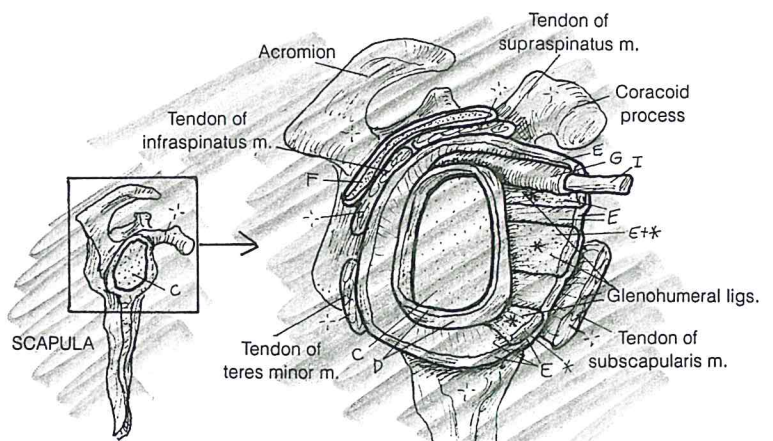
The tendon of the long head of biceps brachii arises from the scapula's supraglenoid tubercle just above the 12 o'clock point of the glenoid labrum. Ensheathed by synovium, the tendon passes over the head of the humerus within the fibrous capsule and emerges below the capsule in the intertubercular groove to join the long head (muscle) of biceps brachii.

The fibrous joint capsule is lax (note the pouch of the axillary recess), yet incorporates thickened bands of glenohumeral ligaments. The capsule/ligament complex is reinforced by a musculotendinous cuff that offers great flexibility to shoulder motion. Movements of the glenohumeral joint can be seen in Plates 55 and 56.

The joint suffers from overuse. Capsules become abnormally lax, the labrum becomes torn from its attachments, the tendon of biceps becomes frayed and torn, and the cavity of the joint may communicate with various bursae. Repetitive dislocations of the humeral head may induce articular cartilage damage.



CORONAL SECTION
(Right shoulder joint)



LATERAL VIEW
(Opened joint with humerus removed)

ELBOW JOINTS

CN: Use the same colors for the three bones as were used on 32 and 33. Use light blue for H. (1) Begin with the three joints of the elbow region. Note that each articulating surface (dotted) receives the color of its bone—in the lower, boxed-in illustration and in the sagittal view, those surfaces (H) are colored light blue. Color K yellow. (2) Color the remaining views of the joint capsule and ligaments.

