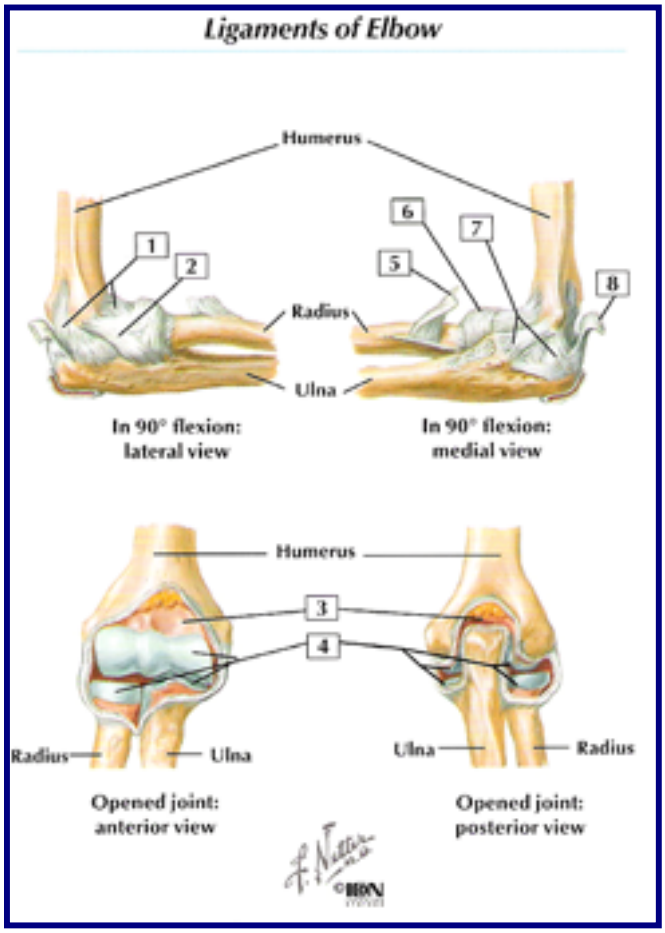
Dissection 4:
Forearm and Hand

Objective 1)
Identify the major processes of the distal humerus, the ulna, the radius and the joints formed by each. Identify the ligaments, joint capsule, the tendons and muscles associated with movement of the elbow joint.



A). Distal Humerus: lateral and medial supracondylar ridges, lateral and medial epicondyles, capitulum (articular surface for head of radius) and trochlea (articular surface for trochlear notch of ulna), olecranon fossa, coronoid fossa, radial fossa

B). Ulna: olecranon (posterior), coronoid process (anterior), trochlear notch, radial notch (lateral), tuberosity of ulna (distal to coronoid process), shaft, head of ulna, and ulnar styloid process

C). Radius: cylindrical head, short neck, radial tuberosity (oval), shaft, ulnar notch of radius, styloid process of radius, dorsal radial tubercle

D). Elbow joint: hinge joint

i. Fibrous capsule: surrounds joint and attaches to humerus at margins of later and medial ends of trochlea and capitulum; anteriorly and posteriorly it carried superiorly to the coronoid process and olecranon

