

**THE "HAND" IN HANDWRITING:
ANATOMY AND NEUROPHYSIOLOGY**

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"The human hand is so beautifully formed, its actions are so powerful, so free and yet so delicate that there is no thought of its complexity as an instrument; we use it as we draw our breath, unconsciously."

Sir Charles Bell, 1833, cited in The Hand by Frank R. Wilson

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Anatomy

Df. structures of the body and how they physically relate to one another

Anatomical position - the body standing upright, facing the observer, with feet flat on the floor, arms hanging at the sides, and palms facing forwards.

Bones

Fingers - 14 **See: Anatomy Plate 27**

Hand - 5

Wrist - 8

Forearm - 2 **See: Anatomy Plate 26**

Arm - 1

Total bones in the arm - 30 **See: Anatomy Plate 28**

Muscles

Movers of hand joints (intrinsic): **See: Anatomy Plate 51**

 Thenar eminence (base of thumb) - 3

 Hypothenar eminence (base of little finger) - 4

 Deep muscles - 11

Muscles of wrist and (extrinsic) hand joints: **See: Anatomy Plate 50**

 Flexors

 Deep - 2

 Intermediate - 1

 Superficial - 3

 Extensors

 Deep - 3

 Superficial - 6

Muscles that act on the elbow and radioulnar joints:

 Flexors - 2 **See: Anatomy Plate 49**

 Flexor and supinator - 1

 Flexor and pronator - 1

 Supinator - 1

 Pronator - 1

 Extensors - 2

Muscles that act on the arm:

Axial (trunk) - 2

Scapular - 7

Total muscles which act on arm down to fingers: 50

Nerves

See: **Anatomy Plate 148**

Spinal nerves → Brachial plexus → 5 nerves to upper limb

Summary:

30 bones

50 muscles

5 nerves

Joint Movement - The Amazing Thumb:

See: **Anatomy Plate 51**

- Flexion
- Abduction
- Adduction
- Opposition
- Circumduction
- Also extension

Joint Movement - The Clever Hand:

- Double grip - grip between hand's last two fingers and palm, while simultaneously gripping between forefinger and thumb
- Unique in *Homo sapiens*
- Two forms of grip → tool-making, weapon-making, etc.

Neurophysiology

Df. neuro - relating to the nervous system

Df. physiology - normal function of the body; that is, how different body parts cooperate with one another in order to maintain life and health

Central Nervous System (CNS): Consists of brain and spinal cord

Peripheral Nervous System (PNS):

Sensory (afferent) nerves - communicate signals from the environment or the body to the CNS.

Motor (efferent) nerves - from CNS to voluntary muscles

See: Human Brain Plate 2-1

Nerve cell = neuron: basic information-processing unit of the nervous system; cell body + dendrites + axon

dendrites: spread out from cell body like branches of tree; carry impulses toward cell body

axon: one; carries impulse away from cell body

See: Human Brain Plate 2-5

Synapse: site at which neurons communicate with each other.

Every synaptic junction has neuron that conducts stimulus (presynaptic terminal) and neuron that receives stimulus (postsynaptic structure).

The electrical stimulus travels down the axon to the end. There, the stimulus causes synaptic vesicles (bubblelike structures) to fuse with the cell membrane. The vesicles then release their contents (chemicals called neurotransmitters) into the synaptic cleft. The neurotransmitters travel to receptors located on the postsynaptic neuron and are taken in by them. The process is repeated. Thus, electrical and chemical transmission takes place.

There are approximately 50 known neurotransmitters. Examples of their actions:

serotonin→mood

dopamine→Parkinson's disease

Substance P→pain perception

In summary: The neurons, through billions of interconnections, make possible the recognition and interpretation of sensory stimuli (understanding), retention of experience (memory) and the elaboration of an enormous range of responses (behavior).

The Brain

The two sides of the major part of the brain can be divided into the left and right hemispheres, commonly referred to as left brain and right brain.

See: Physiology Page 105 (top half)

The cortex lies as a layer on the top and sides of the brain, much like frosting on a cake. Part of the cortex is divided into (from front towards the back): premotor cortex, motor cortex, sensory cortex, and sensory association cortex. Much of the rest of the cortex is divided into association areas, which are involved in higher order associational and integrative activities.

The body is represented anatomically on the motor and sensory cortex strips. The trunk is at the top, hands at the middle and face at the bottom. But the representation is not proportional to the size of the body part. On sensory cortex, areas most sensitive have large representation (hands, fingers and lips) while trunk and legs have small areas of representation. Similarly, on motor cortex, the hands and the face, (which have largest number of muscles and require skillful movement) have much larger representation than the trunk or legs. This representation is called the homunculus (little man).

Df. Wernicke's area:

Region bordering between parietal and temporal lobes, a lesion of which causes sensory or fluent aphasia. This is a disturbance in comprehension of language. Speech can be normal (fluent aphasia) but word order and meaning as well as grammar are highly defective. (Ex: Being lose why would car breakfast). May also be involved in comprehension of written word.

How do we read and write?

See: Physiology Page 105 (bottom half)

To process visual language (reading, writing):

Images of words (1) are analyzed by the vision area at the back of the brain (2). Next, processing by visual association area (3), possibly through Wernicke's area (4), to the hands premotor area (5) on the cortex. The hands premotor cortex communicates to the neighboring hand motor cortex (6) the necessary programs for movement of the hand muscles, resulting in writing (7).

The Hand and Handedness

- 90% right-handed; 10% left-handed
- Genetic influence:
 - One parent left-handed, one parent right-handed: twice as likely offspring will be left-handed
 - Both parents left-handed: three times as likely offspring will be left-handed

In 1971, Oldfield published survey of handedness among 1,100 young adults. Asked 10 questions. Which hand do you use for:

- writing
- drawing
- throwing
- using scissors
 - toothbrush
 - knife
 - spoon
 - broom (upper hand)
 - striking a match (hand holding the match)
 - removing a lid (hand holding the lid)

Proposed a "laterality quotient," strength of handedness based on number of tasks performed with that hand. Spectrum from strongly right-handed through ambidexterity to strongly left-handed.

Why is writing so strongly lateralized?

Two theories, which are not mutually exclusive.

1. Tasks that involve dominant hand activity combine a mixture of slow (postural) and fast (brief, repetitive) muscle contractions. Examples: writing and cutting a carrot with a knife. The forearm and hand muscles are in sustained contraction (slow) while finger muscles must relax and contract over and over again (fast). To handle these complex tasks, the brain automatizes them. That is, it creates simple fine movements, memorizes them and repeats them without variation.
2. The nondominant hand moves in supportive anticipation of action of dominant hand. It is in hold and move sequences, not as rhythmic or stereotyped as movements of the dominant hand.

GLOSSARY

- abduction - lateral movement of limb(s) away from midline of body
- adduction - movement of limb or part of body that brings it closer to midline of body along a frontal plane
- agonist - a muscle in the state of contraction with reference to its opposing muscle
- agraphia - impairment of the ability to write
- alexia - loss of ability to grasp meaning of written words
- allograph - a style (block capital, print script, or cursive form) of one of the 26 graphemes of the English alphabet or of the ligatures and other symbols that accompany it
- anatomical position - the body standing upright, facing the observer, with feet flat on the floor, arms hanging at the sides, and palms facing forwards. When discussing human anatomy, the body is assumed to be in this position.
- anatomy - the structures of the body and how they physically relate to one another
- antagonist - a muscle which resists or opposes the action of another muscle
- anterior - front of the body
- aphasia - impaired or absent comprehension of, or communication by, speech, writing, or signs
- appendicular - relating to limbs as opposed to head and trunk
- axial - axis, or head and trunk as opposed to limbs
- brachial plexus - nerves situated in neck and axilla, comprised of branches arising from last four cervical and first thoracic spinal nerves; carries sensory from and motor innervation to the shoulder, arm, and hand
- circumduction - movement of a limb around a central axis. Ex: drawing circles in the air is circumduction of the arm.
- deep - toward internal aspect, or away from surface of body
- distal - farther from attachment of limb to trunk
- dorsal - back of the body
- dysgraphia - difficulty in writing
- dyslexia - a level of reading ability below that expected on basis of individual's level of over-all intelligence or ability in skills
- extension - increases the joint angle along a sagittal plane
- flexion - decreases the joint angle along a sagittal plane
- graph - the pattern of ink on the paper representing, for that writer, a particular allograph

grapheme - the smallest identifiable unit of writing; not divisible; the abstract concept of a letter of the alphabet

hypothenar - antithenar, or fleshy mass at base of little finger

intermediate - between two structures

lateral - farther away from midline of the body or structure

medial - nearer to midline of the body or structure

midline - imaginary vertical line that divides body into right and left sides

opposition - movement of diagonally opposite limbs, or fingers, toward each other

physiology - normal function of the body; that is, how different body parts cooperate with one another in order to maintain life and health

plexus - network of nerves

posterior - back of the body

pronation - rotation of forearm causing movement of hand from anatomical position to palm facing backwards

proximal - nearer to attachment of limb to trunk

rotation - circular movement; occurs when bone rotates around its own axis

superficial - toward or on surface of body

supination - movement of hand to palms up or forward position

thenar - refers to fleshy mass at the base of the thumb

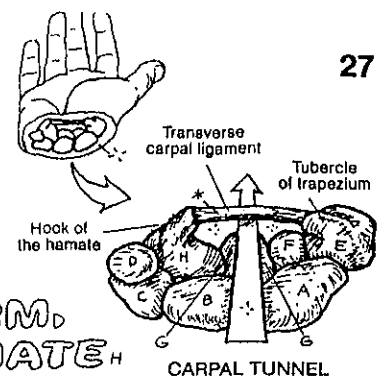
ventral - front of the body

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 three major views simultaneously. Note the hand drawings