ELBOW JOINT:
HUMEROULNAR_B
RADIOHUMERAL_A
RADIOULNAR_B

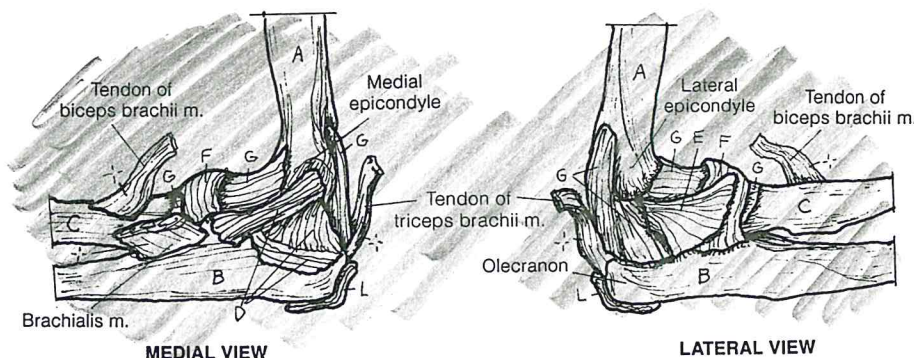
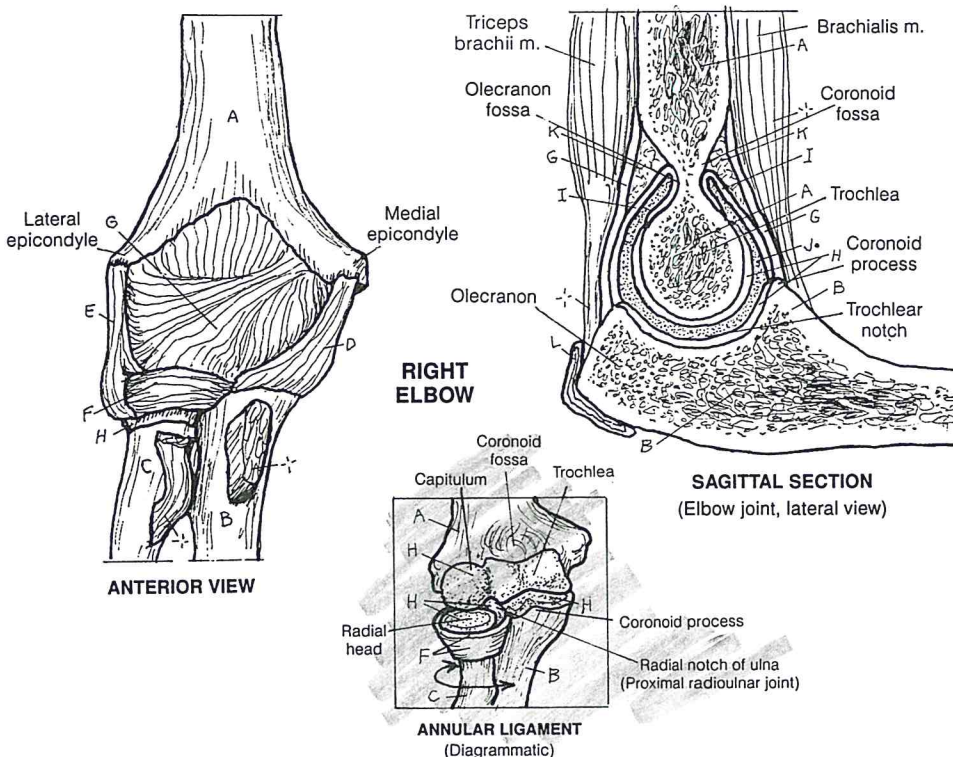
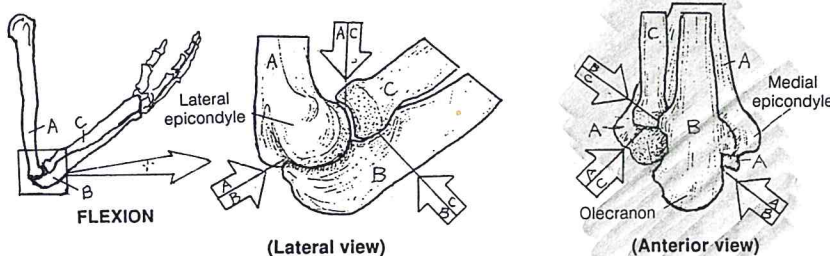
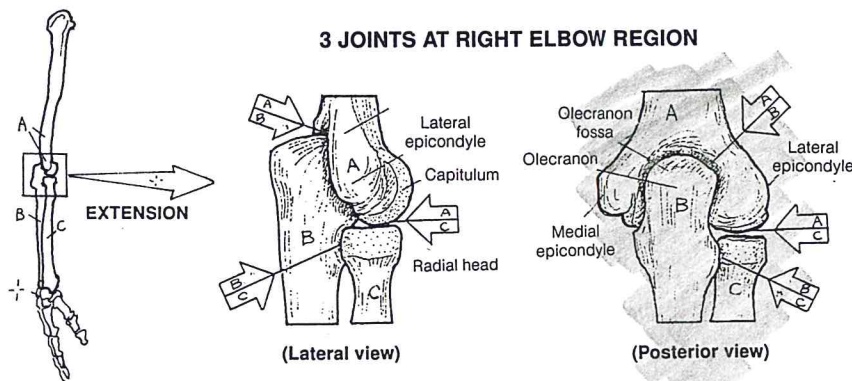
ULNA:
ULNAR COLLATERAL LIG._D
HUMERUS_A
RADIAL COLLATERAL LIG._E
RADIUS:

JOINT CAPSULE:
ARTICULAR CARTILAGE_H
SYNOVIAL MEMBRANE_I
SYNOVIAL CAVITY_J
FAT PAD_K
BURSA_L

The elbow joint consists of two separate articulations with the humerus: the *humero-ulnar* and *radiohumeral* joints (synovial; hinge type). Movements of this joint are limited to flexion and extension. Note that the C-shaped, articular cartilage-lined trochlear notch of the ulna rotates around the pulley-shaped trochlea of the humerus during these movements. In extension, the upper part of the trochlear notch fits into the olecranon fossa of the humerus. In flexion, the coronoid process of the ulna fits into the coronoid fossa of the humerus (see Plate 33). The ligaments of the elbow joint—essentially, the radial and ulnar collateral ligaments—reinforce the fibrous joint capsule.

