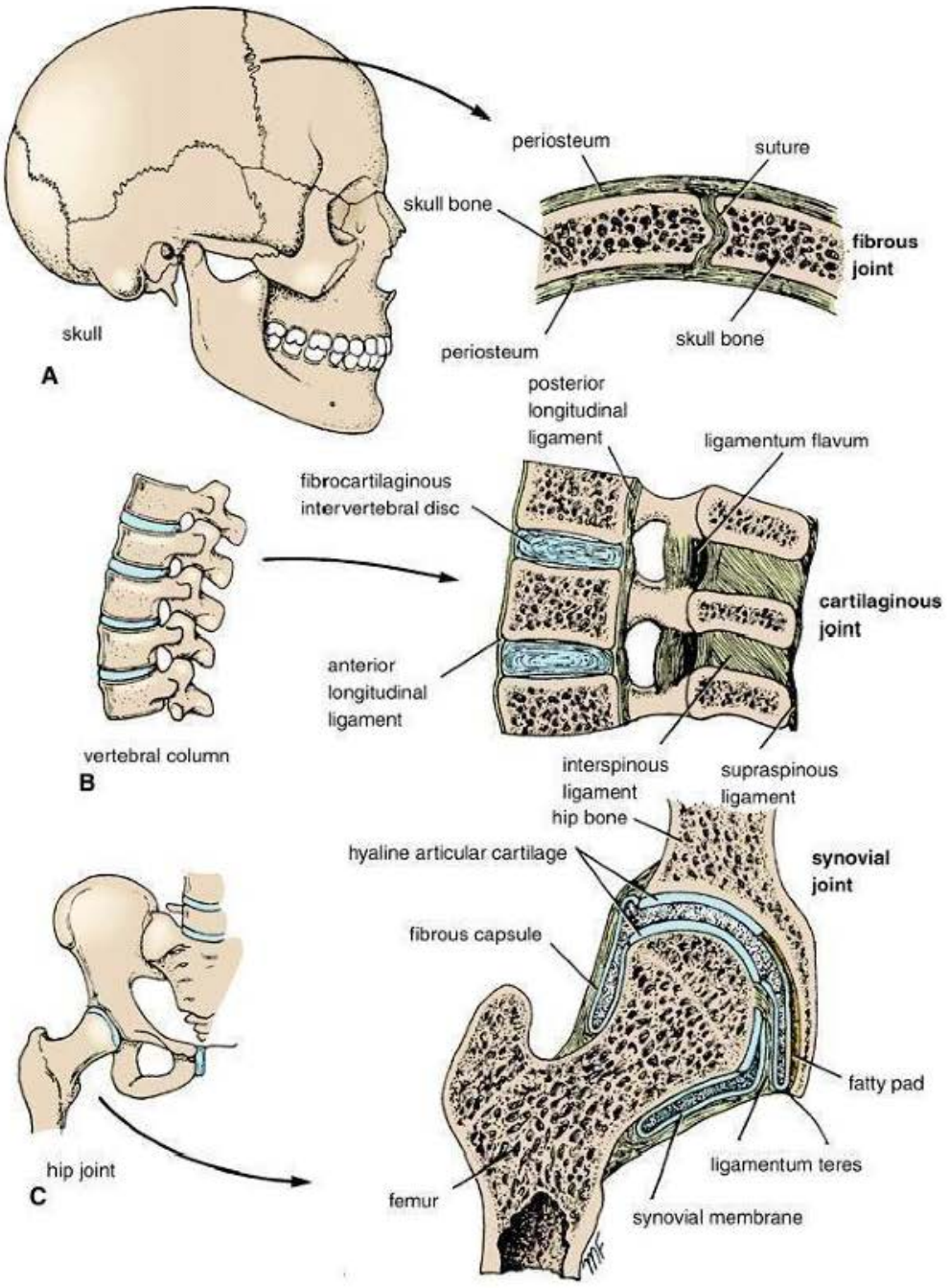
INTRODUCTION TO HUMAN ANATOMY



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ANATOMY

Anatomy – the study of structure of the body – is one of the oldest basic medical sciences; it was first studied formally in Egypt.

Anatomy is a Greek word first used by *Aristotle*;
Ana means through
Tom means to cut
Y suffix forming noun
So, Anatomy means 'to cut through' or 'dissect' which is the mean by which we study the structure of the human body.
The word 'Anatomy' is used as a name for the science of studying the structure, function and relationship of various parts of the human body.

The human body consists of:

- **Systems:** Each performs a special function in the body. Each system is formed of a group of organs.
- **The organ:** Formed of different tissues grouped together forming a distinct structure. Each organ is formed of a group of tissues.
- **The tissue:** Formed of cells similar in structure and function
- **The cell:** The basic structural unit of the body. So, the cell is the simplest structural form of life.