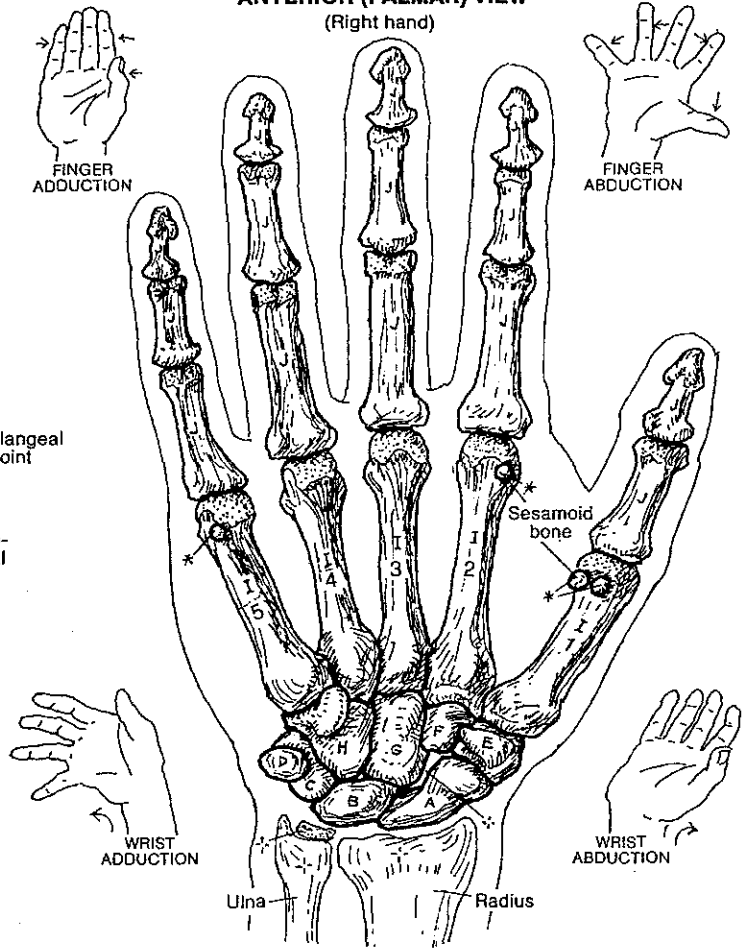
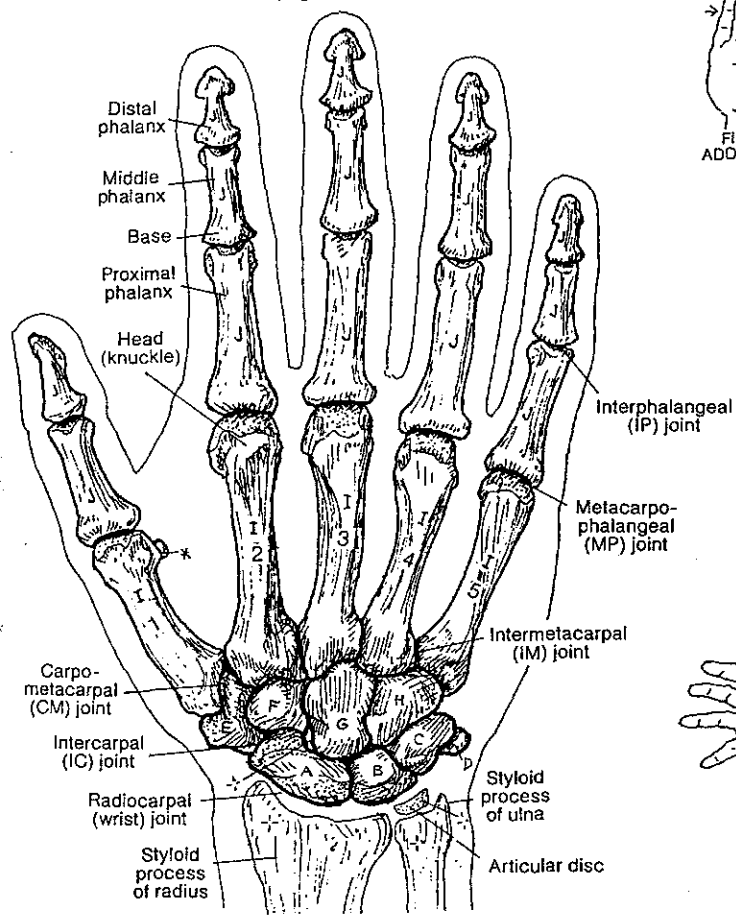
which demonstrate movements at the joints. (2) Color the bones and ligament of the carpal tunnel. You may wish to color those bones in their location in the hand to the left.



CARPALS (8):*
SCAPHOID_A, LUNATE_B, TRIQUETRUM_C, PISIFORM_D, TRAPEZIUM_E, TRAPEZOID_F, CAPITATE_G, HAMATE_H
METACARPALS (5): PHALANGES (14):

POSTERIOR (DORSAL) VIEW
(Right hand)

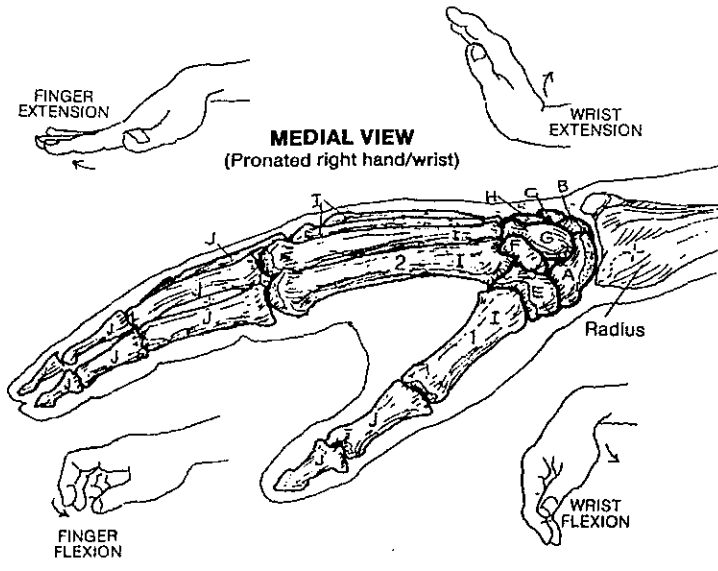
ANTERIOR (PALMAR) VIEW
(Right hand)



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 thumb nail rotates 90°, reflecting medial rotation of the first metacarpal on the *trapezium*.



III. SKELETAL SYSTEM / UPPER LIMB

FOREARM BONES

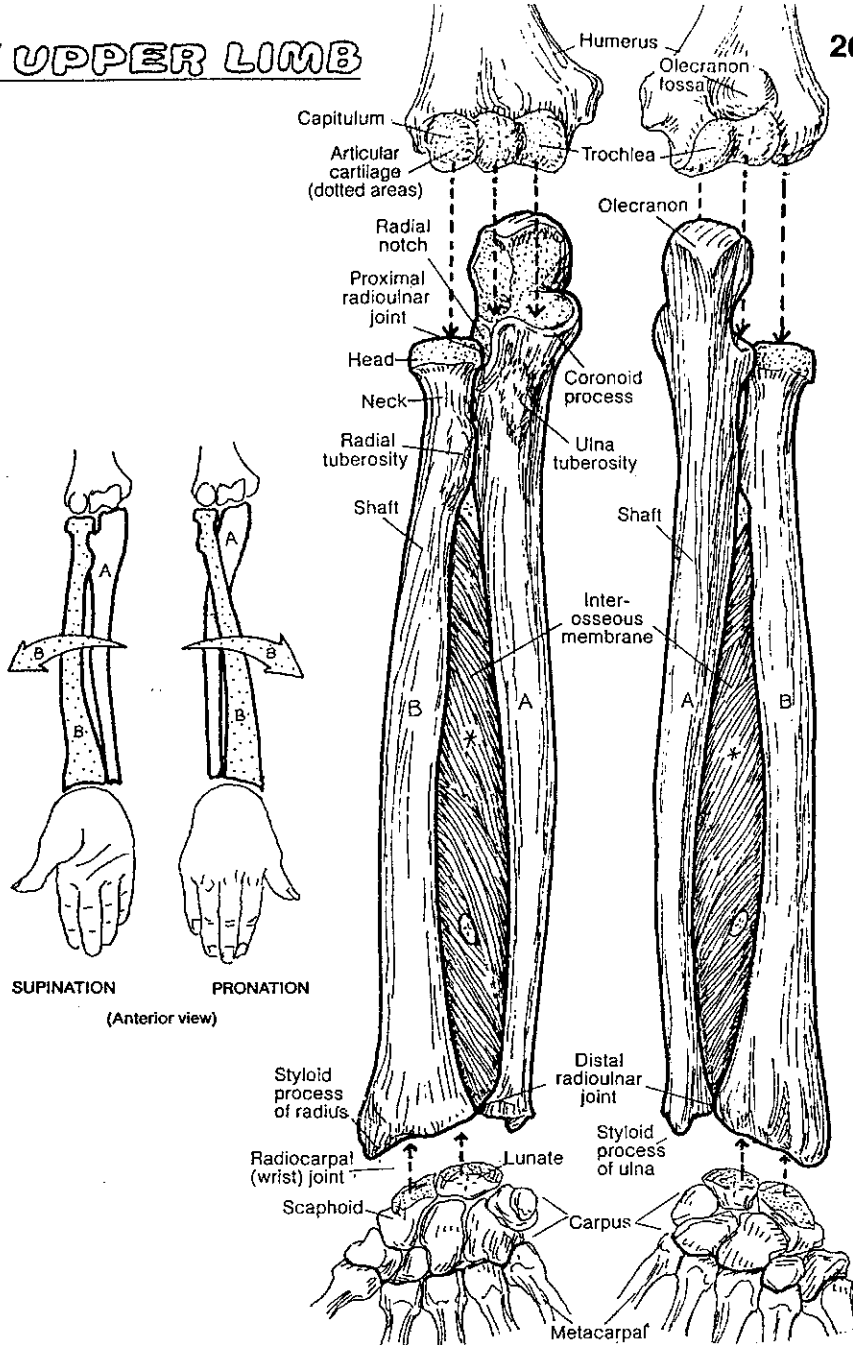
ULNA^A RADIUS^B

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 *humero-ulnar 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.