The joint between the radius and the ulna (*proximal radioulnar joint*) permits the radial head to pivot within the radial notch of the ulna. The ulna cannot pivot around anything because of the shape of the humero-ulnar joint. Though the proximal radioulnar joint is not considered part of the elbow joint, its synovial cavity and fibrous joint capsule is continuous with that of the elbow joint, and it is secured by both radial and ulnar collateral ligaments. The annular ligament is attached at both ends to the sides of the radial notch of the ulna. It is more narrow below than above (i.e., it is beveled). It surrounds and secures the head (above) and the neck (below) of the radius and resists its displacement when the hand is pulled away from the shoulder. The lower part of the annular ligament is lined with synovial membrane; the upper part is fibrocartilaginous and is associated with the rotation of the radius at the proximal radioulnar joint. The joint capsule and the radial collateral ligament reinforce the retaining function of the annular ligament.

3 JOINTS AT RIGHT ELBOW REGION



SACROILIAC & HIP JOINTS

CN: Use light colors for A, C, and L and light blue for B. The hip bone (C) is a fusion of the ilium, ischium, and pubic bones (studied separately on Plate 37). All contribute to the hip joint. (1) The upper left inset shows only one of the two auricular surfaces of the sacrum; the partial arrow (B¹) points to the unseen surface. The synovial membrane (H) of the hip joint is shown only in the large view (where the femur is displaced). (2) In the lower two views, use color for the relevant ligaments that appear among the titles, while coloring the remaining ligaments gray.

