FOREARM BONES

ULNA A

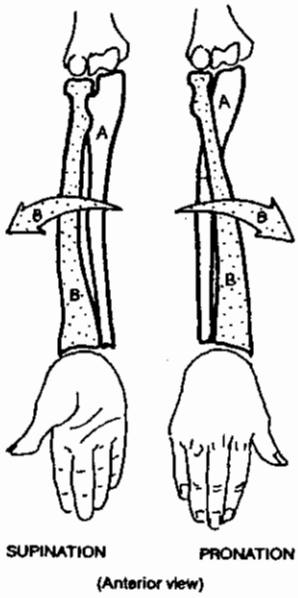
RADIUS B

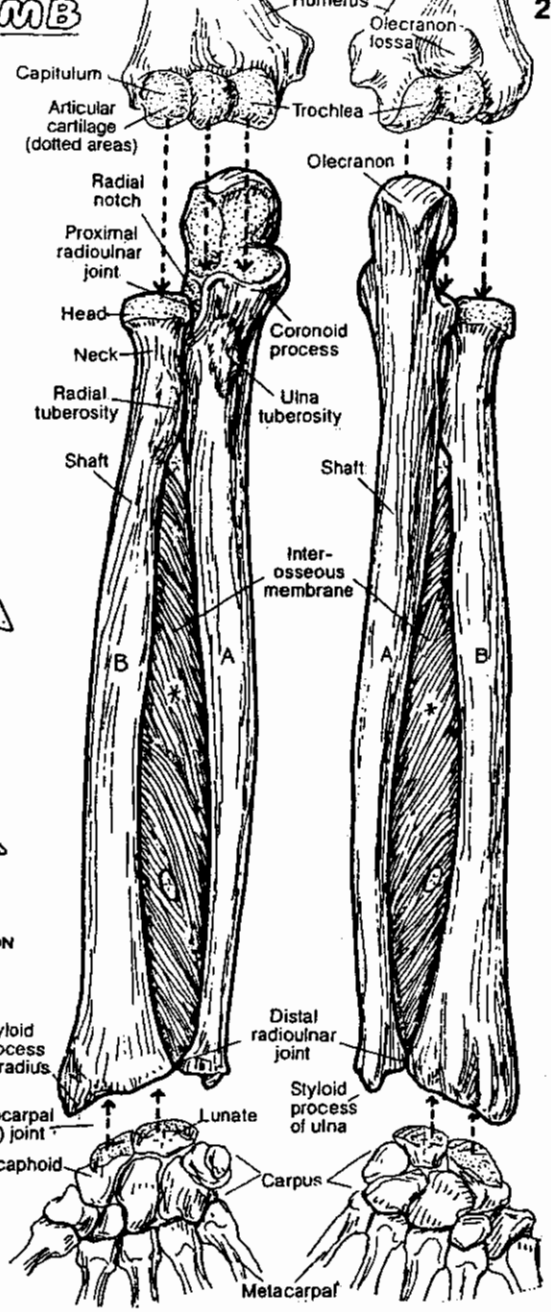
CN: Though the humerus is not colored, the titles and arrows (C) that reflect its participation in the elbow joint should be colored with the same color the bone received on Plate 25. (1) Color the two large views, including the interosseous membrane (gray). (2) Color the four views of the elbow joint. (3) Color the ligaments of the region.

The presence of two bones in the forearm make possible the diverse movements seen at the elbow and reflected in hand motion. The *ulna*, the major, stabilizing forearm bone at the elbow, narrows distally to form an inconsequential joint with the radius (distal radioulnar joint; synovial, pivot-type). The *radius*, smaller above, widens and thickens distally to form the major joint at the wrist (radiocarpal joint; synovial, biaxial, ellipsoid-type). At the elbow, the ulna forms a hinge type synovial *humeroulnar joint* with the trochlea of the humerus, and the radius forms a pivot-type synovial *radiohumeral joint* with the capitulum of the humerus. These joints share the same joint capsule with the proximal *radioulnar joint* (synovial, pivot type) between the radial notch of the ulna and the radial head. The three joints constitute the elbow (cubital) joint.

Rotation of the radius at the elbow (involving two of the three joints at the elbow) rotates the forearm, wrist, and hand without moving the ulna. Movement of the hand to a palm-forward (up) position is supination: movement of the hand to a palm-back (down) position is pronation.

After coloring and studying the supination/pronation and elbow movement diagrams, try this: place the fingers of your left hand on your right olecranon (bump at posterior elbow), elbow flexed so that the palm of your right hand is up (supine). Now rotate (pronate) your right hand so your palm turns away from you, facing down. Move your right hand back and forth in this manner, feeling that the olecranon does not move during these motions. Further, stare at the styloid process of the radius at the base of the right thumb and note that it rotates back and forth with the thumb. You have just demonstrated that the radius moves around the ulna during pronation/supination, and that joint movement occurs at the radiohumeral and proximal radioulnar joints.