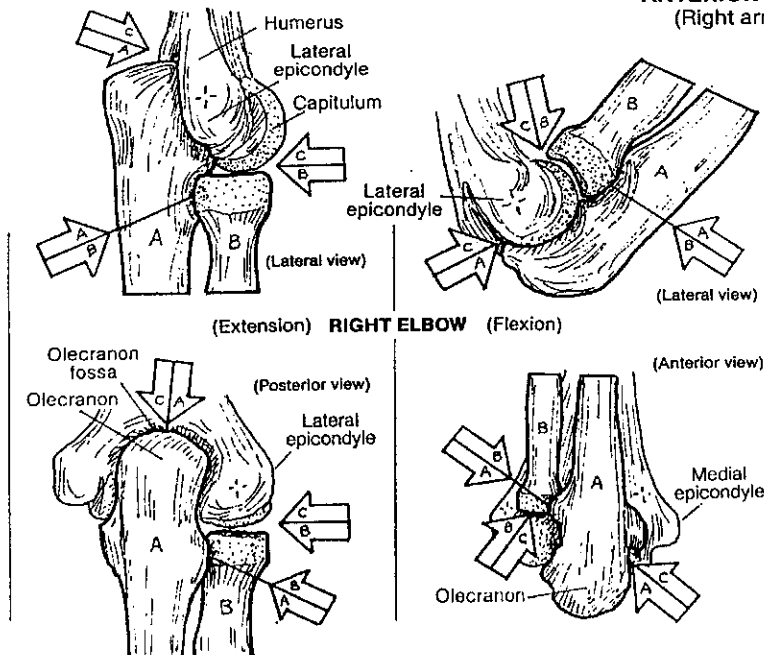


ANTERIOR VIEW (Right arm)

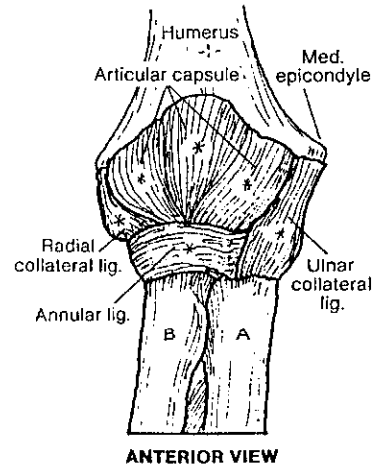
POSTERIOR VIEW (Right arm)

3 JOINTS AT THE RIGHT ELBOW:*

- HUMERO-ULNAR^A
- RADIO-HUMERAL^C
- RADIO-ULNAR^B



LIGAMENTS*



III. SKELETAL SYSTEM / UPPER LIMB

BONES IN REVIEW

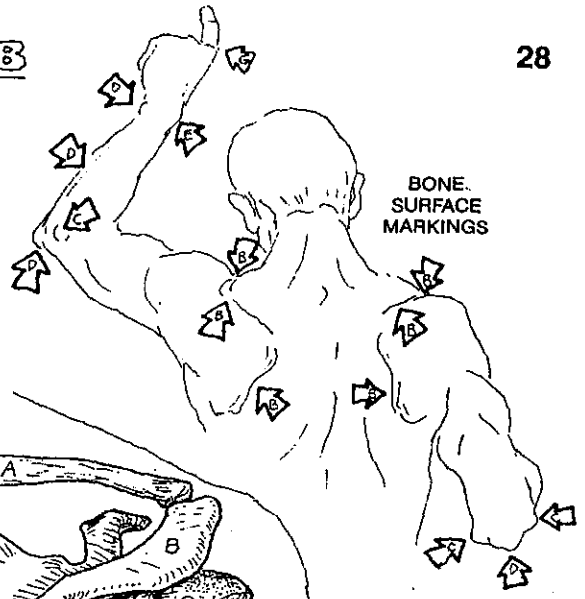
CN: For all of these bones, except the carpals (F), use the same colors you used for them on Plates 25, 26, 27. Select a new, light color for F. (1) Color the arrows pointing to places where these bones can be seen or palpated on the surface of the body. (2) You may wish to test your knowledge of joints 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**

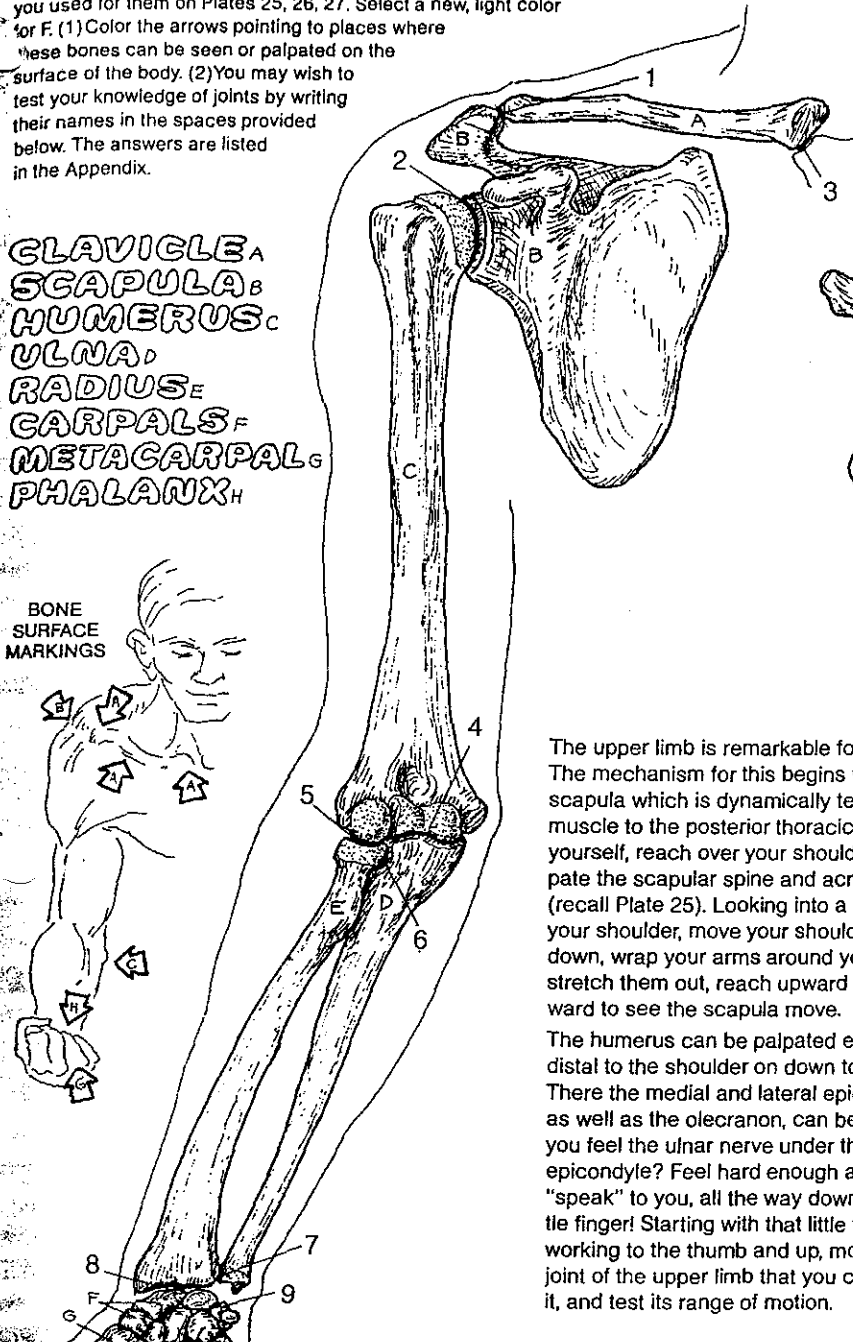
BONE SURFACE MARKINGS



BONE SURFACE MARKINGS



POSTERIOR VIEW
(Right upper limb)



ANTERIOR VIEW
(Right upper limb)

REVIEW OF JOINTS*

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.