SACROILIAC JOINT

SACRUM_A

AURICULAR SURFACE_B

HIP BONE_C

AURICULAR SURFACE_{B'}

SYNOVIAL CAVITY_I

~~INTEROSSEOUS SACROILIAC LIG._D~~

~~POSTERIOR SACROILIAC LIG._E~~

~~ANTERIOR SACROILIAC LIG._F~~

HIP JOINT

HIP BONE_C

ACETABULUM_I

ACETABULAR LABRUM_G

ARTICULAR CARTILAGE_{B²}

SYNOVIAL MEMBRANE_H

~~LIGAMENTUM TERES_J~~

~~SYNOVIAL CAVITY_I~~

FEMUR_K

ARTICULAR CARTILAGE_{B³}

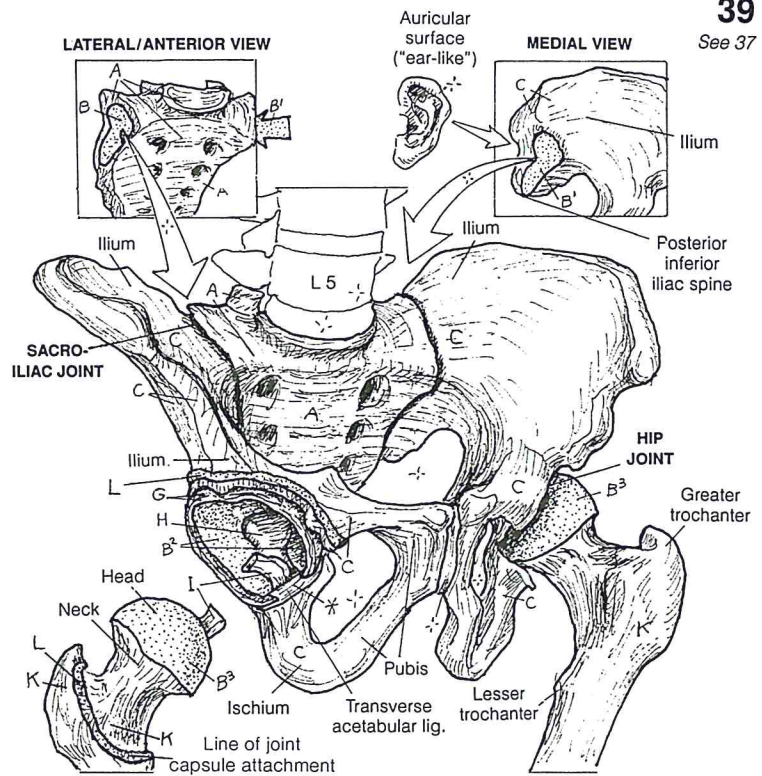
JOINT CAPSULE_L

~~ILIOFEMORAL LIG._M~~

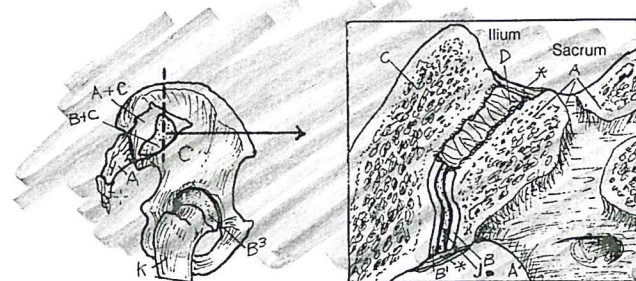
~~ISCHIOFEMORAL LIG._N~~

~~PUBOFEMORAL LIG._O~~

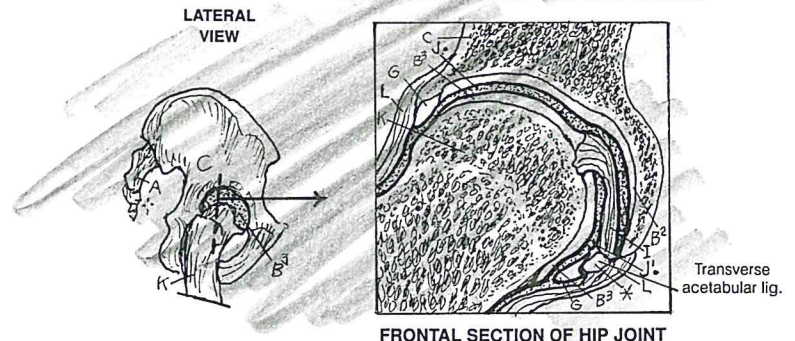
~~ADDITIONAL PELVIC LIGS._{*}~~



LATERAL/ANTERIOR VIEW OF JOINT LOCATIONS



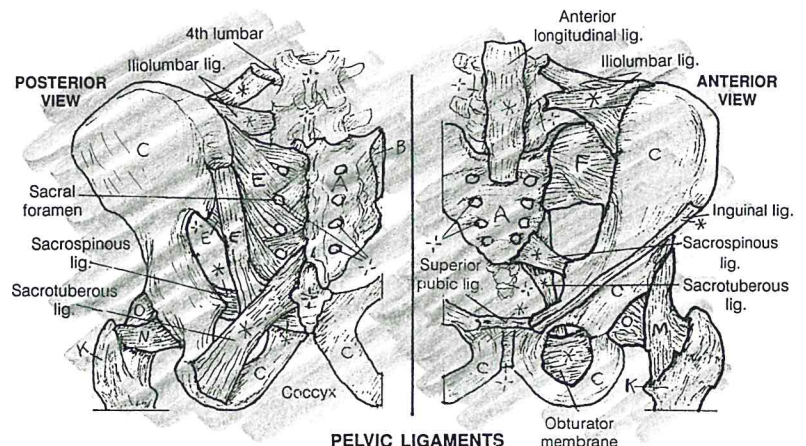
FRONTAL SECTION OF SACROILIAC JOINT



FRONTAL SECTION OF HIP JOINT

The sacroiliac joint is a significant load-bearing articulation. The auricular surfaces of the ilium and sacrum are roughened and cartilage-lined: the sacral surface is hyaline; the iliac surface is fibrocartilaginous and thinner. Only the lower half of the joint is synovial with a cavity; the upper half is ligamentous. A fibrous capsule surrounds the entire joint. The cavity becomes smaller in later life, and the joint surfaces may fuse with advanced age. Movement of the joint is controversial; some anterior and posterior movement, with rotation, has been described. This motion may be increased during pregnancy. Movement is sharply limited by the irregularity of the articular surfaces and by the dense, thick posterior sacroiliac and the thinner anterior sacroiliac ligaments. The joint, its ligaments, and crossing muscles are implicated in the painful "sacroiliac syndrome". Inflammation of the synovial part of the joint (sacroiliitis) is well recognized in many auto-immune-related diseases (e.g., ankylosing spondylitis, rheumatoid arthritis, and inflammatory bowel disease).