Approaches to Study Anatomy:

1. Regional (Topographical) Anatomy (Figure 1):

It considers the organization of the human body as segments or major parts based on form and mass. So, the human body is divided into the following regions:

- **Head**
- **Neck**
- **Trunk:** Which is further divided into:
  - Chest
  - Abdomen
  - Pelvis

Limbs: which are:
- Upper limbs (right and left)
- Lower limbs (right and left)

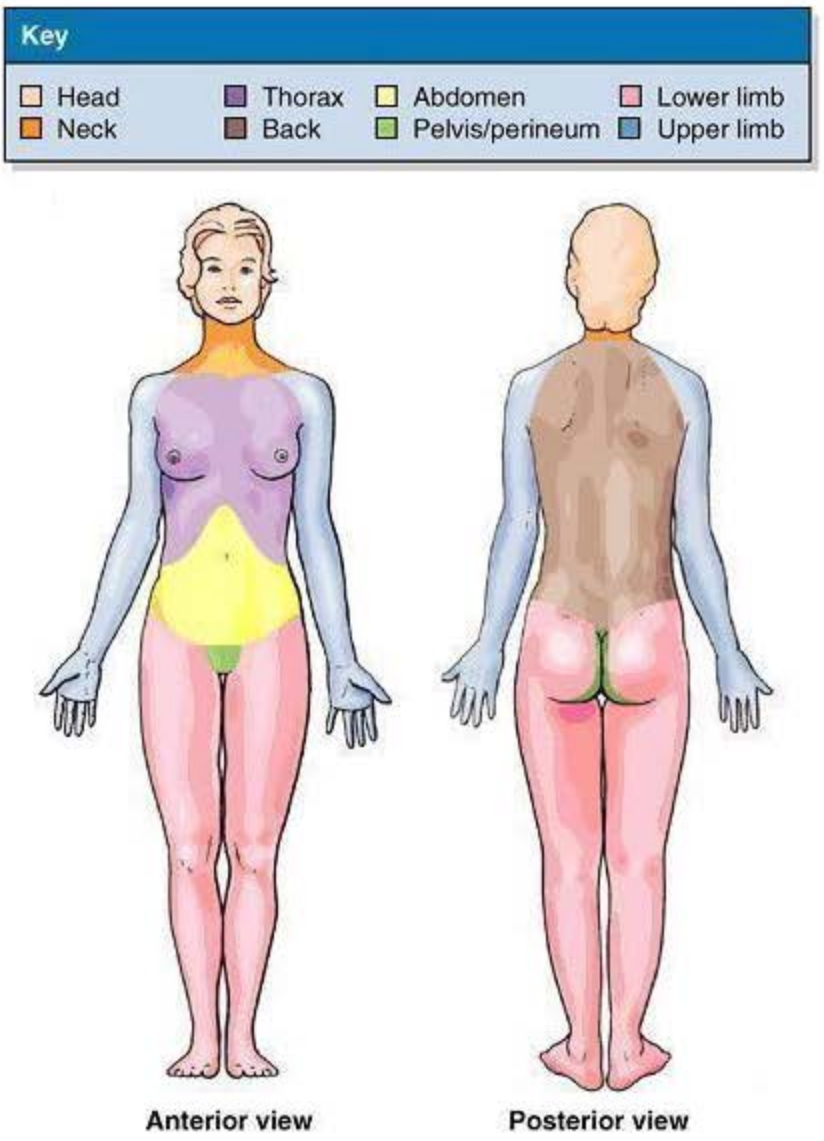

Figure 1: Regional anatomy of the human body

II. Systemic Anatomy:

It recognizes the organization of the body's organs into systems that work together to carry out complex functions:

- **Integumentary System (Dermatology):**
  Consists of the skin and its appendages
- **Skeletal System (Osteology):** Consists of the bones and cartilage
- **Articular System (Arthrology):** Consists of joints and their associated ligaments

- **Muscular System (Myology):** Consists of muscles to move or position parts of the body

- **Nervous System (Neurology):** Consists of central nervous system (brain and spinal cord) and Peripheral nervous system (nerves, ganglia, motor and sensory endings)

- **Circulatory System (Angiology):** Consists of cardiovascular system (heart and blood vessels) and lymphatic system (lymph vessels and lymph nodes)

- **Digestive or Alimentary System: (Gastroenterology):** Consists of Organs and glands associated with digestion

- **Respiratory System (Pulmonology):** Consists of air passages and lungs

- **Urinary System (Urology):** Consists of kidneys, ureters, urinary bladder and urethra

- **Reproductive or Genital System (Gynecology for females and Andrology for males):** Consists of gonads (ovaries and testes), ducts and genitalia
- **Endocrine System (Endocrinology):** Consists of ductless glands e.g. thyroid gland

III. Clinical (Applied) Anatomy:

- Study of macroscopic structure and function of body as it relates to the practice of medicine, dentistry and other related sciences.
- It incorporates the regional and systemic approaches to studying Anatomy and stresses clinical application.

Surface Anatomy: Observing the external form and surface of the body and observing or feeling (by palpation) the superficial aspects of structures beneath its surface.

Physical Examination: Clinical application of surface anatomy by palpation of arterial pulses, using ophthalmoscope to observe features of the eye or stethoscope to listen to heart and lungs or reflex hammer to examine functional state of nerves and muscles.

Radiological Imaging: (Plain x-rays, Computed tomography (CT), Magnetic Resonance Imaging (MRI): Provides regional study of deep structures and abnormalities in a living person.