ii. Synovial membrane: lines fibrous capsule and intracapsular space of humerus

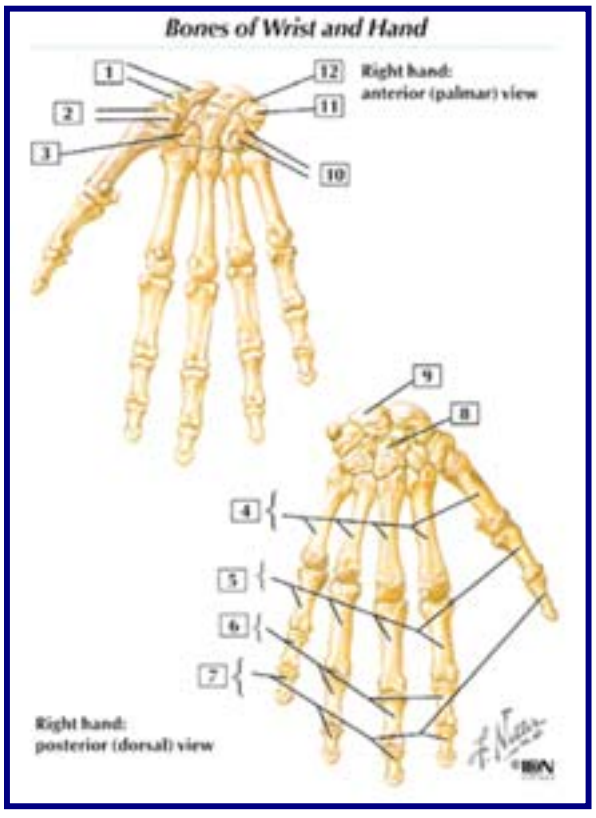
iii. Ligaments:

1. Collateral Ligaments: strong triangular bands that are medial and lateral thickenings of capsule
    a. Radial collateral ligament: extends from lateral epicondyle of humerus and blends distally with anular ligament of radius

b. Ulnar collateral ligament: extends from medial epicondyle of humerus to coronoid process and olecranon of ulna; has 3 bands:
    i. Anterior cordlike band: strongest
    ii. Posterior fanlike band: weakest
    iii. Oblique band: slender and deepens socket for trochlea of humerus
2. Anular ligament of radius: encircles and holds head of radius in radial notch of ulna forming proximal radioulnar joint and permitting pronation and supination of forearm

iv. Tendons and Muscles:
1. Chief flexors: brachialis, biceps brachii, and brachioradialis
2. Chief extensors: triceps brachii, especially medial head, anconeus

Objective 2)
Identify the individual carpal bones on an articulated skeleton or x-ray and indicate the movements possible at the proximal and mid-carpal articular levels and the carpometacarpal joints, the ligaments, joint capsule and joint types illustrated by the articulations. Identify the metacarpal and phalangeal bones, the type of joints formed between them and the ligaments and joint capsule associated with each.



E). Carpal bones:
    i. Proximal row from thumb → medially: scaphoid (boat-shaped), lunate (moon-shaped), triquetrum (3-cornered), pisiform (pea-shaped)
    ii. Distal row form thumb → medially: trapezium (four-sided), trapezoid (wedge-shaped), capitate (bone w/ rounded head), hamate (has hook)

F). Radiocarpal Joint: condyloid type
    i. Movements of proximal carpal articular level: flexion, extension, abduction, adduction, and circumflexion
    ii. Joint capsule: surrounds joint and attaches to distal radius and ulna and proximal row of carpal
    iii. Ligaments:
        1. Anterior and Posterior ligaments: strengthen fibrous capsule

2. Ulnar collateral ligament: attaches to styloid process of ulna and triquetrum
3. Radial collateral ligament: attaches to styloid process of radius and scaphoid

G). Intercarpal Joint: plane type
   i. Movements of mid-carpal articular level: small amount of gliding, flexion and abduction of hand
   ii. Joint capsule: surrounds joints, except pisiform joint, which is separate
   iii. Ligaments:
      1. Anterior and Posterior ligaments
      2. Interosseous ligaments:
         a. Pisohamate ligament: strong fibrous band from pisiform to hook of hamate
         b. Radiate carpal ligament: extends from capitate to scaphoid, lunate, and triquetrum on palmar surface

H). Carpometacarpal joints: plane type, except thumb, which is saddle type
   i. Movements: flexion, extension, abduction, and adduction @ 1st joint, almost no movement @ 2nd and 3rd joints, slight mobility @ 4th joint, and 5th joint very mobile
   ii. Joint capsule: capsule around metacarpal and distal row of carpals
   iii. Ligaments:
      1. Anterior, Posterior, and Interosseous ligaments: interosseous b/w metacarpals → called dorsal and palmar carpometacarpal ligaments