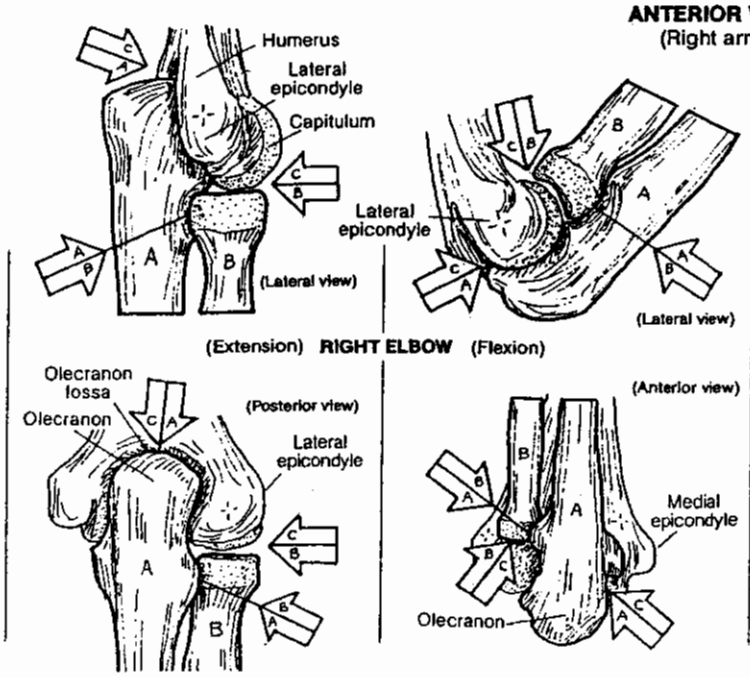


3 JOINTS AT THE RIGHT ELBOW:*

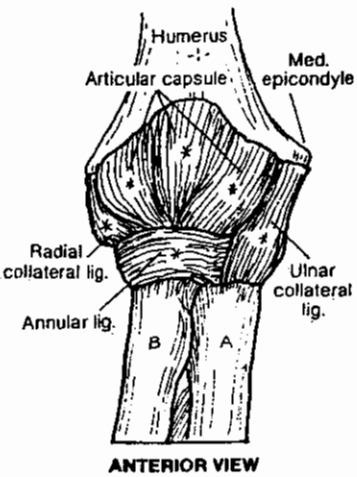
HUMERO-ULNAR C

RADIO-HUMERAL A

RADIO-ULNAR B

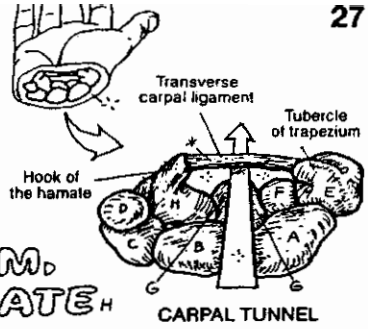


LIGAMENTS*



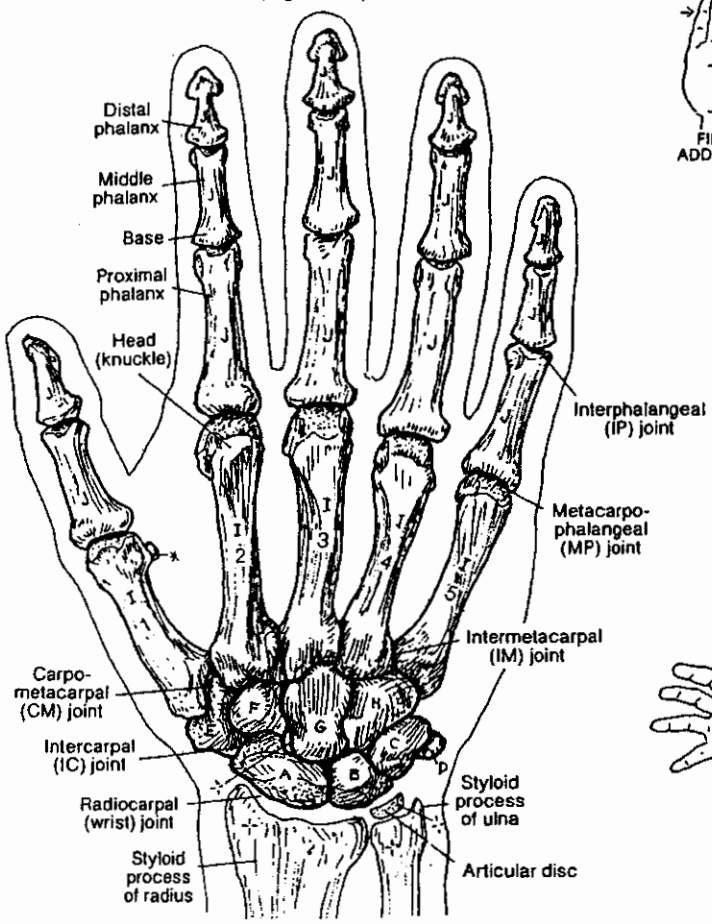
III. SKELETAL SYSTEM / UPPER LIMB
WRIST AND HAND BONES

CN: Use two light colors other than those used on Plates 25 and 26 for I and J. (1) Color each bone, or bone group, in all three major views simultaneously. Note the hand drawings which demonstrate movements at the joints. (2) Color the bones and ligament of the carpal tunnel. You may wish to color those bones in their location in the hand to the left.

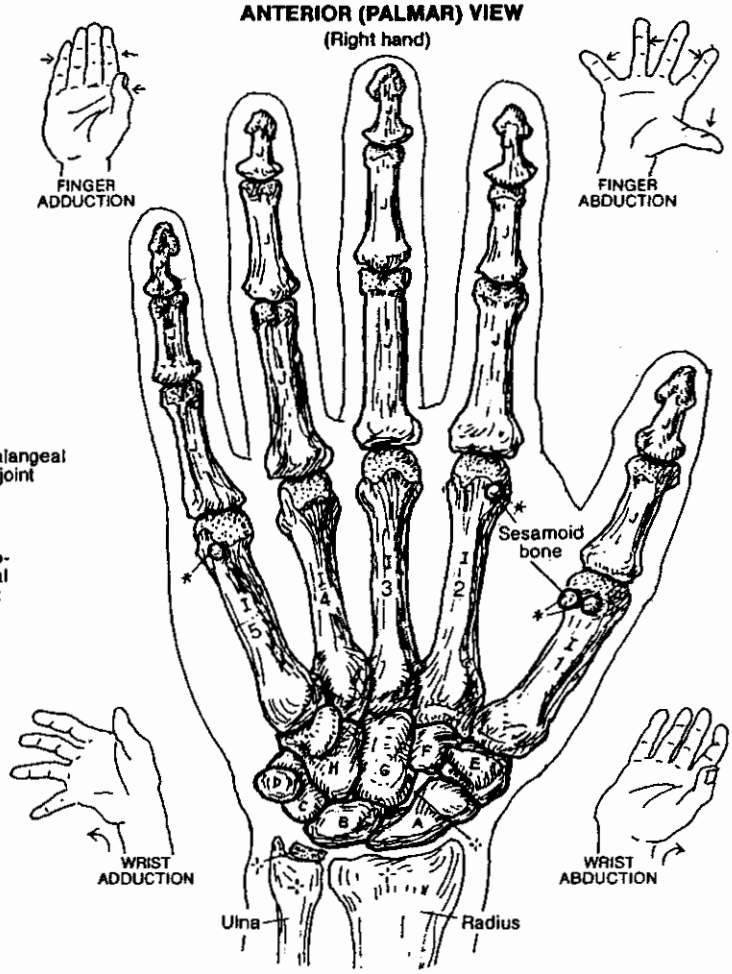


CARPALS (8):*
SCAPHOID$_A$ LUNATE$_B$ TRIQUETRUM$_C$ PISIFORM$_D$
TRAPEZIUM$_E$ TRAPEZOID$_F$ CAPITATE$_G$ HAMATE$_H$
METACARPALS (5)$_I$ PHALANGES (14)$_J$

POSTERIOR (DORSAL) VIEW
(Right hand)



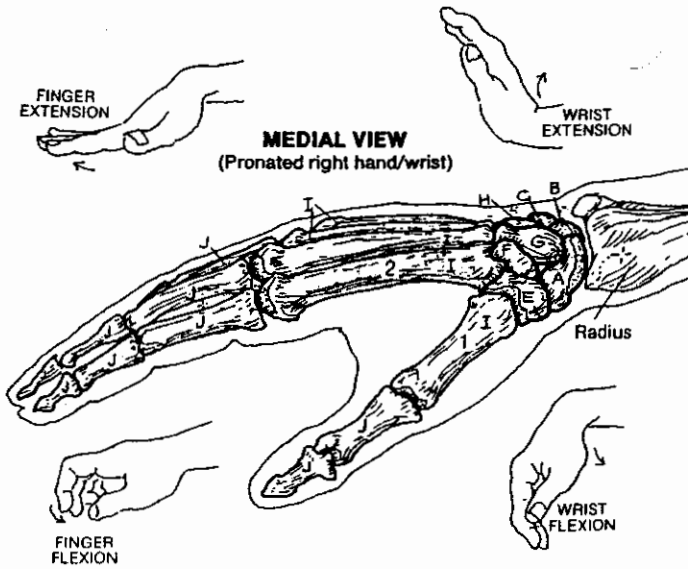
ANTERIOR (PALMAR) VIEW
(Right hand)



The hand is a most remarkable, highly evolved, mechanical device. Movement of the hand and wrist is made possible by the architecture of the joints among the bones. The wrist joint is formed by the distal articular surface of the radius and the distal surface of the articular disc (just distal to the ulna) with the proximal articular surfaces of the *scaphoid, lunate,* and *triquetrum* bones. Forces transmitted from a fall on the hand to the wrist pass largely through the scaphoid, lunate, and radius; thus, fractures of the scaphoid and distal radius are common.