-Radiographic Anatomy: Provides useful information about normal structures in living individuals

-Diagnostic Radiology: Reveals effects of trauma, pathology and aging on normal structures

ANATOMICAL TERMINOLOGY

ANATOMICAL POSITION (Figures 1&2):

- The person is standing erect
- The upper limbs by the sides
- The face and palms of hands are directed forward
- The lower limbs are together with feet parallel

ANATOMICAL PLANES (Figure 2):

1. Median (Midsagittal) Plane: A vertical plane passing through center of the body dividing it into equal right and left halves.

Paramedian (Parasagittal) Plane: Any plane parallel to the median plane

2. Coronal (Frontal) Plane: A vertical plane at right angle to median plane, divides the body into anterior and posterior halves

3. Horizontal (Transverse) Plane: Planes are at right angles to both median & coronal planes, divides the body into superior & inferior halves

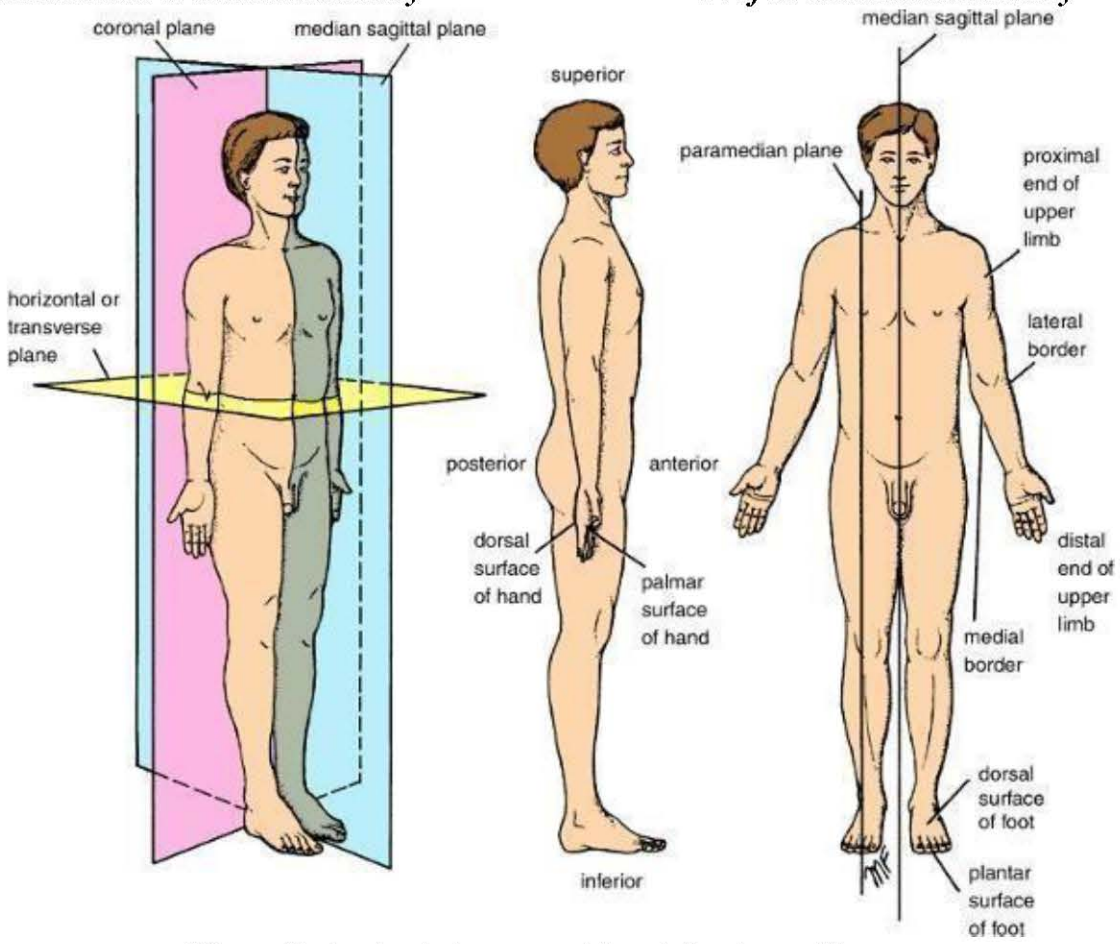

Figure 2: Anatomic terms used in relation to position.
Note: The subjects are standing in the anatomic position.

TERMS OF RELATION AND COMPARISON:

Medial: A structure situated nearer to the median plane than another, e.g. the little finger lies medial to the thumb.

Lateral: Away from the median plane, e.g. little toe lies lateral to big toe.

Anterior (Ventral): To the front or in front e.g. the patella lies anterior to knee

Posterior (Dorsal): To the rear or behind, e.g. gluteus maximus lies posterior to the hip.

- Ventral and dorsal are used more commonly in the four-legged animals.
- In describing the hand, terms palmar & dorsal surfaces are used in place of anterior and posterior.

- In describing foot, terms plantar (sole) & dorsal surfaces are used instead of lower and upper surface.

Proximal: Close to the trunk or root of the limb, e.g. the arm is proximal to forearm.

Distal: Away from the trunk or root of the limb, e.g. the hand is distal to the forearm.

Superficial: Close to surface of the body or skin, e.g. the ulnar nerve passes superficial to flexor retinaculum of the wrist

Deep: Away from body surface or skin, e.g. tendon of tibialis posterior passes deep to flexor retinaculum of the ankle.