I). Metacarpals: 1-5 from thumb to pinky

J). Phalanges: 14 total; 3 per finger, except thumb → proximal, middle, and distal; thumb had only proximal and distal

K). Metacarpophalangeal joints: b/w metacarpals and proximal phalanges; condyloid type
   i. Movements: flexion, extension, abduction, adduction, circumduction; abduction-adduction limited at thumb
   ii. Joint capsule: surrounds each joint with synovial membrane attaching to margins of each joint
   iii. Ligaments:
      1. Palmar ligaments: attach to phalanges and metacarpals
      2. Deep transverse metacarpal ligaments: unite 2nd to 5th joints that hold heads of metacarpals together
      3. Collateral ligaments: pass from heads of metacarpals to bases of phalanges

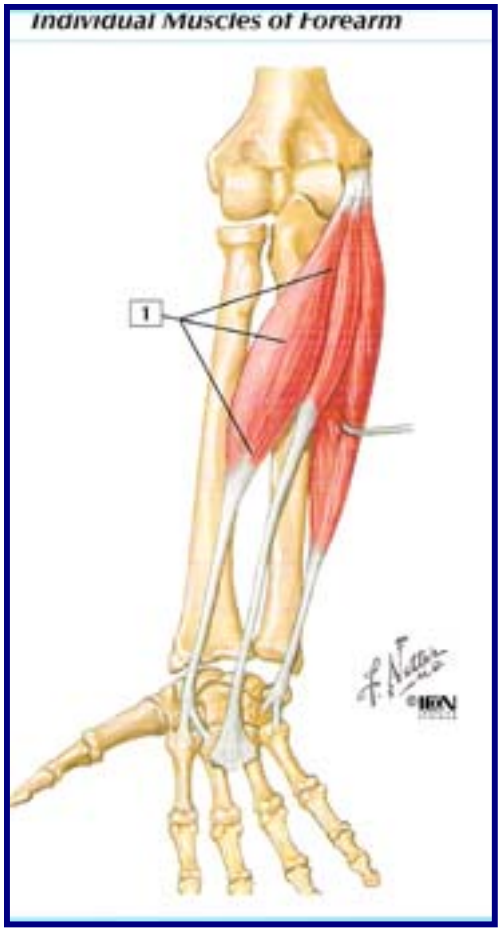
L). Interphalangeal joints: b/w phalanges; hinge type
   i. Movements: flexion, extension
   ii. Joint capsule: surrounds each joint with synovial membrane attaching to margins of each joint
   iii. Ligaments:
      1. Palmar ligaments: attach phalanges
      2. Collateral ligaments: pass from heads of proximal phalanx to bases of distal phalanx

Objective 3)

Identify the individual muscles of the flexor region of the forearm, their actions, innervations and relationships to different fascial layers. Identify the superficial and deep muscles of the extensor region of the forearm. Indicate the innervation and major action of each, the relationship between the extensors of the digits and the lumbrical and interosseous muscles in action.

M). Anterior flexor-pronator muscles of the forearm: (all by median nerve except FCU & ½ FDP)

i. Superficial group:



1. <u>Pronator teres</u>: (part of first layer)
    a. From medial epicondyle of humerus and coronoid process of ulna to middle of lateral surface of radius
    b. Innervated by median nerve
    c. Action: pronates forearm and flexes it (at elbow)
2. <u>Flexor carpi radialis</u>: (part of first layer)
    a. From medial epicondyle of humerus to base of 2nd metacarpal bone
    b. Innervated by median nerve
    c. Action: flexes hand at wrist and abducts it
3. <u>Palmaris longus</u>: (part of first layer)
    a. From medial epicondyle of humerus to distal half of flexor retinaculum and palmar aponeurosis
    b. Innervated by median nerve
    c. Action: flexes hand at wrist and tightens palmar aponeurosis
4. <u>Flexor carpi ulnaris</u>: (part of first layer)
    a. From medial epicondyle of humerus (humeral head) and olecranon and posterior border of ulna (ulnar head) to pisiform bone, hook of hamate, and 5th metacarpal
    b. Innervated by ulnar nerve
    c. Action: flexes hand and adducts it at wrist
5. <u>Flexor digitorum superficialis</u>: (second layer)
    a. From medial epicondyle of humerus, ulnar collateral ligament, and coronoid process (humeroulnar head) and