- 6 _____
- 7 _____
- 8 _____
- 9 _____
- 10 _____
- 11 _____
- 12 _____
- 13 _____

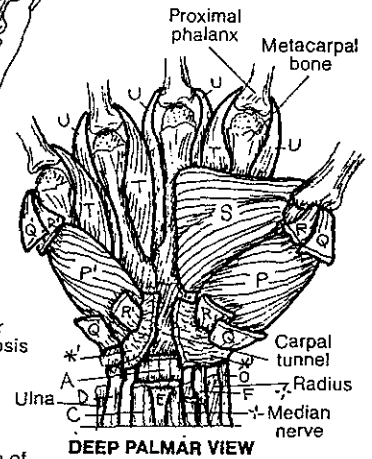
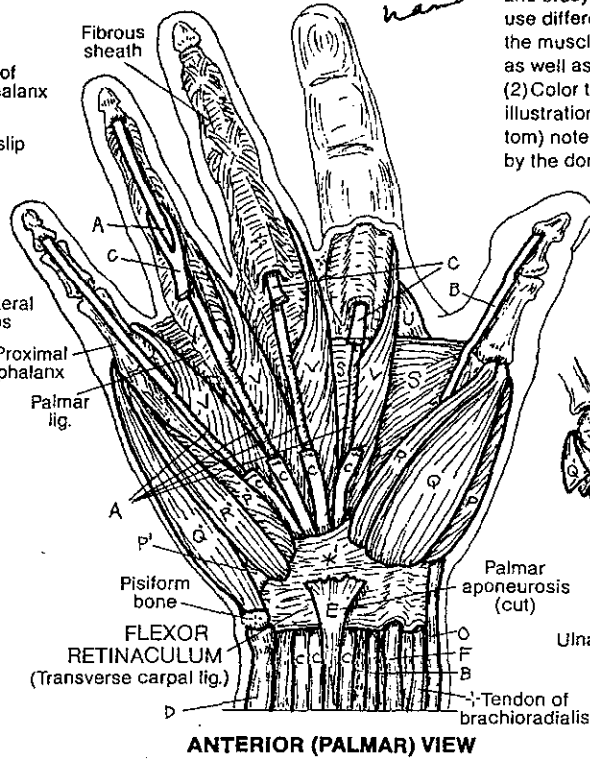
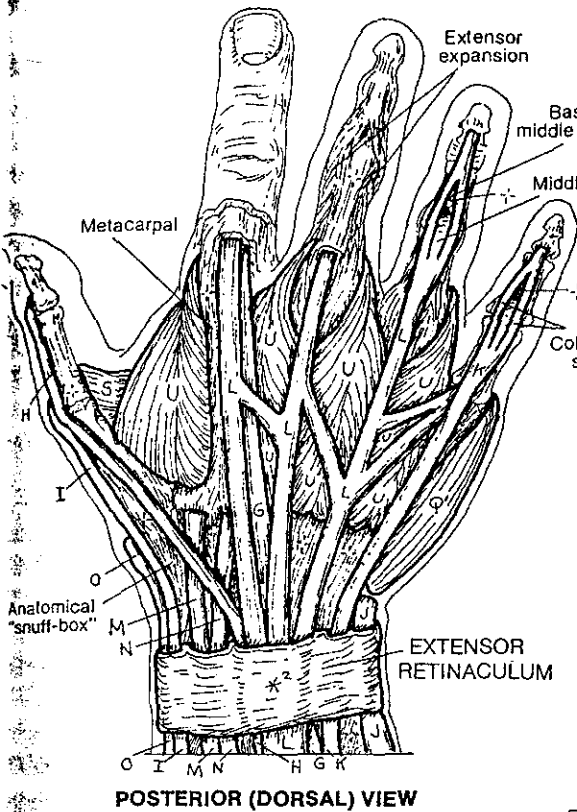
(See appendix for answers)



MOVERS OF HAND JOINTS (INTRINSICS)

start & end in the hand.

CN: The extrinsic muscles which move the wrist and finger joints were covered on Plate 50, and their tendons are shown in dark line and labeled here for identification and study, but not for coloring. If possible, use different colors on this plate. (1) Color the muscles of the two anterior views, as well as the flexor retinaculum (gray). (2) Color the posterior view. (3) In the illustration of finger abduction (at the bottom) note that the little finger is not moved by the dorsal interossei (U).



THENAR EMINENCE*
OPPONENS POLLICIS,
ABDUCTOR POLLICIS BREVIS,
FLEXOR POLLICIS BREVIS



Note the palpable bulge of muscle (*thenar eminence*) just proximal to the thumb on your own hand. Integrated with the action of the other thumb movers, these three muscles make possible complex movements of the thumb. The thenar muscles arise/insert in the same general area as one another; however, their different orientation orders different functions.

HYPOTHENAR EMINENCE*
OPPONENS DIGITI MINIMI,
ABDUCTOR DIGITI MINIMI,
FLEXOR DIGITI MINIMI BREVIS

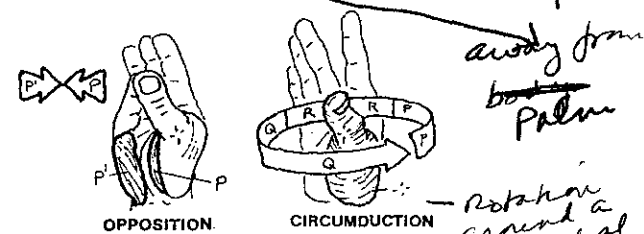
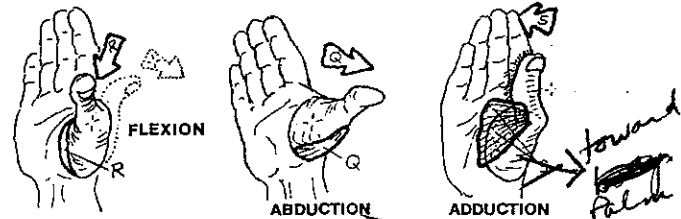


These muscles move the 5th digit; they are complementary to the thenar muscles in attachment and function. The function of opposition is basic to some of the complex grasping functions of the hand.

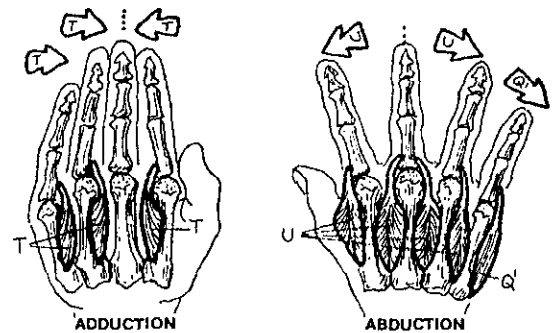
DEEP MUSCLES!*
ADDUCTOR POLLICIS,
PALMAR INTEROSSEUS,
DORSAL INTEROSSEUS,
LUMBRICAL

... for pollicis, in concert with the first dorsal interossei muscle provides great strength in grasping an object between thumb and index finger... try it. The *interossei* and *lumbrical* muscles insert into expanded finger extensor tendons (extensor expansion; see posterior view) forming a complex mechanism for flexing the metacarpophalangeal joints and extending the interphalangeal joints. By their phalangeal insertions, the interossei abduct/adduct certain digits.

ACTIONS OF INTRINSIC MUSCLES ON THE THUMB*



ON THE FINGERS*



V. MUSCULAR SYSTEM / UPPER LIMB

MOVERS OF WRIST & HAND JOINTS

FLEXORS: *

DEEP LAYER

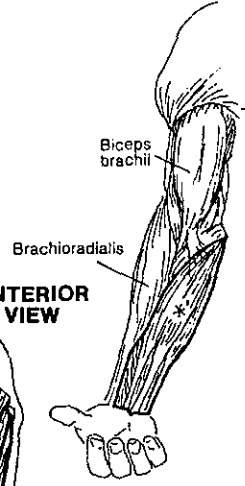
- FLEX. DIGITORUM PROFUNDUS_A
- FLEX. POLLICIS LONGUS_B

INTERMEDIATE LAYER

- FLEX. DIGITORUM SUPERFICIALIS_C

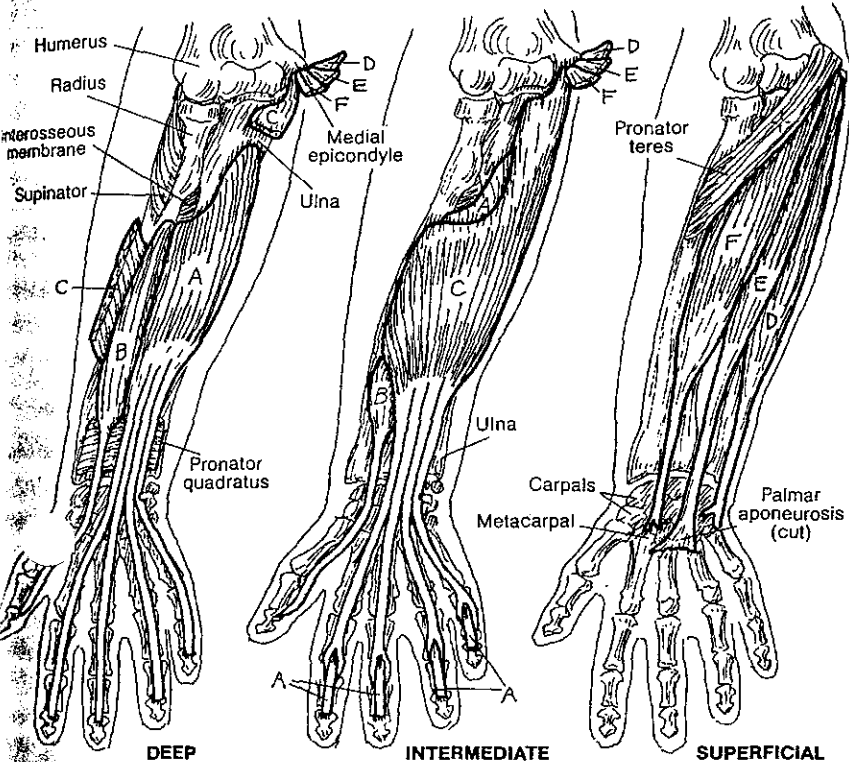
SUPERFICIAL LAYER

- FLEX. CARPI ULNARIS_D
- PALMARIS LONGUS_E
- FLEX. CARPI RADIALIS_F



ANTERIOR VIEW

CN: A more detailed view of the tendons of these muscles (with the same subscripts) can be seen among the intrinsic muscles of the hand on the next plate. (1) Begin with the flexors; note the deeper muscles have been omitted from the superficial view. Color gray the entire flexor mass in the smaller illustration. (2) Continue with the extensors, coloring gray the entire extensor mass in the smaller illustration.