Superior (Cephalic): Above, e.g. the head is superior to trunk.

Inferior (Caudal): Below, e.g. knee is inferior to hip. Cephalic (head) and caudal (tail) may be used in relation to the trunk.

Internal and External: Describe relative distance of a structure from centre of an organ or cavity, e.g. the internal carotid artery is inside the cranial cavity. External carotid artery is external to the cranial cavity.

Supine position: The body is lying on the back.

Prone position: The body is lying face downward.

TERMS OF LATERALITY

Bilateral: Paired structures having right and left members e.g. kidneys.

Unilateral: Structures occur on one side only e.g. the spleen

Ipsilateral: Refers to the same side of the body, e.g. the left hand and left foot are ipsilateral.

Contralateral: Opposite side of body (left biceps brachii and right rectus femoris are contralateral).

TERMS OF MOVEMENT (Figures 3&4):

Flexion: A movement in a sagittal plane, (bending of adjacent body segments in median / paramedian planes; their anterior / posterior surfaces are brought together). For the elbow, approximates anterior surface of the forearm to anterior surface of the arm. For the knee, posterior surfaces of the leg and thigh are opposed.

Extension: Straightening the joint (of elbow or knee). The moving apart of two opposing surfaces is in a paramedian plane.

Lateral flexion: A movement of the trunk in a coronal plane.

Abduction: of a limb away from the median plane in the coronal plane, e.g. movement of the upper limb away from side of the trunk.

Adduction: of a limb toward the body in a coronal plane, e.g. movement of the upper limb back towards the trunk.

Circumduction: Combination of movements of flexion, extension, abduction and adduction.

Rotation: A movement of a part of the body around its long axis**:**

- **Medial rotation:** A movement that results in anterior surface of the part facing medially.

- **Lateral rotation:** A movement that results in anterior surface of the part facing laterally.

Supination of the forearm: Lateral rotation of the forearm from the pronated position

Pronation of the forearm: Medial rotation of the forearm so, the palm of the hand facing posteriorly**.**

Opposition: Movement by which pad of the thumb is brought to another digit pad

Reposition: Movement of thumb from position of opposition back to its anatomical position

Protraction (Protrusion): To move forward

Retraction (Retrusion): To move backward. Protraction and retraction are used in movements of temporo-mandibular joint and that of scapula.

Elevation: Raises or moves a part superiorly, as in elevating the shoulders when shrugging, the upper lid when opening the eye, or the tongue when pushing it up against the palate

Depression: Lowers or moves a part inferiorly, as in depressing the shoulders when standing at ease, the upper lid when closing the eye, or pulling the tongue away from the palate.

Inversion: The movement of the foot so that the sole faces in a medial direction.

Eversion: The opposite movement of the foot so that the sole faces in a lateral direction.