The hip joint is a ball and socket, synovial joint between the acetabulum of the hip bone and the head of the femur. The joint permits flexion, extension, adduction, abduction, medial and lateral rotation, and circumduction. Each joint surface is lined with articular cartilage; that of the acetabulum is C-shaped. The incomplete bony socket of the acetabulum is completed by the transverse acetabular ligament and is enhanced by a 360° fibrocartilaginous labrum. The joint is encapsulated; the three strong iliofemoral, ischiofemoral, and pubofemoral ligaments reinforce this fibrous capsule. Arising within the acetabulum between the arms of the acetabular cartilage is the ligament of the head of the femur (lig. teres). It offers little resistance to forced distraction, but it does transmit vessels to the femoral head. An adequate blood supply to the joint requires both femoral circumflex vessels in addition to the vessels in the ligamentum teres.



PELVIC LIGAMENTS

KNEE JOINT

CN: The femur, tibia, fibula, and patella bones are not to be colored. (1) In the sagittal section, color (A) blue and (B) black. The synovial membrane that lines the cavity is not shown. (3) In the anterior view, color the facets on the posterior surface of the patella. (4) Color relationship between attachments and function of cruciate ligaments (E, E').

ARTICULAR CARTILAGE_A

SYNOVIAL CAVITY_B

JOINT CAPSULE_C

BURSA_D

CRUCIATE LIG._E, ANT._E / POST._{E'}

MENISCUS, LAT._F / MED._{F'}

PATELLAR LIG._G

COLLATERAL LIG._H, TIBIAL_H / FIBULAR_{H'}

The knee joint consists of *two condylar synovial joints* between the femoral and tibial condyles, and a *gliding synovial joint* between the patella and the femur. Note that the fibula and the tibiofibular joint are not part of the knee joint. The movements of the knee joint, involving essentially flexion and extension with varying degrees of rotation and gliding, can be seen in Plates 62 and 64.

In the sagittal view of the joint, note the *articular cartilage*-lined patellofemoral articulation. The patella is a sesamoid bone that developed in the tendon of the quadriceps femoris muscle. It resists wear-and-tear stresses on the tendon during knee flexion and extension. Note the two facets of the patella in the anterior view and the corresponding patellar articular surface on the femur. The various bursae shown are variable in size. The *suprapatellar bursa* is an extension of the synovial joint cavity.

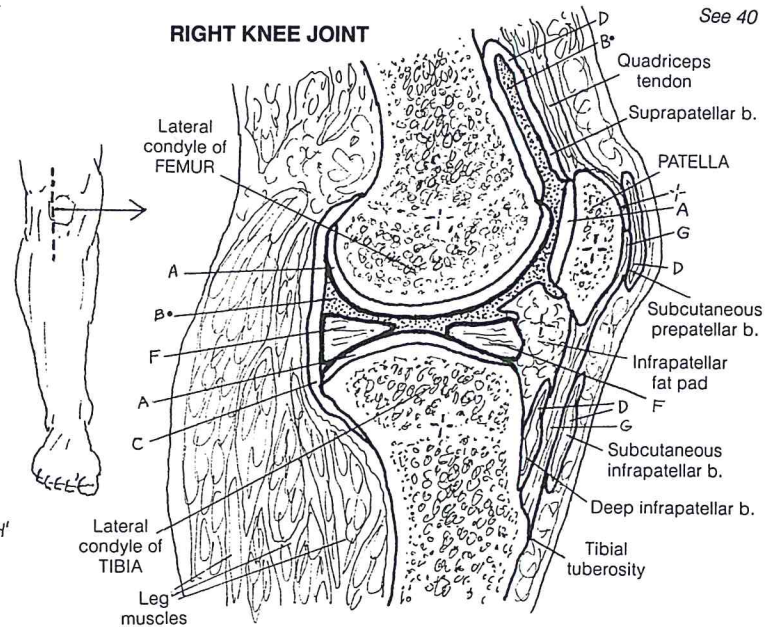
The fibrous (joint) capsule is incomplete around the joint, reinforced by ligaments where absent or deficient and replaced by the patella anteriorly. The synovial membrane (not shown) lines the internal surface of the fibrous capsule; it does not cover the *menisci* and the joint surfaces or the posterior fibrous capsule.

The menisci can be seen from the side in the sagittal view and from above in the superior view of the joint. They are semilunar-shaped fibrocartilaginous discs attached to the tibial condyles by ligaments; they enhance the depth of fit of the femoral condyles. The ends of the menisci (horns) are attached in the tibial intercondylar region. These horns are richly innervated, a fact reinforced to one experiencing a painful tear of the posterior horn of the medial meniscus. The medial meniscus is more fixed on the tibia than is the lateral. Thus, it is less flexible and more easily torn in the face of excessive rotation and forced abduction of the knee joint while bearing weight.