The flexors of the wrist (carpus) and fingers (digits) take up most of the anterior compartment of the forearm, arising as a group from the medial epicondyle, the upper radius and ulna, and the intervening interosseous membrane. The deep layer of muscles in the anterior forearm (*flexor pollicis longus* or FPL in the radial half, *flexor digitorum profundus* or FDP in the ulnar half) lie in contact with the radius and ulna. The superficial layer of muscles (wrist flexors: the "carpi" muscles and *palmaris longus*) is seen just under the skin and thin superficial fascia. The intermediate layer (*flexor digitorum superficialis*, FDP) exists between the superficial and deep groups. In the anterior (palmar) fingers, note how the tendons of FDS, which insert on the sides of the middle phalanges, split at the level of the proximal phalanges, permitting the deeper (posterior) tendons of FDP to pass on through to the bases of the distal phalanges.

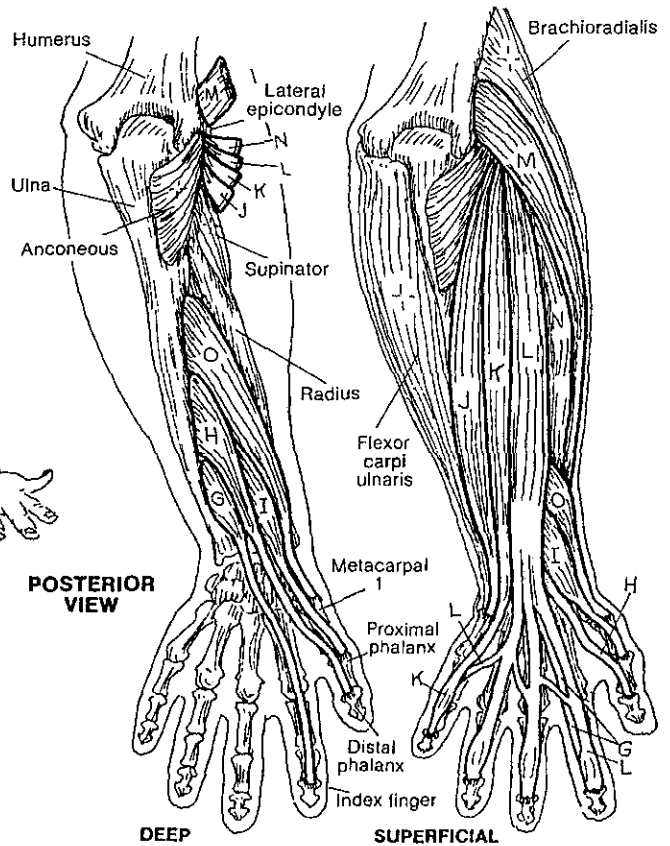
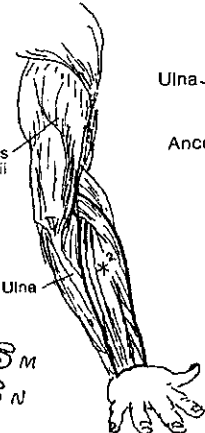
EXTENSORS: *²

DEEP LAYER

- EXT. INDICIS_G
- EXT. POLLICIS LONGUS_H
- EXT. POLLICIS BREVIS_I

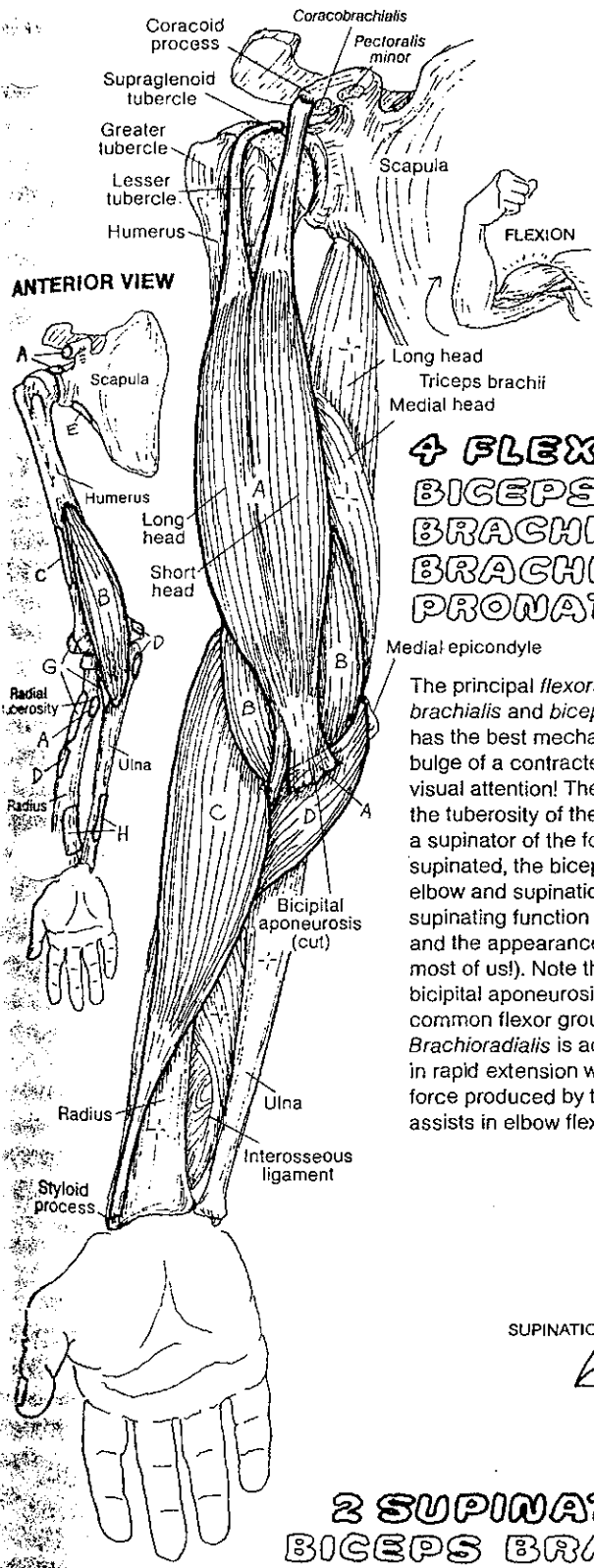
SUPERFICIAL LAYER

- EXT. CARPI ULNARIS_J
- EXT. DIGITI MINIMI_K
- EXT. DIGITORUM_L
- EXT. CARPI RADIALIS LONGUS_M
- EXT. CARPI RADIALIS BREVIS_N
- ABDUCTOR POLLICIS LONGUS_O



POSTERIOR VIEW

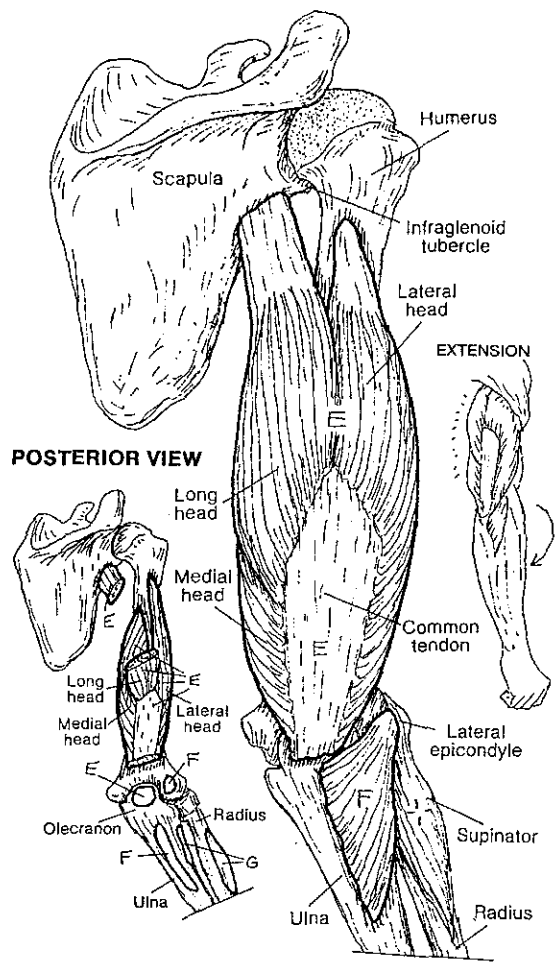
The extensors of the wrist and fingers arise from the lateral epicondyle and upper parts of the bones and interosseous membrane of the forearm, forming an extensor compartment on the posterior side of the forearm. The wrist extensors insert on the distal carpal bones or metacarpals, while the finger extensors form an expansion of tendon over the middle and distal phalanges to which the small intrinsic muscles of the hand insert. The wrist extensor muscles are critical to hand function: grasp a finger of one hand with your fingers and an extended wrist of the other; now try it with wrist fully flexed. Note the power of the hand exists only with an extended wrist.



CN: Use the same colors for biceps brachii (A) and triceps brachii (E) as you did for those muscles on Plate 48. (1) Color the four flexors and their attachment sites on the drawings to their left. Do the same for the extensors on the right. (2) Color the supinators and pronators below, the arrows demonstrating their actions, and their attachment sites at upper left.