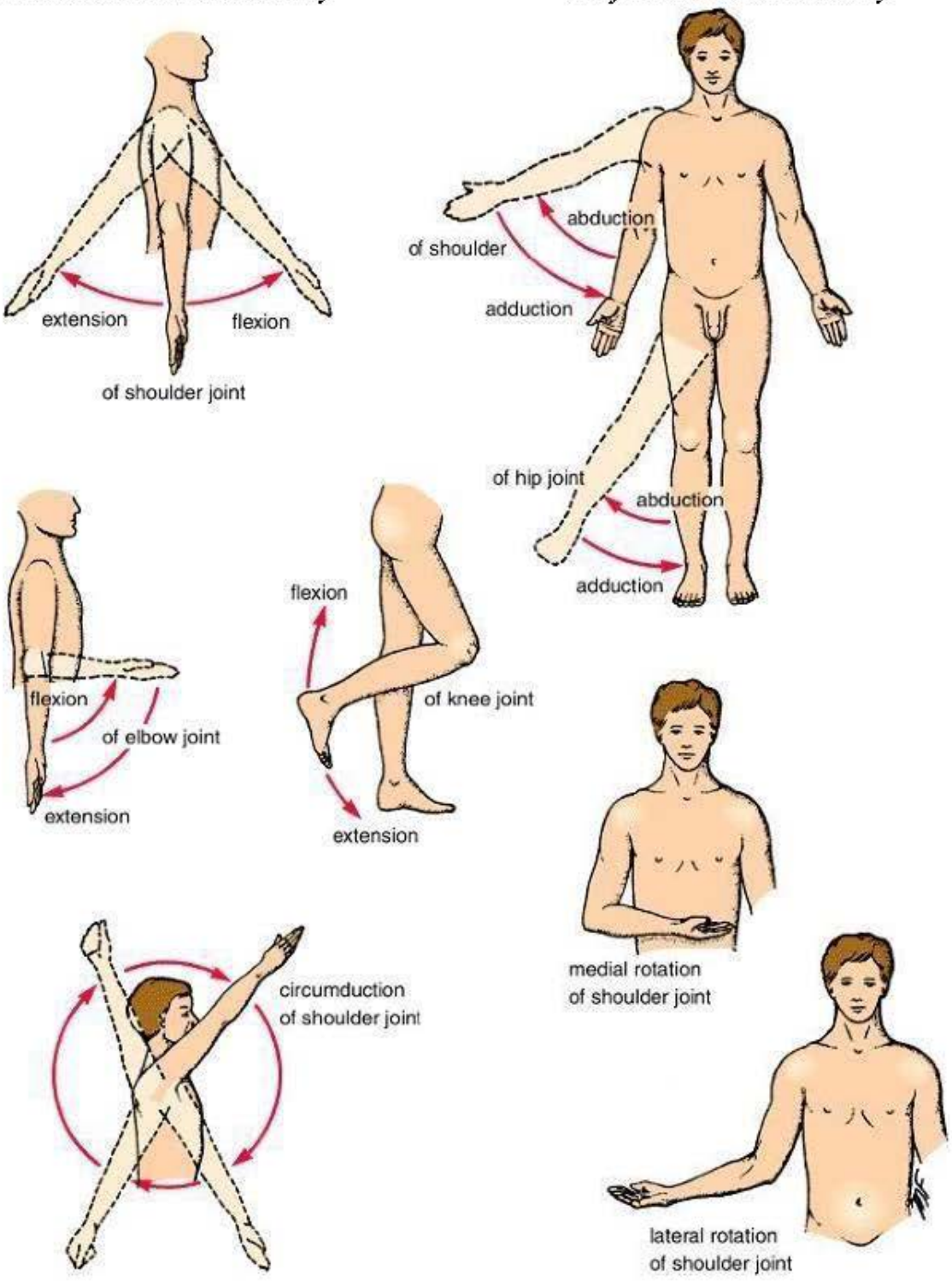

Figure 3: Some anatomic terms used in relation to movement. Note the difference between flexion of the elbow and that of the knee.

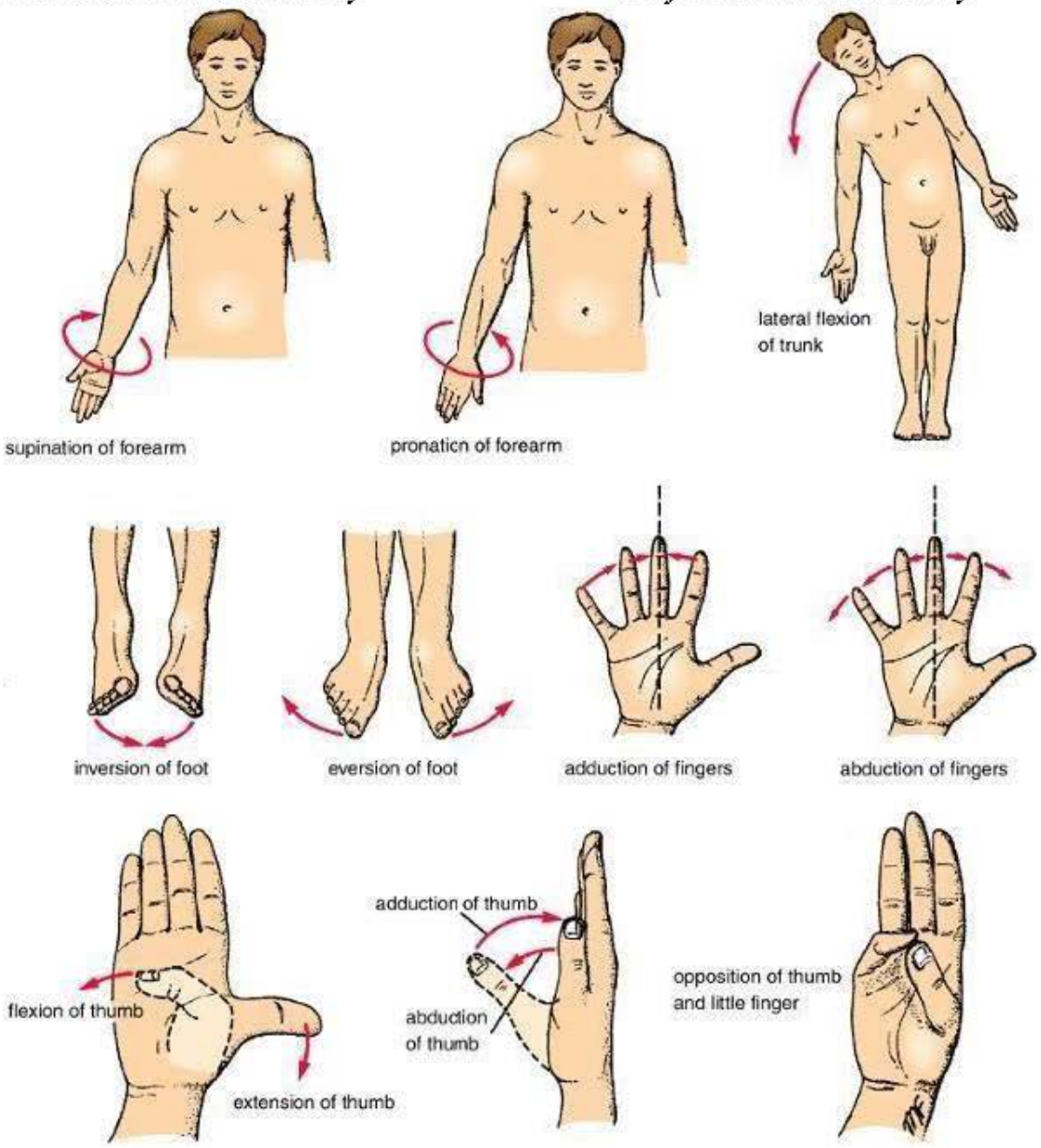

Figure 4: Additional anatomic terms used in relation to movement

THE SKIN

- The largest organ in the body
- The outer layer covering the body

It is divided into 2 parts (Figure 5):

I. EPIDERMIS:

- A keratinized stratified squamous epithelium.
- Ectodermal in origin
- Formed of several layers of cells. Uppermost layer is thick and formed of keratinized cells. Basal layer contains melanocytes to form melanin pigments.