Crossing the wrist bones between the hook of the *hamate/pisiform* and the tubercle of the *trapezium*/scaphoid bones, the thin, broad transverse carpal ligament (flexor retinaculum) creates a carpal tunnel through which pass the long flexor tendons to the fingers and thumb as well as the median nerve. Compression of the nerve there can cause numbness in the radial three fingers (thumb, index, middle) and some weakness in the thumb (carpal tunnel syndrome).

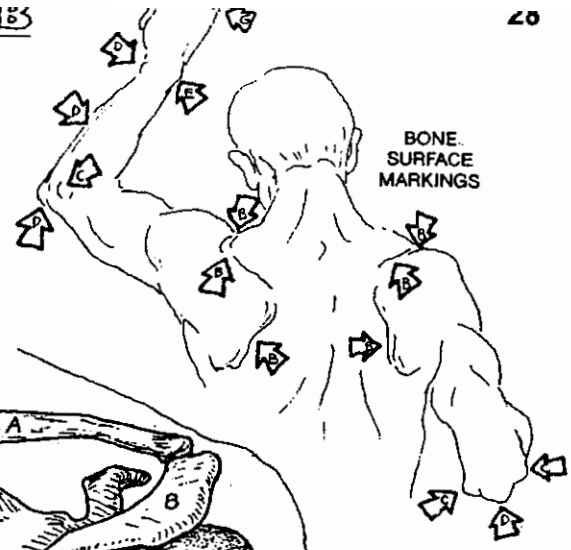
Using your own hand, note that the interphalangeal (IP) joints are limited to movements of flexion/extension. The metacarpophalangeal (MP) joints permit the added movements of finger adduction/abduction. Of the carpometacarpal (CM) joints, the first (thumb) has exceptional movement (saddle type, synovial); when moving the thumb toward the little finger in an arcing motion, note that the thumbnail rotates 90°, reflecting medial rotation of the first metacarpal on the *trapezium.*

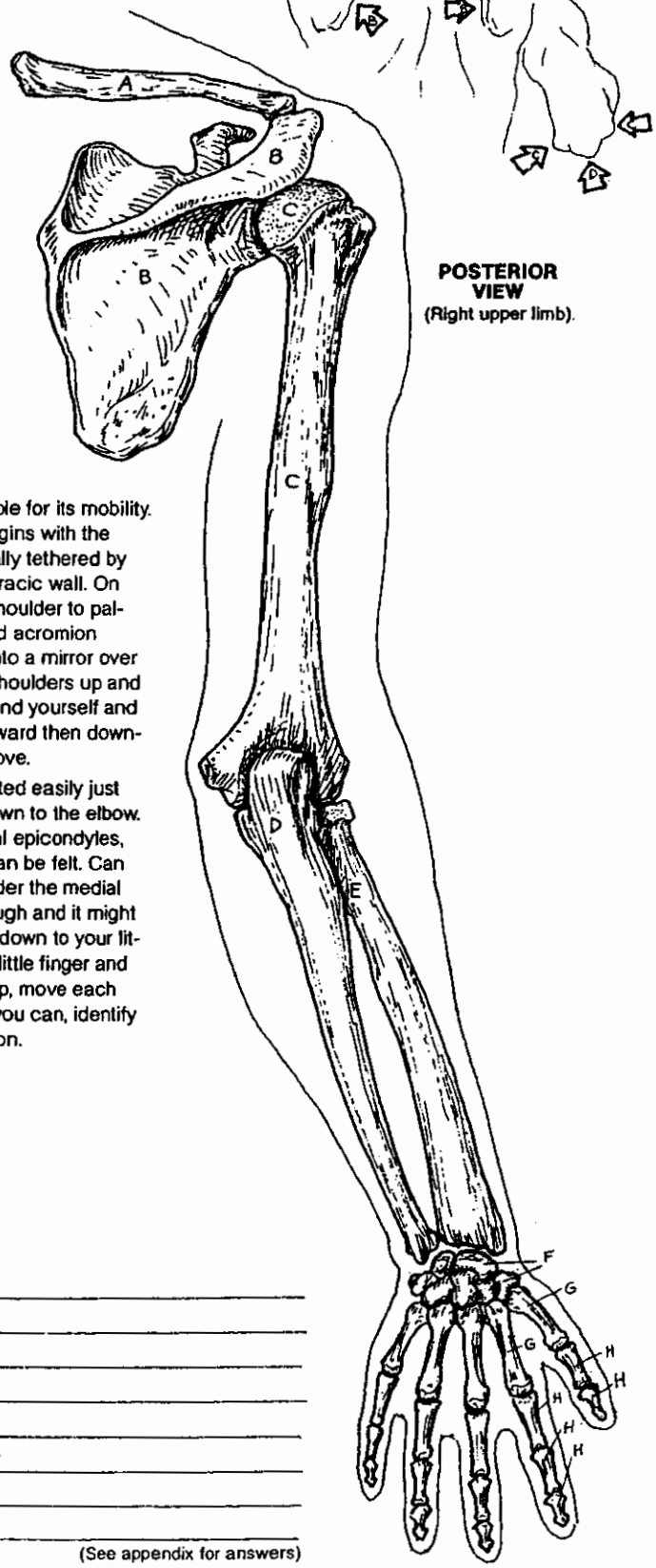


BONES IN REVIEW

CN: For all of these bones, except the carpals (F), use the same colors you used for them on Plates 25, 26, 27. Select a new, light color for F. (1) Color the arrows pointing to places where these bones can be seen or palpated on the surface of the body. (2) You may wish to test your knowledge of joints by writing their names in the spaces provided below. The answers are listed in the Appendix.

CLAVICLE A
SCAPULA B
HUMERUS C
ULNA D
RADIUS E
CARPALS F
METACARPAL G
PHALANX H





The upper limb is remarkable for its mobility. The mechanism for this begins with the scapula which is dynamically tethered by muscle to the posterior thoracic wall. On yourself, reach over your shoulder to palpate the scapular spine and acromion (recall Plate 25). Looking into a mirror over your shoulder, move your shoulders up and down, wrap your arms around yourself and stretch them out, reach upward then downward to see the scapula move.

The humerus can be palpated easily just distal to the shoulder on down to the elbow. There the medial and lateral epicondyles, as well as the olecranon, can be felt. Can you feel the ulnar nerve under the medial epicondyle? Feel hard enough and it might "speak" to you, all the way down to your little finger! Starting with that little finger and working to the thumb and up, move each joint of the upper limb that you can, identify it, and test its range of motion.