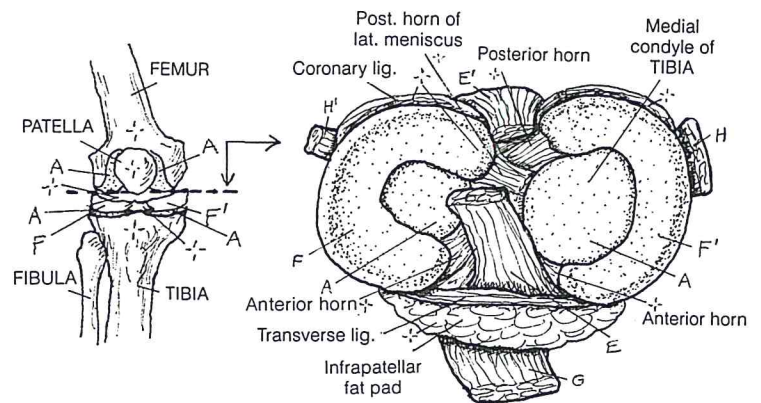
The knee joint is without bony security. It is secured by ligaments and the tendons of the muscles that cross it, including the tendon of quadriceps femoris anteriorly and the iliotibial tract and the tendon of biceps femoris laterally (Plate 62), the muscles popliteus and semimembranosus posteriorly (Plate 66), and the tendons of sartorius, gracilis, and semitendinosus (pes anserinus) medially (Plate 66). See also Plate 40.

The ligaments are particularly important in limiting ranges of motion of the knee and securing the menisci. The *collateral ligaments* resist unwanted sideward movements at the knee. The *anterior cruciate* is named for its anterior tibial attachment, the *posterior cruciate* for its posterior tibial attachment. In their ascent proximally, they cross (crux, cross). The anterior cruciate passes posteriorly and laterally to end on the posteromedial aspect of the lateral femoral condyle; the posterior cruciate passes anteriorly and medially to end on the medial aspect of the medial femoral condyle. The cruciates essentially resist forward/backward displacement of the tibia/femur; indeed, a torn cruciate ligament generally results in excessive anteroposterior movements of the tibia on the femur.

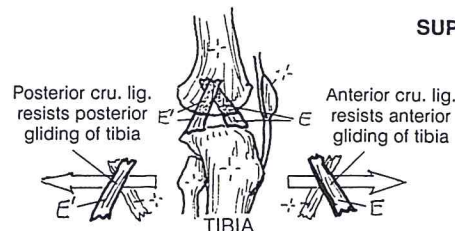
RIGHT KNEE JOINT



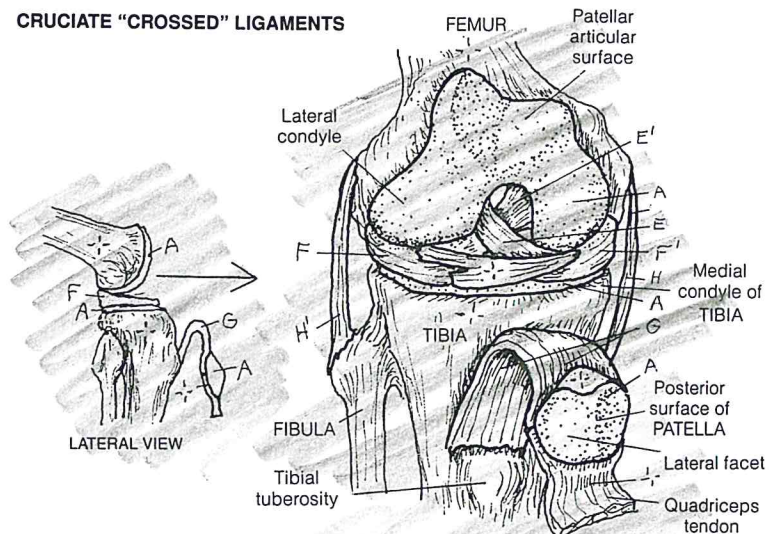
SAGITTAL SECTION



SUPERIOR VIEW OF KNEE JOINT



CRUCIATE "CROSSED" LIGAMENTS



ANTERIOR VIEW OF EXPOSED JOINT