- **Thick epidermis:**
  1. palms of the hands
  2. Soles of the feet

To withstand the wear and tear that occurs in these regions.

- **Thin epidermis:** on anterior surface of the arm and forearm

II. DERMIS:

-Deep connective tissue layer.

- Contains many blood vessels, lymphatic vessels and nerves.
- Mesodermal in origin
- **Thinner:** on anterior than posterior surface and in women than on men
- Connected to the underlying deep fascia or bones by superficial fascia (subcutaneous tissue).

Langer's (cleavage) lines (Figure 6):

- The bundles of collagen fibres are mostly arranged in parallel rows.
- Their direction is called lines of cleavage or Langer's lines. - They tend to run longitudinally in the limbs and circumferentially in the neck and trunk.

Skin Creases:

The skin is thinner at these sites than elsewhere and is firmly attached to underlying structures by fibrous tissue.

Finger Prints: Dermatoglyphics

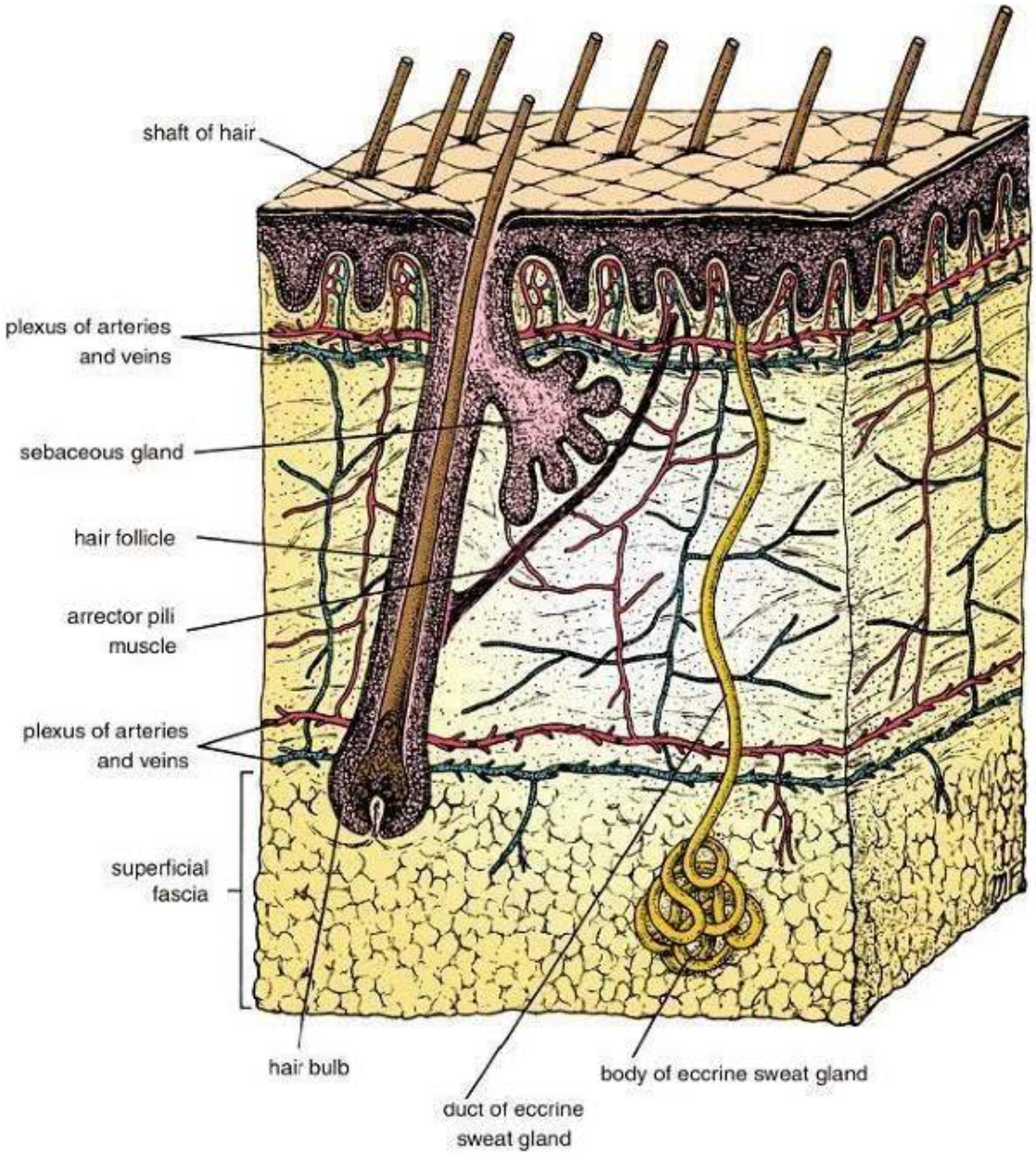

Figure 5: General structure of the skin and its relationship to the superficial fascia. Note: Hair follicles extend down into the deeper part of the dermis or into the superficial fascia, but sweat glands extend deeply into the superficial fascia.