superior half of anterior border of radius (radial head) to bodies of middle phalanges of medial four digits
    b. Innervated by median nerve
    c. Action: flexes middle phalanges of medial 4 digits; acting more strongly it flexes proximal phalanges of hand

ii. Deep group:
    1. Flexor digitorum profundus: (part of third layer)
        a. From proximal ¾ of medial and anterior surfaces of ulna and interosseous membrane to bases of distal 4 phalanges of medial 4 digits
        b. Innervated by median nerve (lateral part) and ulnar nerve (medial part)
        c. Action: flexes distal phalanges of medial 4 digits; assists with flexion of hand
    2. Flexor pollicus longus: (part of third layer)
        a. From anterior surface of radius and adjacent interosseous membrane to base of distal phalanx of thumb
        b. Innervated by anterior interosseous nerve from median nerve
        c. Flexes phalanges of 1st digit (thumb)
    3. Pronator quadratus: (fourth layer)
        a. From distal ¼ of anterior surface of ulna to distal ¼ of anterior surface of radius
        b. Innervated by anterior interosseous nerve from median nerve
        c. Action: pronates forearm; deep fibers bind ulna and radius together

N). Posterior extensor-supinator muscle of the forearm:
i. Brachioradialis:
    1. From proximal 2/3 of lateral supracondylar ridges of humerus (common extensor attachment) to the lateral surface of distal end of radius
    2. Innervated by radial nerve
    3. Action: **flexes** forearm
ii. Extensor carpi radialis longus:
    1. From lateral supracondylar ridges to base of 2nd metacarpal
    2. Innervated by radial nerve
    3. Action: extend and abduct hand at wrist joint
iii. Extensor carpi radialis brevis:
    1. From lateral supracondylar ridges of humerus (common extensor attachment) to base of 3rd metacarpal
    2. Innervated by deep branch of radial nerve
    3. Action: extend and abduct hand at wrist joint
iv. Extensor digitorum:
    1. From lateral epicondyle of humerus to extensor expansion of medial 4 digits
    2. Innervated by posterior interosseous nerve, a branch of the radial nerve
    3. Action: extends medial 4 digits at MCP joints; extends hand at wrist joint
v. Extensor digiti minimi:

1. From lateral epicondyle of humerus to the extensor expansion of 5th digit
2. Innervated by posterior interosseous nerve, a branch of the radial nerve
3. Action: extends 5th digit at MCP and Interphalangeal joints

vi. Extensor carpi ulnaris:
1. From lateral epicondyle ridges of humerus and posterior border of ulna to base of 5th metacarpal
2. Innervated by posterior interosseous nerve, a branch of the radial nerve
3. Action: extends and adducts hand at wrist joint

vii. Anconeus:
1. From lateral epicondyle of humerus to lateral surface of olecranon and superior part of posterior surface of ulna
2. Innervated by radial nerve
3. Action: helps triceps brachii extend forearm, stabilizes forearm, and abducts ulna during pronation

viii. Supinator:
1. From lateral epicondyle of humerus, radial collateral and anular ligaments, supinator fossa, and crest of ulna to the lateral, posterior, and anterior surfaces of proximal 1/3 of radius
2. Innervated by deep branch of radial nerve
3. Action: supinates forearm

ix. Abductor pollicus longus:
1. From posterior surfaces of ulna, radius, and interosseous membrane to base of 1st metacarpal
2. Innervated by posterior interosseous nerve, a branch of the radial nerve
3. Action: abducts thumb and extends it at carpometacarpal joint