4 FLEXORS:*
BICEPS BRACHII_A
BRACHIALIS_B
BRACHIORADIALIS_C
PROMOTOR TERES_D

The principal flexors of the elbow joint are *brachialis* and *biceps brachii*, of which the former has the best mechanical advantage. Yet it's the bulge of a contracted biceps that gets all the visual attention! The tendon of biceps inserts at the tuberosity of the radius, making the muscle a supinator of the forearm as well. With the limb supinated, the biceps works to fulfill flexion of the elbow and supination of the elbow. Take away the supinating function (flexing the pronated elbow), and the appearance of biceps is disappointing (in most of us!). Note the additional attachment of the bicipital aponeurosis into the deep fascia of the common flexor group (not shown) in the forearm. *Brachioradialis* is active in flexion of the elbow and in rapid extension where it counters the centrifugal force produced by that movement. *Pronator teres* assists in elbow flexion as well as pronation.



2 EXTENSORS:*
TRICEPS BRACHII_E
ANCONEUS_F

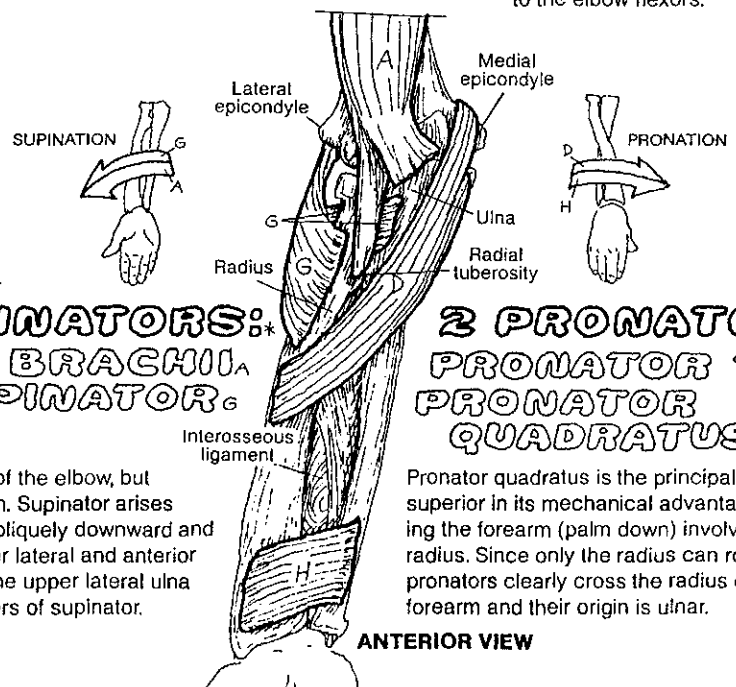
The principal extensor of the elbow joint is the three-headed *triceps brachii* with its massive tendon of insertion. The smaller *anconeus* assists in this function. Triceps is a powerful antagonist to the elbow flexors.

2 SUPINATORS:*
BICEPS BRACHII_A
SUPINATOR_G

Biceps brachii is the more powerful supinator of the elbow, but *supinator* is important in maintaining supination. *Supinator* arises from the lateral aspect of the elbow, passing obliquely downward and forward to a rather broad insertion on the upper lateral and anterior surface of the radius. A bundle of fibers from the upper lateral ulna passes behind the radius to join the lateral fibers of *supinator*.

2 PRONATORS:*
PROMOTOR TERES_D
PROMOTOR QUADRATUS_H

Pronator quadratus is the principal pronator of the elbow joint, superior in its mechanical advantage to *pronator teres*. Pronating the forearm (palm down) involves medial rotation of the radius. Since only the radius can rotate in the forearm, the pronators clearly cross the radius on the anterior side of the forearm and their origin is ulnar.



ANTERIOR VIEW

XIV. NERVOUS SYSTEM

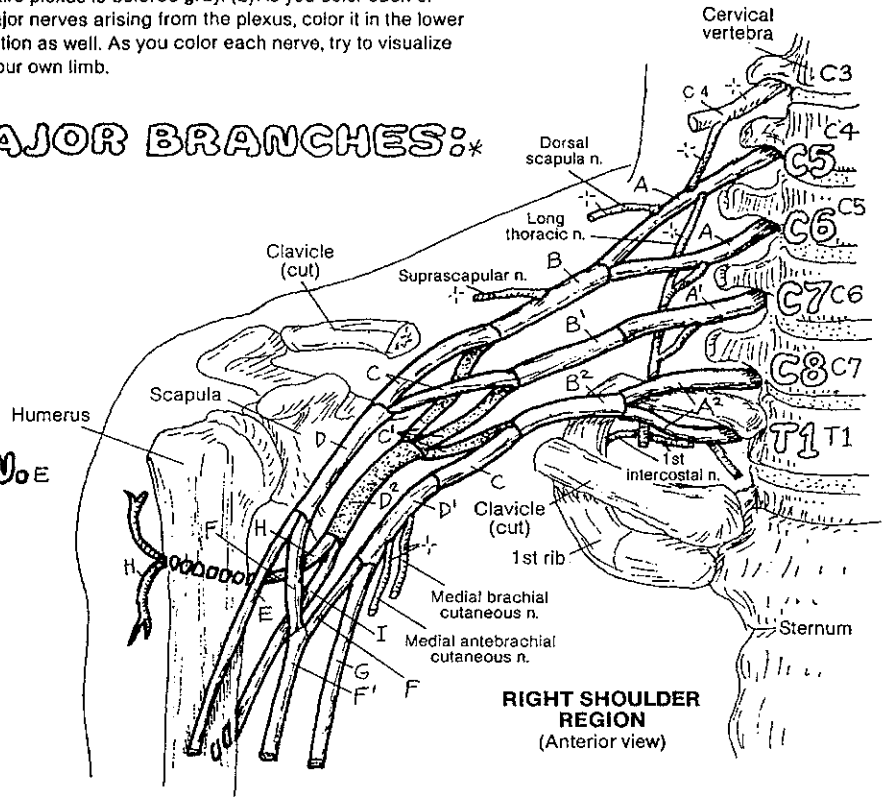
NERVES TO THE UPPER LIMB

CN: Use light colors for A-D. (1) In the upper illustration, color letters and numbers identifying the five roots of the brachial plexus. Note but do not color the small branches of the plexus as you color the plexus itself. Note in the lower illustration the

entire plexus is colored gray. (2) As you color each of the major nerves arising from the plexus, color it in the lower illustration as well. As you color each nerve, try to visualize it on your own limb.

BRACHIAL PLEXUS & MAJOR BRANCHES:*

- ROOTS C5, C6^A
- UPPER TRUNK^B
- ROOT C7^{A'}
- MIDDLE TRUNK^{B'}
- ROOTS C8, T1^{A²}
- LOWER TRUNK^{B²}
- ANTERIOR DIVISION^C
- LATERAL CORD^D
- MUSCULOCUTANEOUS N.^E
- BR. TO MEDIAN N.^F
- MEDIAL CORD^{D'}
- BR. TO MEDIAN N.^F
- MEDIAN N.^{F'}
- ULNAR N.^G
- POSTERIOR DIVISION^{C'}
- POSTERIOR CORD^{D²}
- AXILLARY N.^H
- RADIAL N.^I



RIGHT SHOULDER REGION (Anterior view)

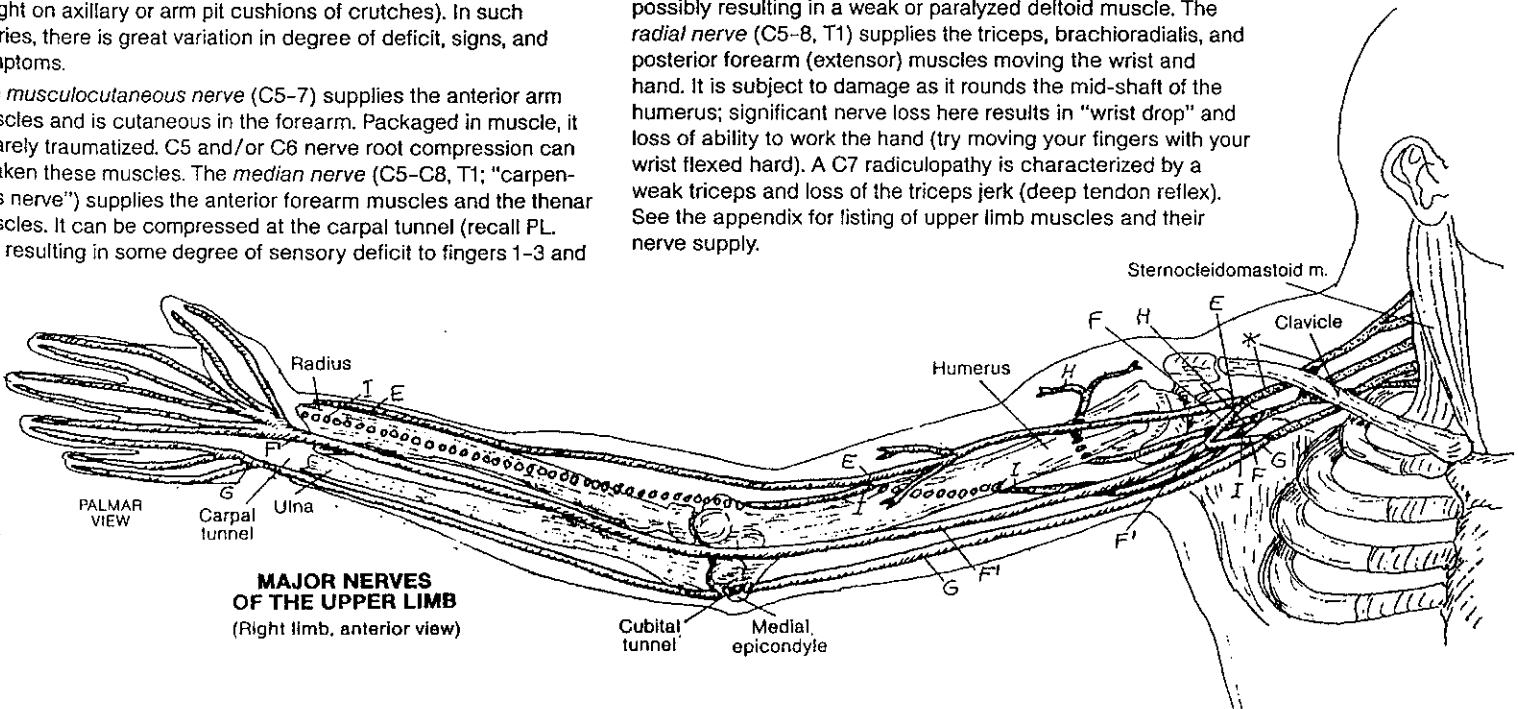
The major nerves to the structures of the upper limb arise from the brachial plexus, formed from the anterior rami of spinal nerves C5-T1 (plus or minus one level). These rami form the roots of the plexus. In the pattern illustrated, further branching and joining of fibers in the neck, supraclavicular area, and axilla result in the formation of the five major nerves of the upper limb.