Figure 6: Tension (Langer) lines in the skin. The dashed lines indicate the predominant direction of the collagen fiber bundles in the dermis. Incisions or lacerations running parallel to these lines have less tendency to gape than those crossing them.

Appendages Of The Skin (Figure 7):

1. Nails
2. Hair follicles
3. Sebaceous glands
4. Sweat glands

- **Nails:** Keratinized plates on dorsal surfaces of the tips of the fingers and toes. It has root of the nail, nail folds and nail bed.

- **Hairs:** Hair follicles Hair bulbs Hair papilla.

Sites Of Skin Having No Hairs:

1. Lips
2. Palms of the hands
3. Sides of the hands
4. Sides of fingers
5. Sole of the feet
6. Sides of the feet
7. Sides of the toes
8. Glans penis
9. Clitoris
10. Labia minora
11. Internal surface of the labia majora

- **Sebaceous Glands:**

Pours sebum; an oily material that helps preserve flexibility of emerging hair. It also oils surface of epidermis around mouth of follicle.

- **Sweat Glands:**

The most deeply penetrating structure of all the epidermal appendages.

Sites Of Skin Having No Sweat Glands:

1. Red margin of the lips
2. Nail beds
3. Glans penis
4. Clitoris

Rule Of Nines: Burns

9% head and neck
18% upper limbs (9X2)
36% lower limbs (18% X 2)
18% front of the trunk
18% back of the trunk
1% external genitalia

100% Total

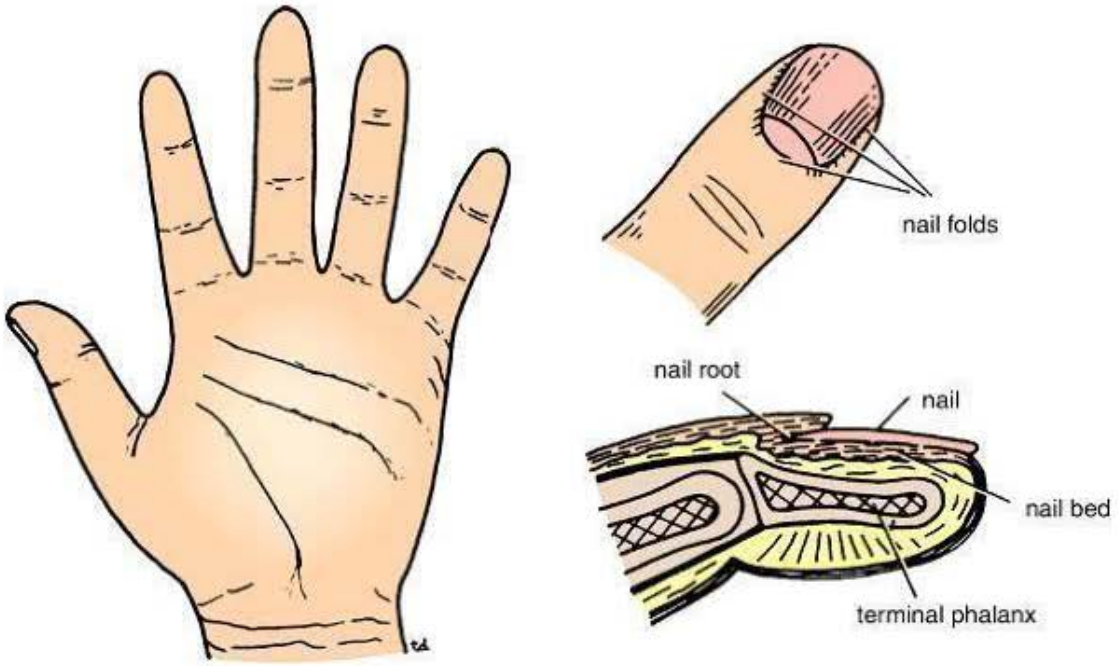

Figure 7: Various skin creases on the palmar surface of the hand and the anterior surface of the wrist joint. Note: Relationship of the nail to other structures of the finger.

Function of The Skin:

1. Protection: of the body from environmental effects such as abrasions, fluid loss, ultraviolet radiations, micro-organisms
2. Sensation (pain, temperature, touch) by way of superficial nerves and their sensory endings
3. Heat-regulation: through evaporation of sweat and/or dilation or constriction of superficial blood vessels.
4. Synthesis and storage of vitamin D.
5. Containment for the body's structures (tissues and organs) and vital substances (extra-cellular fluids) preventing dehydration.

Skin Ligaments (Retinacula Cutis) (Figure 8):

They extend from deep surface of dermis to underlying deep fascia. Their length and density determines mobility of skin over deep structures; more mobile on back of hand than its palm.