REVIEW OF JOINTS*

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____
9 _____
10 _____
11 _____
12 _____
13 _____

(See appendix for answers)

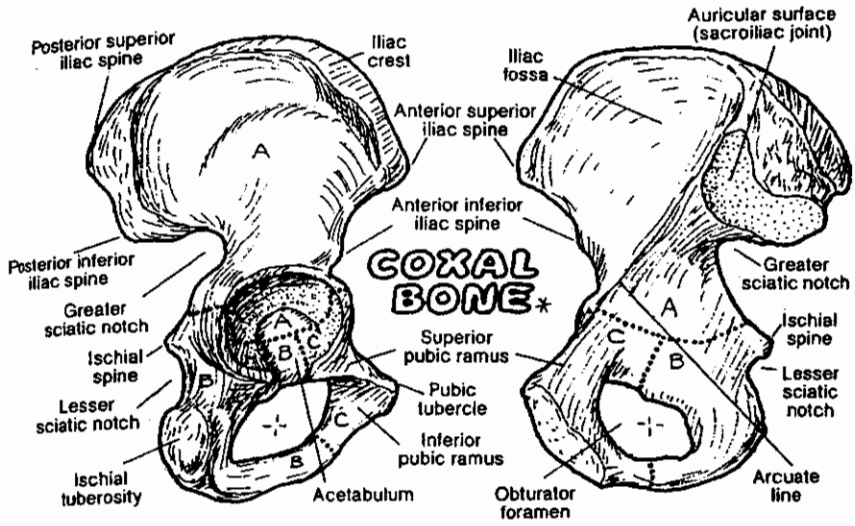
COXAL BONE, PELVIC GIRDLE, & PELVIS

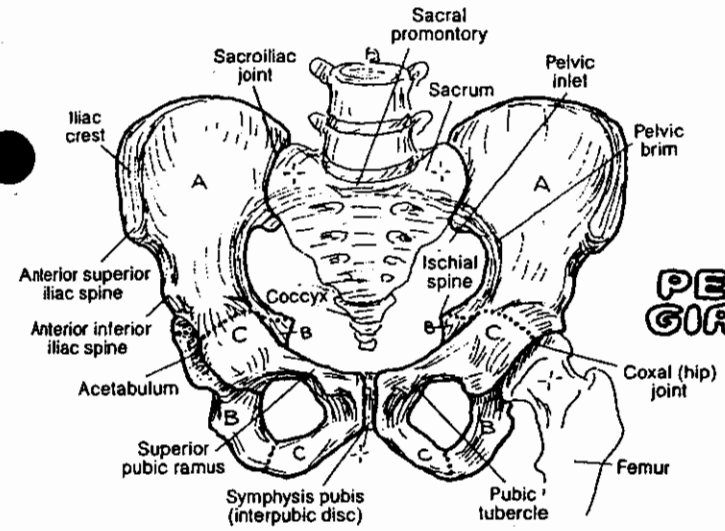
ILIUM A
ISCHIUM B
PUBIS C

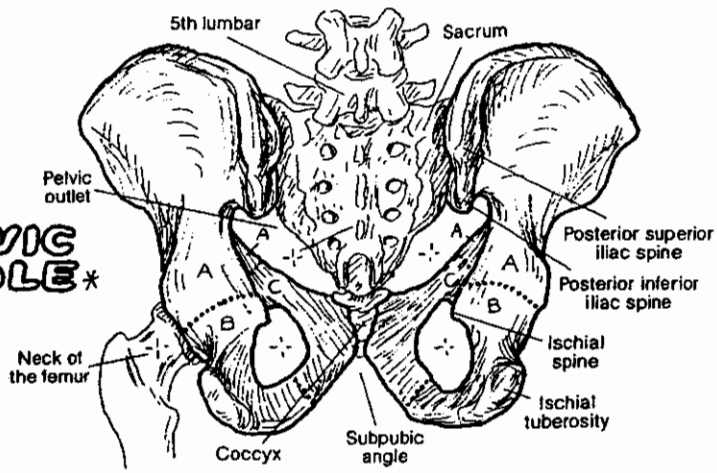
CN: (1) Color the two views of the coxal bone with light colors. Then color the views of the pelvic girdle. (2) Use a new color for bones of the pelvis (D) which includes the sacrum and coccyx. Then color the title *ligaments*, and all the ligaments a light gray color.

The *coxal bone* (hip bone, innominate bone, os coxa) consists of three fused bones in the adult: the *ilium*, the *ischium*, and *pubis*. The paired coxal bones constitute the *pelvic girdle*. The two somewhat-twisted coxal bones form a weightbearing arch with the sacrum and the femoral (thigh) bones, accommodating the body weight and forces imposed vertically up from the feet. The two hip bones and the sacrum constitute the *pelvis*. The pelvic inlet (superior pelvic aperture; from sacral promontory around the arcuate line at the pelvic brim) separates the true (lesser) pelvis below from the false (greater) pelvis above. The pelvic oulet (inferior pelvic aperture) is bound by the same structures as the perineum (see next plate).

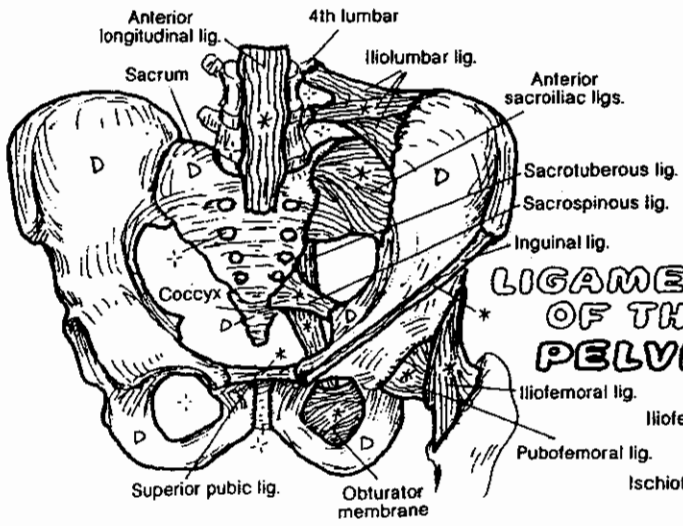
The sacroiliac joint is a movable, partly synovial, partly fibrocartilaginous joint. The articular surfaces are flat but roughened. Note the larger posterior sacroiliac ligaments (compared to the anterior ligaments): they resist downward displacement of the sacrum. The sacrospinous and sacrotuberous ligaments secure the apex of the sacrum to the pelvic girdle, resisting the effects of weightbearing and gravity on the sacroiliac joint. Still, sacroiliac dysfunction is common. The iliolumbar ligaments are often involved in postural low back pain. The symphysis pubis (pubic symphysis, interpubic joint) is a partly movable, cartilaginous joint composed of a fibrocartilaginous disc interposed between cartilaginous articular surfaces.