x. Extensor pollicus brevis:
1. From posterior surfaces of radius and interosseous membrane to base of proximal phalanx of thumb
2. Innervated by posterior interosseous nerve, a branch of the radial nerve
3. Action: extends proximal phalanx of thumb at carpometacarpal joint

xi. Extensor pollicus longus:
1. From posterior surfaces of middle 1/3 of ulna and interosseous membrane to base of distal phalanx of thumb
2. Innervated by posterior interosseous nerve, a branch of the radial nerve
3. Action: extends distal phalanx of thumb at MCP and IP joints

xii. Extensor indicis:
1. From posterior surface of ulna and interosseous membrane to extensor expansion of 2nd digit
2. Innervated by posterior interosseous nerve, a branch of the radial nerve
3. Action: extends 2nd digit and helps to extend the hand

O). Relationship between the extensors of the digits and the lumbrical and interosseous muscles in action:

i. The lumbricals and interosseous muscles attach to the extensor expansions ("dorsal hoods") of the digit extensor tendons
ii. The digit extensors extend the digits at the MCP and IP joints, while the lumbricals flex the digits at the MCP joints and extend them at the IP joints, and the interosseous muscles do the same, as well as adduct and abduct the digits.

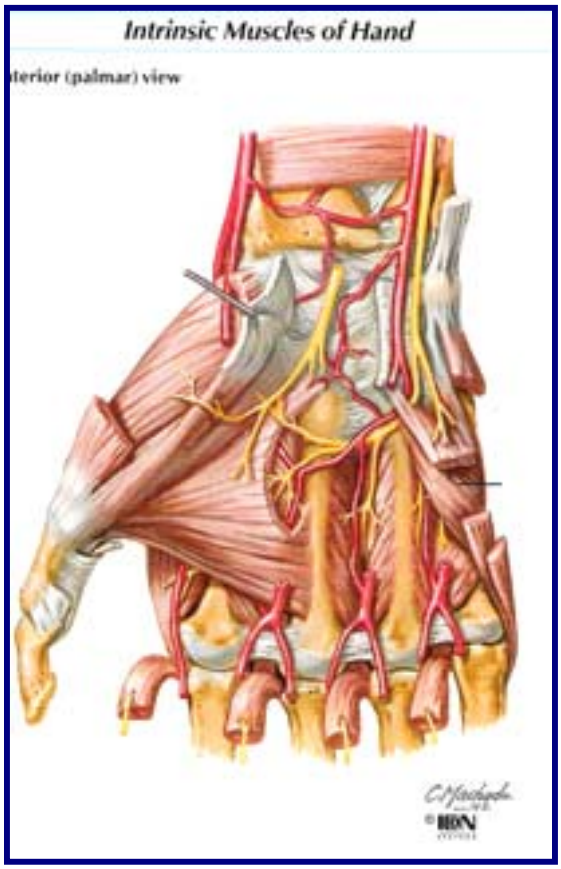
Objective 4)
Identify the extrinsic and intrinsic muscles on the palmar surface of the hand. Indicate the primary action of each and the interaction of extrinsic and intrinsic muscles in producing hand movements.

P). Thenar muscles:

i. Abductor pollicus brevis:
   1. From flexor retinaculum and tubercles of scaphoid and trapezium to lateral side of proximal phalanx of thumb
   2. Innervated by recurrent branch of median nerve
   3. Action: abducts thumb and helps oppose it

ii. Flexor pollicus brevis:
   1. From flexor retinaculum and tubercles of scaphoid and trapezium to lateral side of proximal phalanx of thumb
   2. Innervated by recurrent branch of median nerve
   3. Action: flexes thumb

iii. Opponens pollicus:
   1. From flexor retinaculum and tubercles of scaphoid and trapezium to lateral side of 1st metacarpal
   2. Innervated by recurrent branch of median nerve
   3. Action: draws 1st metacarpal bone laterally to oppose thumb toward center of palm and rotates it medially