The brachial plexus is subject to injury (plexopathy) from excessive stretching or traction (e.g., rapid, forceful pulling of the upper limb) and compression (e.g., long-term placement of body weight on axillary or arm pit cushions of crutches). In such injuries, there is great variation in degree of deficit, signs, and symptoms.

The musculocutaneous nerve (C5-7) supplies the anterior arm muscles and is cutaneous in the forearm. Packaged in muscle, it is rarely traumatized. C5 and/or C6 nerve root compression can weaken these muscles. The median nerve (C5-C8, T1; "carpenter's nerve") supplies the anterior forearm muscles and the thenar muscles. It can be compressed at the carpal tunnel (recall PL 27), resulting in some degree of sensory deficit to fingers 1-3 and

weakness in thumb movement (carpal tunnel syndrome). Similar complaints can be associated with a C6 nerve root compression.

The ulnar nerve (C8-T1; "musician's nerve") supplies certain muscles of the forearm and most intrinsic muscles of the hand. It is subject to trauma as it rounds the elbow in the cubital tunnel, possibly resulting in ulnar-side finger pain, hand weakness or abnormal little finger position. Similar complaints can be associated with a C8 nerve root compression. The axillary nerve (C5-6) wraps around the neck of the humerus to supply deltoid and teres minor. It is vulnerable in fractures of the humeral neck, possibly resulting in a weak or paralyzed deltoid muscle. The radial nerve (C5-8, T1) supplies the triceps, brachioradialis, and posterior forearm (extensor) muscles moving the wrist and hand. It is subject to damage as it rounds the mid-shaft of the humerus; significant nerve loss here results in "wrist drop" and loss of ability to work the hand (try moving your fingers with your wrist flexed hard). A C7 radiculopathy is characterized by a weak triceps and loss of the triceps jerk (deep tendon reflex). See the appendix for listing of upper limb muscles and their nerve supply.



MAJOR NERVES OF THE UPPER LIMB (Right limb, anterior view)

Neurons communicate with each other -
Makes the brain work.

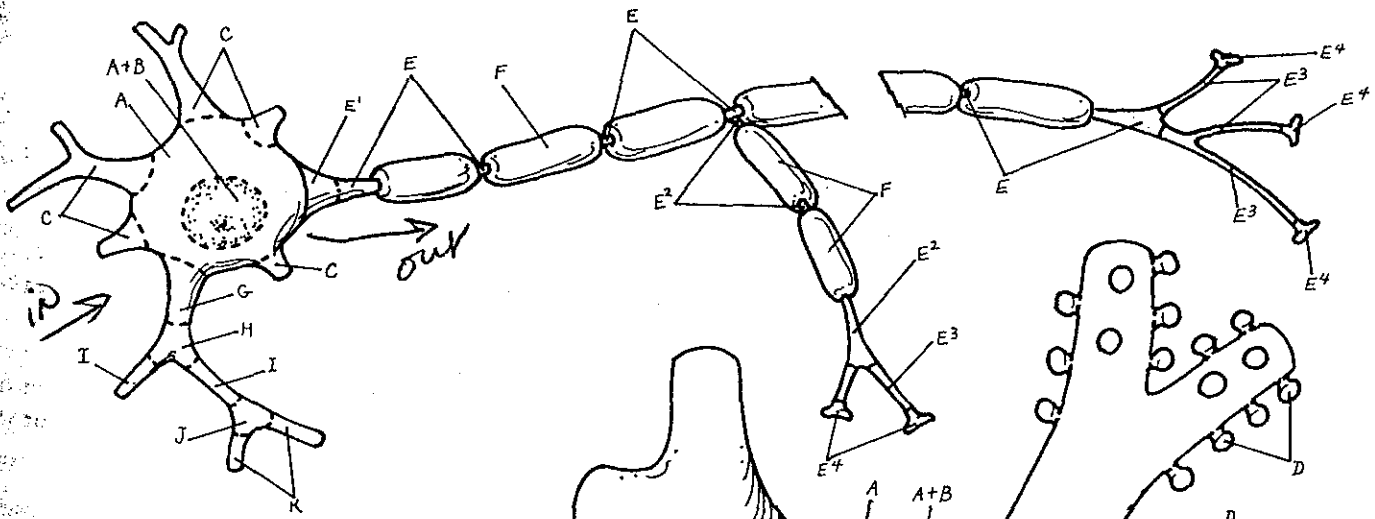
THE NEURON.

NEURON*

- CELL BODY_A
- NUCLEUS_B
- PROCESSES_C*
- DENDRITE_D
- DENDRITIC SPINE_E

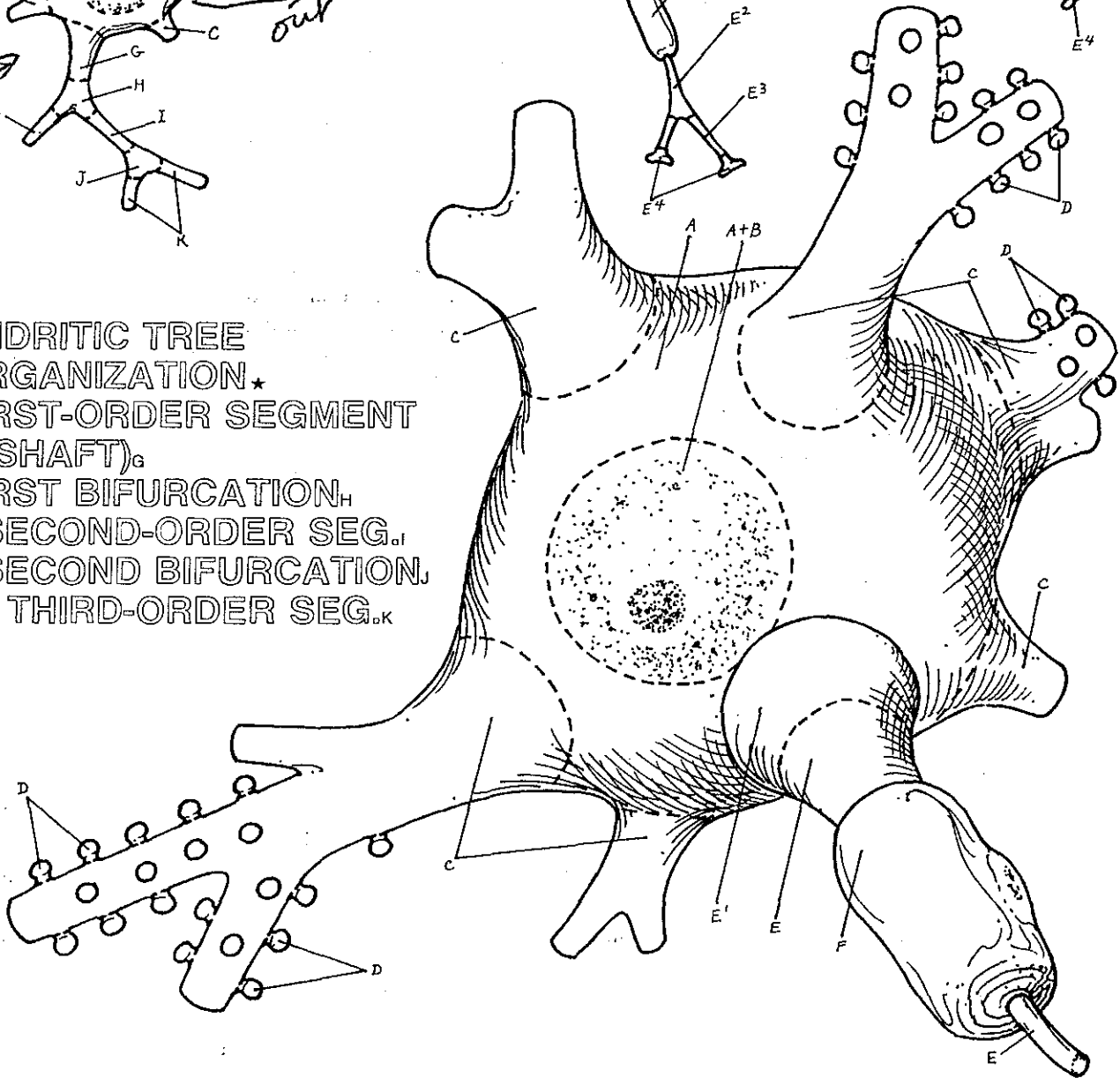
AXON_E

- AXON HILLOCK_F
- SHEATH_G
- AXON COLLATERAL_H
- TERMINAL BRANCH_I
- SYNAPTIC TERMINAL_J



DENDRITIC TREE ORGANIZATION*

- FIRST-ORDER SEGMENT (SHAFT)_C
- FIRST BIFURCATION_D
- SECOND-ORDER SEG._E
- SECOND BIFURCATION_F
- THIRD-ORDER SEG._G



Neurons communicate at the Synapse

THE SYNAPSE: STRUCTURAL AND FUNCTIONAL DYNAMICS.