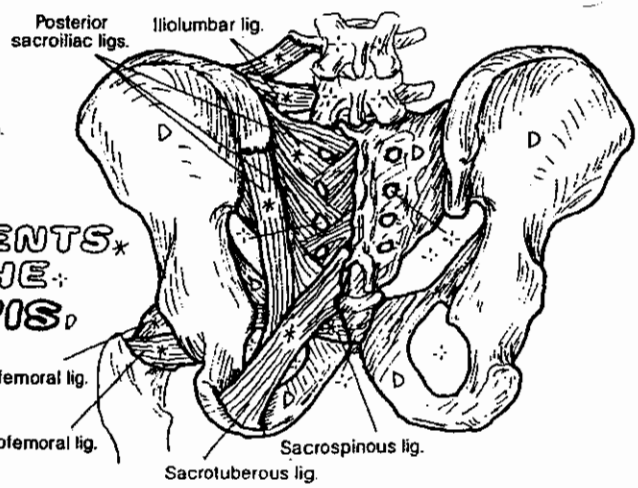




PELVIC GIRDLE*



LIGAMENTS* OF THE PELVIS D

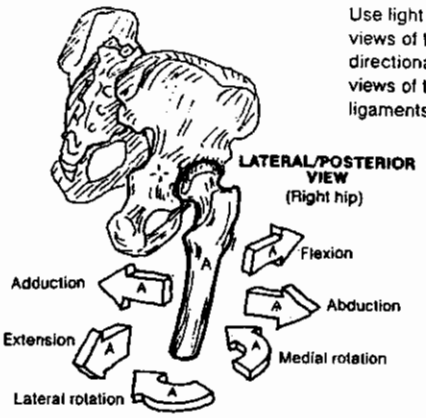


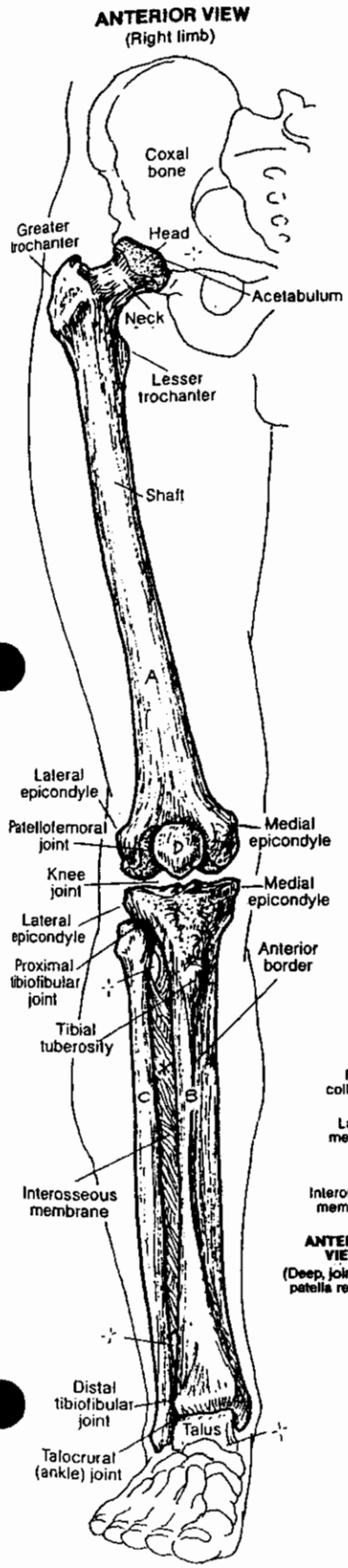
III. SKELETAL SYSTEM / LOWER LIMB

THIGH & LEG BONES

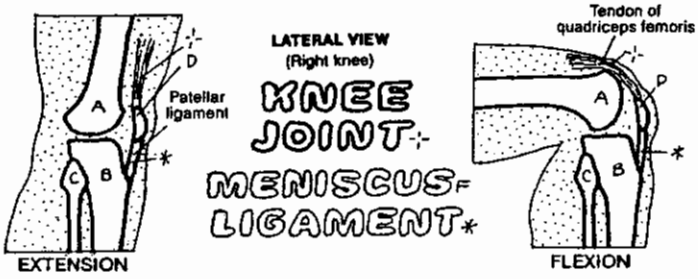
FEMUR A
TIBIA B
FIBULA C
PATELLA D

CN: Do not use the color used for the ilium on Plate 29. Use light colors and a bright color for F. (1) Color the two large views of the lower limb. (2) Next color the femur and the six directional arrows for the hip joint. (3) Color the extension/flexion views of the knee joint. (4) Color the two views of the major ligaments and the menisci of the knee joint.

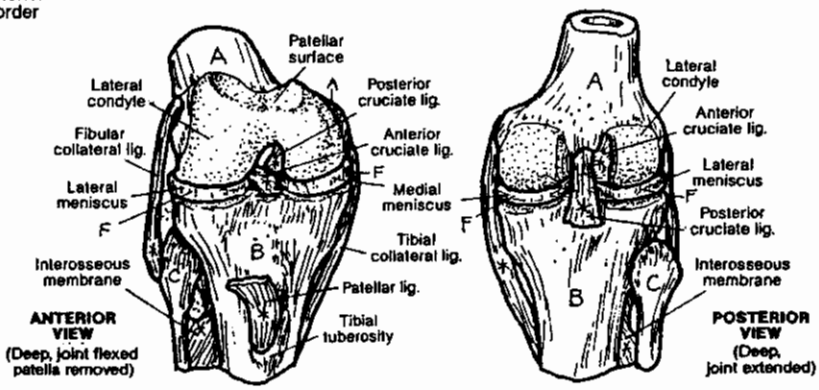




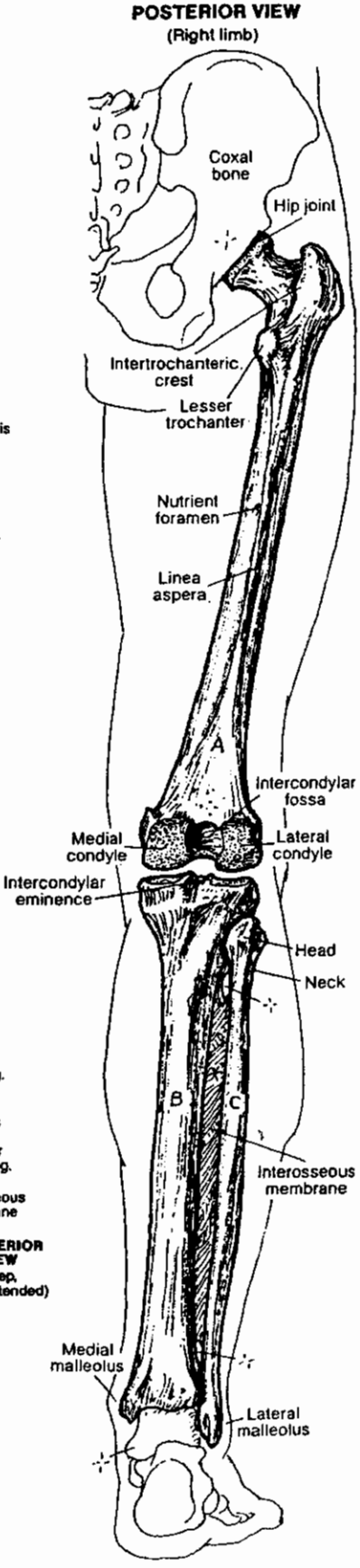
The hip (coxal) joint (multiaxial, ball and socket synovial joint) is concerned with the transmission of considerable weightbearing forces; the head of the femur is particularly subject to pathologic changes with any significant alteration of blood supply (avascular necrosis). The greater trochanter is the site of attachment for several important muscles crossing the hip joint.



The knee (genual) joint consists of two condylar-type, synovial (tibiofemoral) joints between the condyles of the *femur* and the flat, plateau-like articular surfaces on the condyles of the *tibia*. The principal movements at these joints are flexion and extension. The knee joint includes the saddle-type synovial (patellofemoral) joint between the *patella* and femur. The deep surface of the patella is cartilaginous and exhibits medial and lateral facets (note patellar surface of the femur). Premature wear of the patellar cartilage is common (chondromalacia patellae). The patella is a sesamoid bone which develops in the tendon of the quadriceps femoris muscle; as such, it resists the stress imposed on that tendon during knee movements.



The stability of the knee joint comes from ligaments and the muscles crossing the joint. The collateral ligaments resist sideward displacement and rotation. The cruciate (crossing) ligaments resist hyperextension (anterior cruciate) and hyperflexion (posterior cruciate) of the joint. The C-shaped menisci (the medial larger than the lateral) deepen the articulating surfaces of the tibial condyles. Often torn by misuse of the knee joints (rotation and adduction/abduction with weightbearing), the menisci can often be repaired by arthroscopy.