iv. Adductor pollicis:
   1. From bases of 2nd and 3rd metacarpals, capitate, and adjacent carpals (oblique head) and anterior surface of body of 3rd metacarpal (transverse head) to medial side of proximal phalanx of thumb
   2. Innervated by deep branch of ulnar nerve
   3. Action: adducts thumb toward middle digit

v. Palmaris brevis

Q). Hypothenar muscles:
- i. Abductor digiti minimi:
  1. From pisiform to medial side of base of proximal phalanx of digits
  2. Innervated by deep branch of ulnar nerve
  3. Action: abducts 5th digit
- ii. Flexor digiti minimi brevis:
  1. From hook of hamate and flexor retinaculum to medial side of base of proximal phalanx of digits
  2. Innervated by deep branch of ulnar nerve
  3. Action: flex proximal phalanx of 5th digit
- iii. Opponens digiti minimi:
  1. From hook of hamate and flexor retinaculum to medial border of 5th metacarpal
  2. Innervated by deep branch of ulnar nerve
  3. Action: draws 5th metacarpal anteriorly and rotates it, bringing digit 5 into opposition w/ thumb

R). Short muscles:
- i. Lumbricals 1 and 2:
  1. From lateral 2 tendons of flexor digitorum profundus to the lateral sides of extensor expansions of digits 2-5
  2. Innervated by median nerve
  3. Action: flexes the digits at the MCP joints and extends them at the IP joints
- ii. Lumbricals 3 and 4:
  1. From medial 3 tendons of flexor digitorum profundus to the lateral sides of extensor expansions of digits 2-5
  2. Innervated by deep branch of the ulnar nerve
  3. Action: flexes the digits at the MCP joints and extends them at the IP joints
- iii. Dorsal interosseoi 1-4:
  1. From adjacent sides of 2 metacarpals (bipennate muscles) to extensor expansions and bases of proximal phalanges of digits 2-4
  2. Innervated by deep branch of the ulnar nerve
  3. Action: abducts digits from axial line and acts with the lumbricals to flex the digits at the MCP joints and extend them at the IP joints
- iv. Palmar interosseoi 1-3:
  1. From palmar surfaces of 2nd, 4th, and 5th metacarpals (unipennate muscles) to extensor expansions and bases of proximal phalanges of digits 2, 4, and 5
  2. Innervated by deep branch of the ulnar nerve
  3. Action: adducts digits 2, 4, and 5 toward axial line and acts with the lumbricals to flex the digits at the MCP joints and extend them at the IP joints

S). Movements of thumb and hand:
- i. Thumb:
  1. Abduction: abductor pollicus longus and abductor pollicus brevis
  2. Adduction: adductor pollicus
  3. Flexion: flexor pollicus longus and flexor pollicus brevis
  4. Extension: extensor pollicus longus, extensor pollicus brevis, and abductor pollicus longus

5. Opposition: opponens pollicus, flexor pollicus brevis, adductor pollicus, and flexor pollicus longus to increase pressure of pulp b/w fingers

ii. Hand:
1. Abduction: extensor carpi radialis longus, extensor carpi radials brevis, and flexor carpi radialis
2. Adduction: flexor carpi ulnaris and extensor carpi ulnaris
3. Flexion: flexor carpi ulnaris, flexor carpi radialis, palmaris longus, and flexor digitorum profundus
4. Extension: extensor carpi radialis longus, extensor carpi radials brevis, extensor digitorum, extensor carpi ulnaris, and extensor indicis

iii. Fingers:
1. Abduction: abductor digiti minimi and dorsal interosseoi 1-4
2. Adduction: palmar interosseoi 1-3
3. Flexion: flexor digitorum superficialis, flexor digitorum profundus, lumbricals 1-4 and dorsal and palmer interosseoi (at MCP joints only)
4. Extension: extensor digitorum, extensor digiti minimi, extensor indicis, lumbricals 1-4 and dorsal and palmer interosseoi (at IP joints only)

Objective 5)
Trace the course of sensory and motor innervation to the forearm and the hand and predict the functional deficit (motor and sensory) expected following destruction or injury to one of the major nerve trunks.