PRESYNAPTIC TERMINAL *

NEUROTUBULE_A

VESICLE_B

SYNAPTIC VESICLE_{B'}

NEUROTRANSMITTER_C

CALCIUM IONS (Ca⁺⁺)_D

CALMODULIN_E

PRESYNAPTIC MEMBRANE_F

FUSION_G

EXOCYTOSIS_H

SYNAPTIC CLEFT_I

FREE NEUROTRANSMITTER_{C'}

NEUROTRANS. FRAGMENT_{C''}

POSTSYNAPTIC

STRUCTURE *

POSTSYNAPTIC

MEMBRANE_K

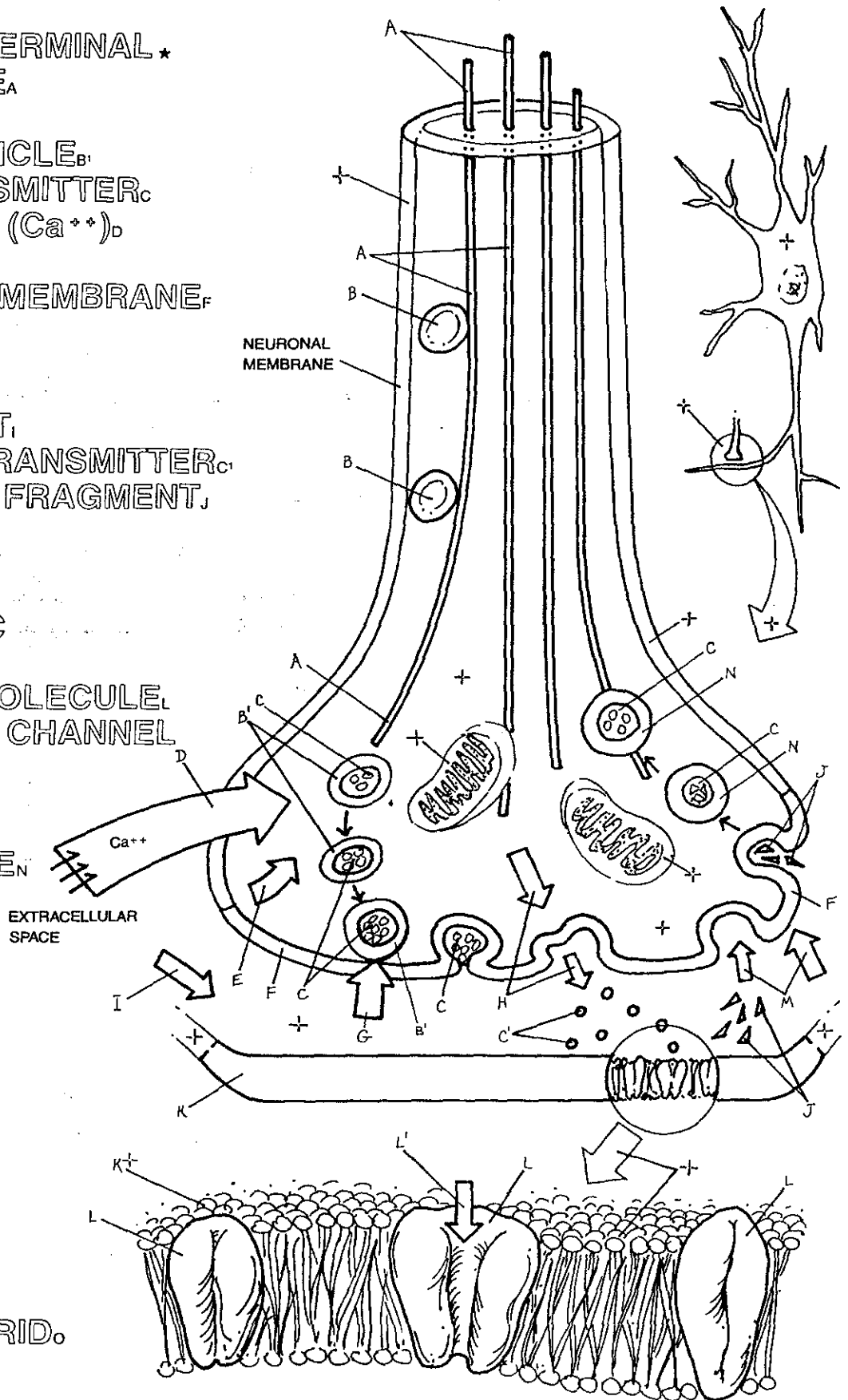
RECEPTOR MOLECULE_L

ION-SPECIFIC CHANNEL

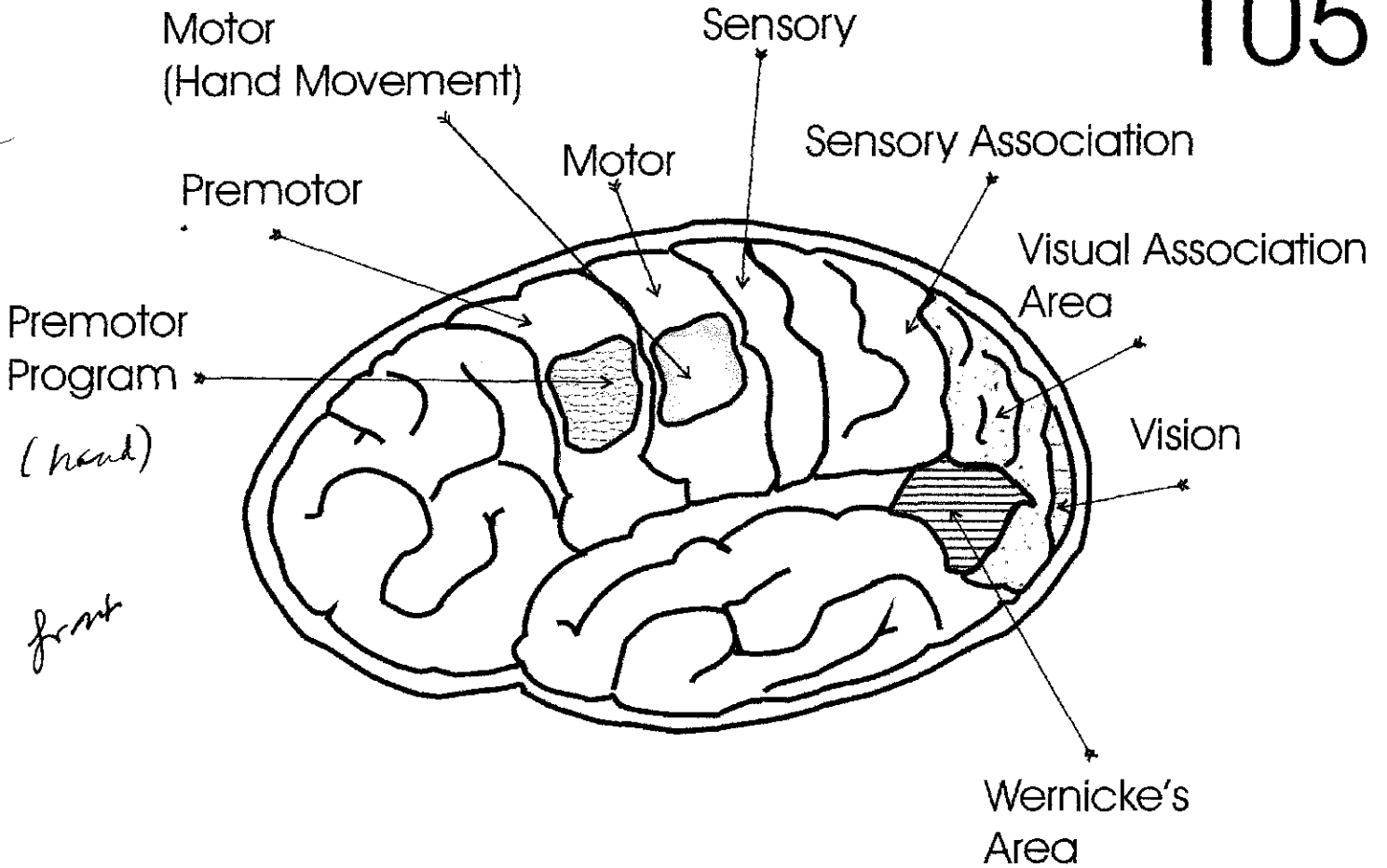
(OPEN)_{L'}

ENDOCYTOSIS_M

COATED VESICLE_N



PRESYNAPTIC GRID.



- (1) Reading - images of words
- (2) Vision Area
- (3) Visual Association
- (4) Wernicke's Area
- (5) Hand premotor cortex
- (6) Hand motor cortex
- (7) Writing