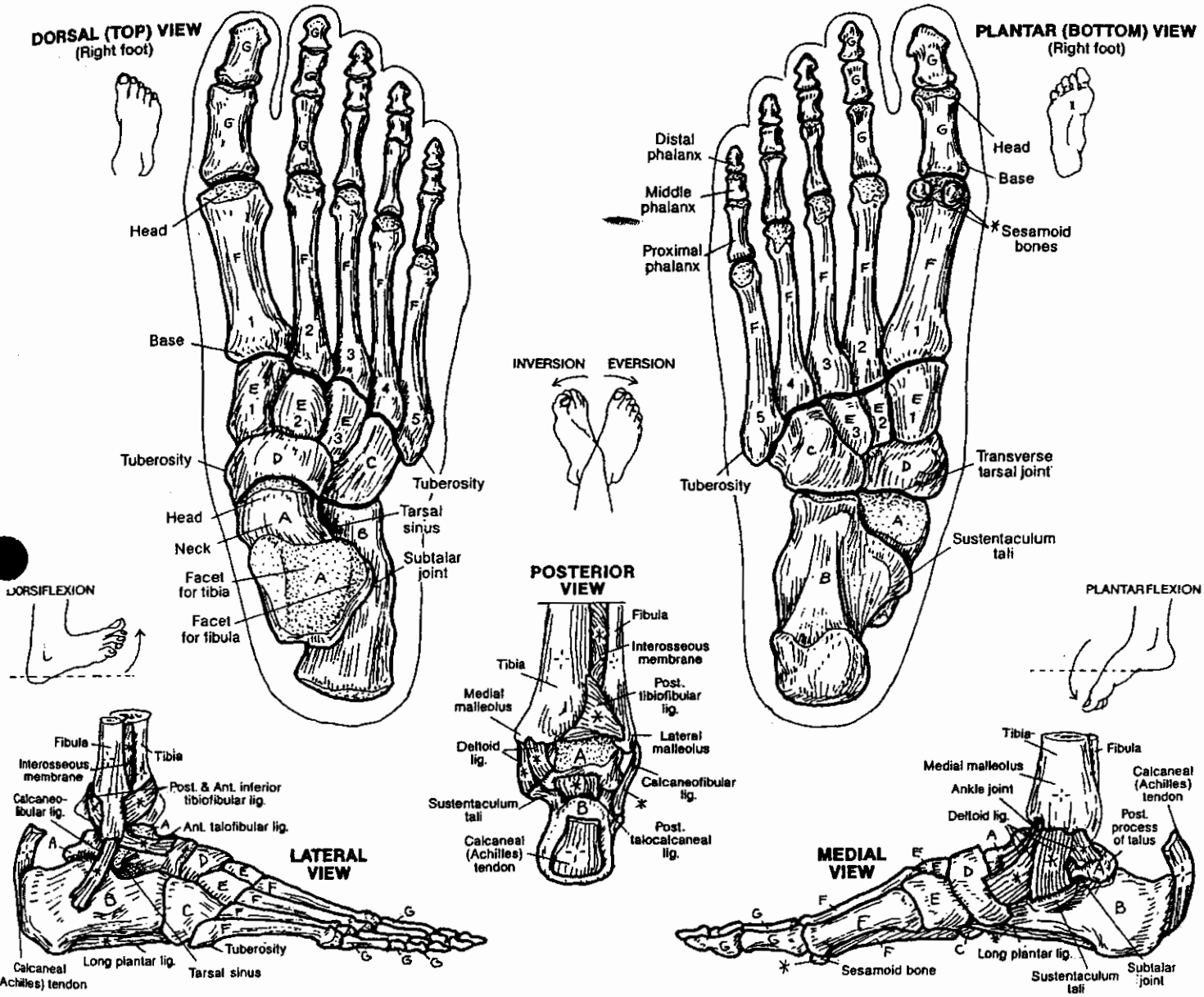


ANKLE & FOOT BONES

TARSALS: (7)*
TALUS A CALCANEUS B
CUBOID C NAVICULAR D
CUNEIFORMS (3) E

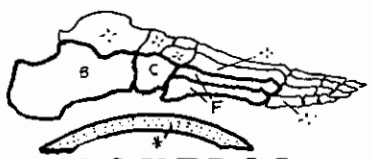
METATARSALS (5) F
PHALANGES (14) G
LIGAMENTS*

CN: Use different colors from those used for the ilium on Plate 29 and for the femur, tibia, fibula, and patella on Plate 30. (1) Begin with the talus (A); color that bone wherever it appears on the plate. Follow that procedure with each of the other bones. (2) Color gray all of the ligaments.



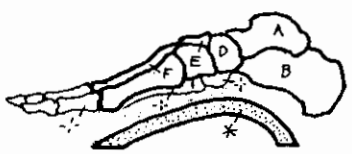
The foot is a mobile, weightbearing structure. The ankle joint (hinge-type synovial joint) between tibia, fibula, and the *talus* forms a mortise, permitting only flexion (plantar flexion) and extension (dorsiflexion) here. With excessive rotation of this joint, characteristic fractures and torn ligaments occur. The foot can adjust to walking/running on tilted surfaces by virtue of the subtalar (talocalcaneal) and transverse tarsal (talocalcaneonavicular and calcaneocuboid) joints. Here inversion and eversion movements occur. The ankle has strong medial ligamentous (deltoid ligaments) and weaker lateral ligamentous support. The relatively high frequency of inversion sprains (tearing the lateral ligaments) over eversion sprains seems to reflect this fact.

The bony architecture of the foot includes a number of arches that are reinforced and maintained by ligaments and influenced by muscles. The *medial longitudinal arch* transmits the force of body weight to the ground when standing and to the great toe in locomotion, creating a giant lever that gives spring to the gait. Both longitudinal arches function in absorbing shock loads and balancing the body.