T). Median nerve: (principle nerve of the anterior flexor-pronator compartment of the forearm
i. Course: Enters forearm lateral to brachial artery→ leaves the cubital fossa by passing b/w the heads of the pronator teres and runs deep to the flexor digitorum superficialis and superficial to the flexor digitorum profundus down the forearm→ near wrist, it becomes superficial passing b/w the tendons of the flexor carpi radialis and flexor digitorum superficialis, deep to the palmaris longus tendon → Enters hand deep to flexor retinaculum.
ii. Motor: Innervates all muscles of the anterior compartment of the forearm, except the flexor carpi ulnaris and medial part of the flexor digitorum profundus, the thenar muscles via **recurrent branch**, and the lumbricals 1-2 via **lateral branch and medial branch**.
iii. Sensory: Innervates the anterior surface of thumb and lateral side of index finger via **lateral branch**, adjacent sides of index finger and middle finder and ring fingers via **medial branch**, and palm b/w thumb and ring finger via **palmar cutaneous branch**.

U). Ulnar nerve:
i. Course: Posterior to medial epicondyle of humerus and enters forearm b/w heads of flexor carpi ulnaris → descends through forearm b/w flexor carpi ulnaris and flexor digitorum profundus → superficial in distal part of forearm and passes superficial to flexor retinaculum.

ii. Motor: Innervates flexor carpi ulnaris and medial part of the flexor digitorum profundus and hypothenar muscles, adductor pollicis, lumbricals 3-4, and all interosseoi via **deep branch**.
iii. Sensory: Innervates skin of one and ½ medial digits posteriorly via **superficial branch** and anteriorly via **palmar cutaneous branch**.

V). Radial nerve:
i. Course: Passes into cubital fossa and descends b/w brachialis and brachioradialis; at level of lateral epicondyle of humerus, it divides into superficial and deep branches. The **superficial branch** passes distally, anterior to pronator teres and deep to brachioradialis; pierces deep fascia at wrist and passes into dorsum of hand. The deep branch winds around the neck radius in supinator and enters posterior compartment as posterior interosseous nerve The posterior interosseous nerve passes deep to extensor pollicus longus and ends on interosseous membrane.
ii. Motor: All muscles of posterior compartment of forearm → brachioradialis, extensor carpi radialis longus, and anconeus via **radial nerve**, extensor carpi radialis brevis and supinator via **deep branch**, and extensor digitorum, extensor digiti minimi, extensor carpi ulnaris, abductor pollicus longus, extensor pollicus brevis, extensor pollicus longus, and extensor indicis via **posterior interosseous nerve**.
iii. Sensory: Innervates lateral side of arm, posterior side of forearm, and posterior wrist via **posterior cutaneous nerve of forearm**.

W). Later cutaneous branch of forearm: Continuation of musculocutaneous nerve and innervates lateral side of forearm and wrist.

X). Medial cutaneous branch of forearm: From medial cord of brachial plexus and innervates medial side of forearm.

Objective 6)
Trace the flow of blood (arterial and venous [superficial and deep]) through the forearm and hand, indicating the different sources of this vascular network and known collateral connections. Follow the course of lymph vessels and note the location of lymph nodes (whether or not they are present in your cadaver) from the hand and forearm to the elbow.