LATERAL LONGITUDINAL ARCH*

TRANSVERSE ARCH*

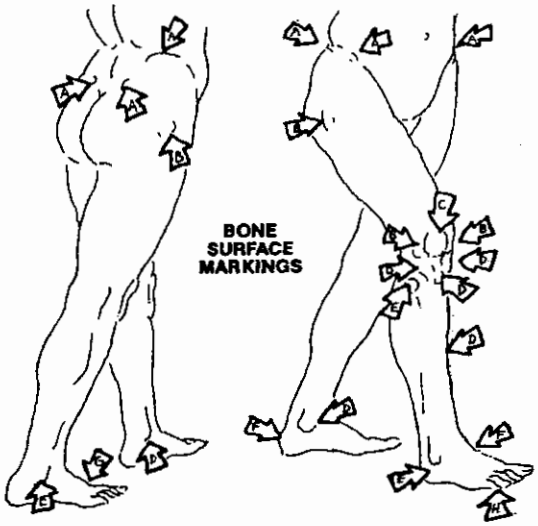


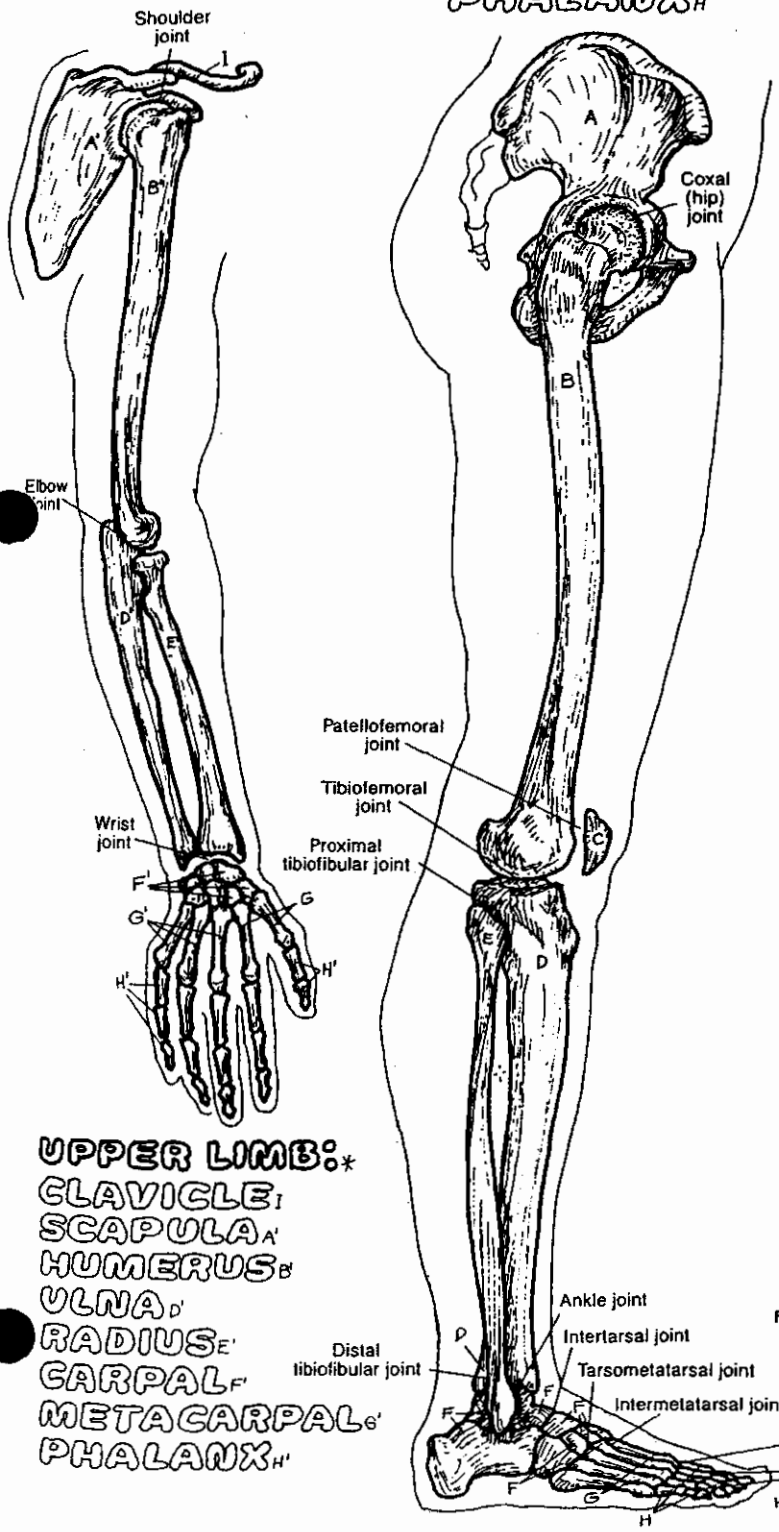
MEDIAL LONGITUDINAL ARCH*

III. SKELETAL SYSTEM/LOWER LIMB
BONES IN REVIEW

CN: Use the same colors for these bones that you used for them on Plates 29–31. In the case of the coxal bone (A), use the color given to the ilium on Plate 29; for the tarsal bones (F), use any one of the tarsal colors. (1) Color the bones of the lower limb, their surface markings, and the corresponding bones on the hind limb of the dog. (2) Color the names and bones of the upper limb and the forelimb of the dog. The clavicle of the dog is not shown in this view.

LOWER LIMB:*
- COXAL A
- FEMUR B
- PATELLA C
- TIBIA D
- FIBULA E
- TARSAL F
- METATARSAL G
- PHALANX H

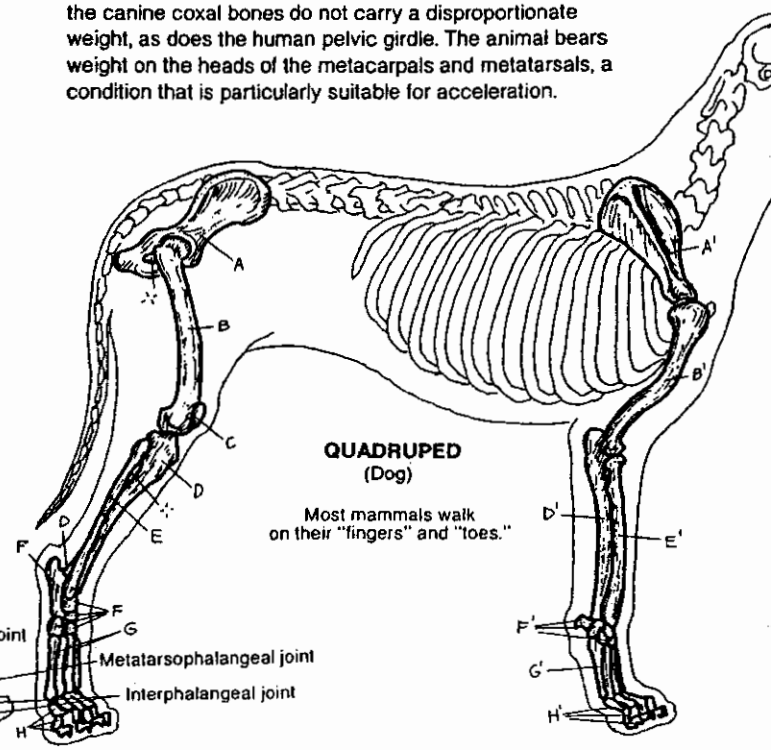




UPPER LIMB:*
- CLAVICLE I
- SCAPULA A'
- HUMERUS B'
- ULNA D'
- RADIUS E'
- CARPAL F'
- METACARPAL G'
- PHALANX H'

The structure of a part reflects an adaptation for function. The truth of this statement is borne out in comparing the bones of the upper and lower limbs in a biped (human) with those of a quadruped. The pectoral girdle provides a basis for mobility; the more sturdy pelvic girdle provides stability in both locomotion and weight bearing. The limb bones of the lower limb are large and solid, consistent with weight-bearing; the related joints are structurally secure, except the knee, which gives up stability for flexibility. In the upper limb, the bones are lighter, and the joints are more flexible and capable of greater ranges of motion (compare shoulder with hip, elbow with knee, wrist with ankle). Although forearm and leg each have two bones, there is little functional correlation between those pairs of bones. The foot is clearly adapted for locomotion and weight bearing, the hand (especially the thumb) for mobility and dexterity.

The quadruped (in this case, the domestic dog) uses both forelimbs and hindlimbs for supporting body weight and locomotion. The girdle (coxal/scapular) bones are adapted for locomotion, and are not as differentiated structurally or functionally as they are in humans. The canine scapula has much less scapulothoracic motion than the human scapula; the canine coxal bones do not carry a disproportionate weight, as does the human pelvic girdle. The animal bears weight on the heads of the metacarpals and metatarsals, a condition that is particularly suitable for acceleration.



QUADRUPED
(Dog)

Most mammals walk on their "fingers" and "toes."

IV. ARTICULAR SYSTEM

CLASSIFICATION OF JOINTS

Bones are connected at joints (articulations), and all bone movements occur at joints. Joints are structurally classified as fibrous, cartilaginous, or synovial. They are functionally classified as immovable, partly movable, or freely movable. The most secure joints are immovable; the most vulnerable are freely movable. The architecture of freely movable joints determines their directions and ranges of motion.

FIBROUS JOINT*
IMMOVABLE$_A$ / PARTLY MOVABLE$_{A'}$

Fibrous joints, where bone is connected to bone by fibrous tissue, are immovable or partly movable. Sutures are *immovable* fibrous joints; so are teeth and their sockets. Syndesmoses, here represented by the interosseous ligament of the forearm, are *partly movable* fibrous joints.

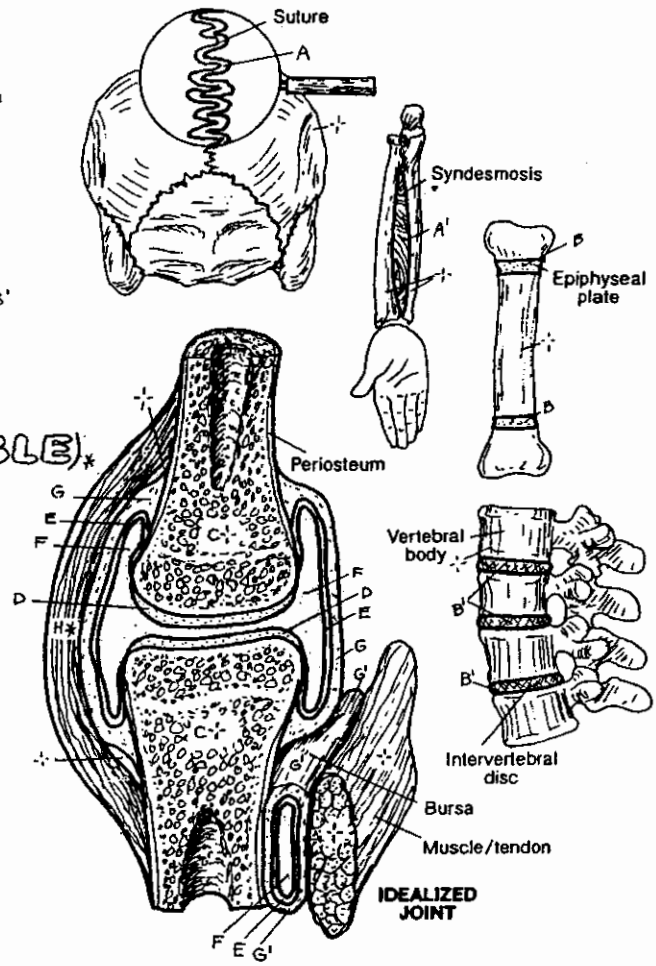
CARTILAGINOUS JOINT*
IMMOVABLE$_B$ / PARTLY MOVABLE$_{B'}$

Cartilaginous joints, where bone is connected to bone by cartilaginous or fibrocartilaginous tissues, are immovable or partly movable. The epiphyseal growth plates are *immovable* cartilaginous joints, replaced by bone at skeletal maturity. The intervertebral discs are *partly movable* fibrocartilaginous joints.

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$_{H}$*

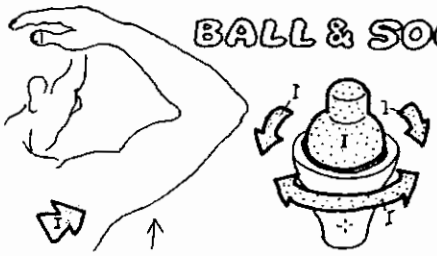
Synovial joints are all *freely movable* within in the limitations of the bony architecture. *Articular bones* are capped with *articular cartilage* at the joint interface. The joint cavity is lined internally with vascular *synovial membrane* (except over the articular cartilage) and secretes a nutrient, lubricating synovial *fluid*. The fibrous, sensitive *joint capsule* is reinforced by *ligaments*. A cushion of synovial membrane reinforced by dense irregular connective tissue can be found interposed between bone and a moving structure (tendon, muscle). Such a device (*bursa*) facilitates friction-free movement.

CN: Use a light blue for D, and dark color for F, and gray for H. (1) Do not color the bones in the upper half of the plate. (2) Below, color the arrows pointing to the location of the joints as well as the joint representations.



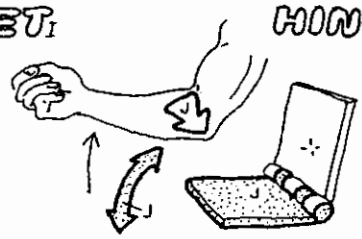
TYPES OF SYNOVIAL JOINTS:*

BALL & SOCKET$_I$



The *ball and socket* joint is best seen at the hip and shoulder joints. Movements in all directions are permitted.

HINGE$_J$

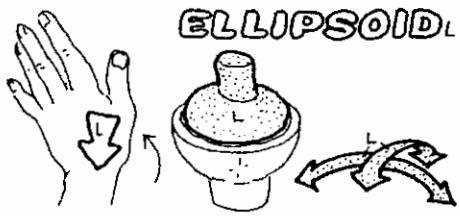


A *hinge* joint permits movement in only one plane: flexion/extension. It can be seen at the ankle, interphalangeal, and elbow (humeroulnar) joints.

SADDLE$_K$

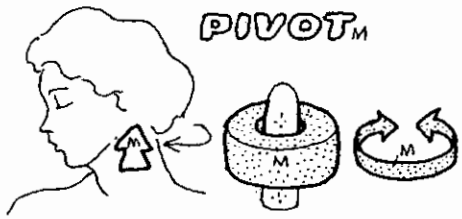
The *saddle* (sellar) joint has two concave surfaces articulating with one another. The carpometacarpal joint of the thumb is the best example of this joint which permits all movements but rotation.

ELLIPSOID$_L$



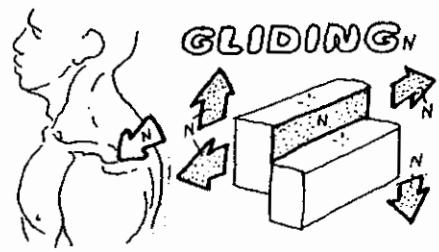
The *ellipsoid* (condyloid, condylar) joint is a reduced ball and socket configuration in which significant rotation is largely excluded, e.g., the bicondylar knee and temporomandibular joints, and radiocarpal (wrist) joints.

PIVOT$_M$



A ring of bone (C1 vertebra) rotating about an axle of bone (odontoid process of C2 vertebra) is a *pivot* joint (atlantoaxial joint). Also the rounded humeral capitulum and the radial head (radiohumeral joint).

GLIDING$_N$



A *gliding* joint consists of generally flat surfaces gliding across one another during movement, such as the facet joints of the vertebrae, acromioclavicular, and intercarpal/intertarsal joints.

IV. ARTICULAR SYSTEM

TERMS OF MOVEMENTS

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

EXTENSION$_A$
DORSIFLEXION$_B$
FLEXION$_C$
PLANTARFLEXION$_D$
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 is to 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 directed 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 medially 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 laterally in the coronal plane.

Circumduction is a circular movement permitted at ball and socket, condylar, and saddle joints. It consists of the movements of flexion, abduction, extension, and adduction performed 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 an external rotation of the radiohumeral joint. In the foot, it is the combined movements of inversion, adduction around a vertical axis, and plantar flexion.

Pronation is an internal rotation of the radiohumeral joint. In the foot, it is the combined movements of eversion, abduction around a vertical axis, and dorsiflexion. The joints involved in both supination and pronation are the tarsal and ankle joints.

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. Both inversion and eversion occur at subtalar (talocalcaneal) and transverse tarsal joints.