Y). Arterial blood flow:
i. Brachial artery at cubital fossa →
1. Ulnar artery: larger terminal branch of brachial artery in cubital fossa. Passes inferomedially and then directly inferiorly, deep to pronator teres, palmaris longus, and flexor digitorum superficialis to reach medial side of forearm; passes superficial to flexor retinaculum at wrist and gives deep palmar branch to deep arch and continues as superficial palmar artery.
2. Radial artery: smaller terminal branch of brachial artery in cubital fossa. Runs inferiolaterally under cover of brachioradialis and distally lies lateral to flexor carpi radialis tendon; winds around lateral aspect of radius and crosses floor of anatomical snuff box to pierce fascia; ends by forming deep palmer arch with deep branch of ulnar artery.
ii. Ulnar artery →

1. Anterior and posterior ulnar recurrent arteries: Branch off of ulnar artery just distal to elbow. Anterior recurrent passes superiorly and posterior recurrent passes posteriorly to anastomose with ulnar collateral and interosseous recurrent arteries.
2. Common interosseous artery: Branch off of ulnar artery just distal to bifurcation of brachial artery. Terminates into anterior and posterior branches.
    a. Anterior and posterior interosseous arteries: Anterior interosseous runs anterior to the membrane and supplies both the anterior and posterior compartments. Posterior interosseous runs posterior to the membranes and gives rise to interosseous recurrent artery, which anastomoses around the elbow.
3. Dorsal and palmar carpal branches: Branch off ulnar artery at wrist to anastomose with corresponding branches of radial artery to form dorsal and palmar carpal arches providing collateral circulation to wrist.

iii. Radial artery →
1. Radial recurrent artery: Branches of lateral side of radial artery just distal to its origin. Ascends on supinator and then passes b/w brachioradialis and brachialis.
2. Dorsal and palmar carpal branches: Branches of radial artery at wrist to anastomose with corresponding branches of ulnar artery to form dorsal and palmar carpal arches providing collateral circulation to wrist.

iv. Hand:
1. Superficial palmar arch: Direct continuation of ulnar artery into hand and curves laterally deep to palmaris aponeurosis and superficial to long flexor tendon. The curve of the arch lies across the palm at level of distal border of extended thumb. Completed by superficial branch of radial artery or another of its braches.
2. Deep palmar arch: Direct continuation of radial artery into the hand and curves medially deep to long flexor tendons and is in contact with bases of metacarpals. Completed by deep branch of ulnar artery.
3. Common palmar digitalis arteries: Branches off superficial palmar arch and passes distally on lumbricals to webbings of digits.
4. Proper palmar digitalis arteries: Branches off common palmar digitalis arteries and run along sides of digits 2-5.
5. Princeps pollicis: Branches off radial artery as it turns into palm. Descends on palmar aspect of 1st metacarpal and divides at the base of proximal phalanx into two branches that run along sides thumb.
6. Radialis indicis: Branches off radial artery or princeps pollicis. Passes along lateral side of index finger to its distal end.
7. Dorsal carpal arch: Branches from radial and ulnar arteries. Arches w/in fascia on dorsum of hand.

Z). Venous drainage:

i. **Superficial and deep palmar venous arches** accompany the superficial and deep palmar arches, respectively. The dorsal digital veins drain into 3 **dorsal metacarpal veins**, which unite to form a **dorsal venous network**. The lateral aspect gives rise to the **cephalic vein** that has **perforating veins** that connect it to deep veins, and the medial side gives rise to the **basilic vein**, which goes deep to merge with other accompanying veins and eventually form the axillary vein. The cephalic vein and basilic vein communicate at the **median cubital vein**, which is in the anterior side of the elbow. The **median vein of the forearm** ascends the forearm b/w the other two veins, and it may join the basilic vein in the cubital fossa.

ii. Deep veins that accompany the deep arteries (ulnar and radial arteries) accomplish deep drainage of the forearm.

AA). Lymph flow: **Superficial lymphatic vessels** arise from lymphatic plexuses in the fingers, palm, and dorsum of the hand and ascend with the superficial veins. The lymphatics accompanying the cephalic vein will enter the **apical group of axillary lymph nodes** or **deltopectoral lymph nodes**. Lymphatics accompanying the basilic vein will go into the **cubital lymph nodes** in the cubital fossa and go to the humeral group of the **axillary lymph nodes**. **Deep lymphatic vessels**, which are less numerous, accompany major deep veins and terminate in the humeral group of axillary lymph nodes.