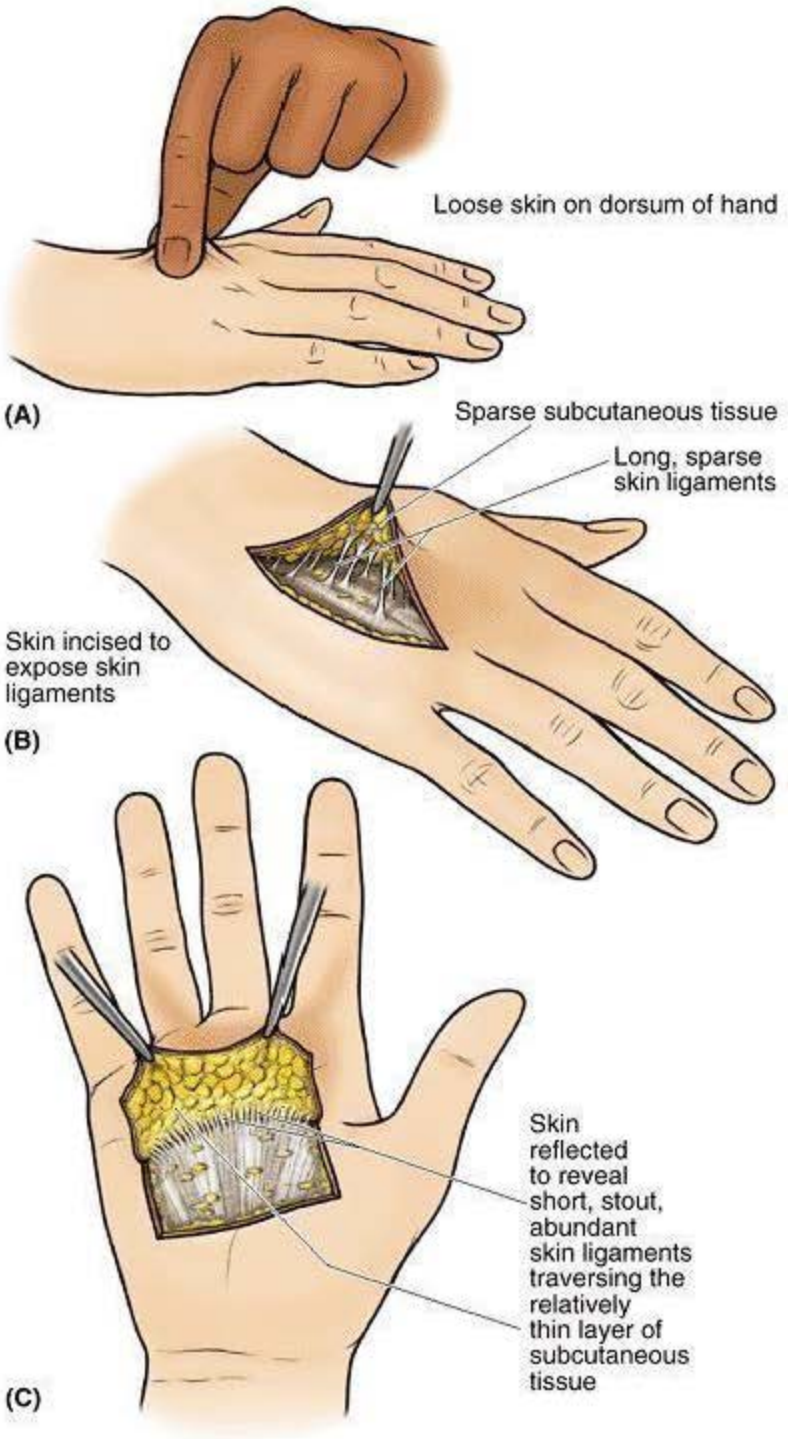

Figure 8: Skin ligaments of subcutaneous tissue. A. Thickness of subcutaneous tissue can be estimated as being about half that of a pinched fold of skin. Dorsum of the hand has relatively little subcutaneous tissue. B. Long, sparse skin ligaments allow mobility of the skin demonstrated in part A. C. Skin of palm of the hand (or soles of the feet) is firmly attached to the underlying deep fascia.

FASCIAE

They lie between the skin and the underlying muscles and bones.

I. SUPERFICIAL FASCIA (SUBCUTANEOUS TISSUE):

A mixture of loose areolar and adipose tissues that unites dermis of the skin to underlying deep fascia (Figures 5&9) .

Consists of:

1. Superficial fatty layer
2. Deep membranous layer
   - Main factor responsible for the smooth external contour of the female.

Sites of superficial fascia having numerous bundles of collagen fibres (dense C.T.):

1. Scalp
2. Back of the neck
3. Palms of the hands
4. Sole of the feet

Sites of superficial fascia devoid of adipose tissue:

1. Eyelids
2. Auricle of the ear
3. Penis
4. Scrotum
5. Clitoris
6. Nipple and areola of the breast

Functions of Superficial Fascia:

1. Acts as a distributing layer in which blood vessels, lymphatics and nerves can travel before entering the dermis.
2. Allows for mobility of the skin on underlying structures, particularly over the joints since its loss as in severe burns can lead to restriction of movement.
3. Provides a depot for food storage.
4. Forms a useful insulating layer over body.

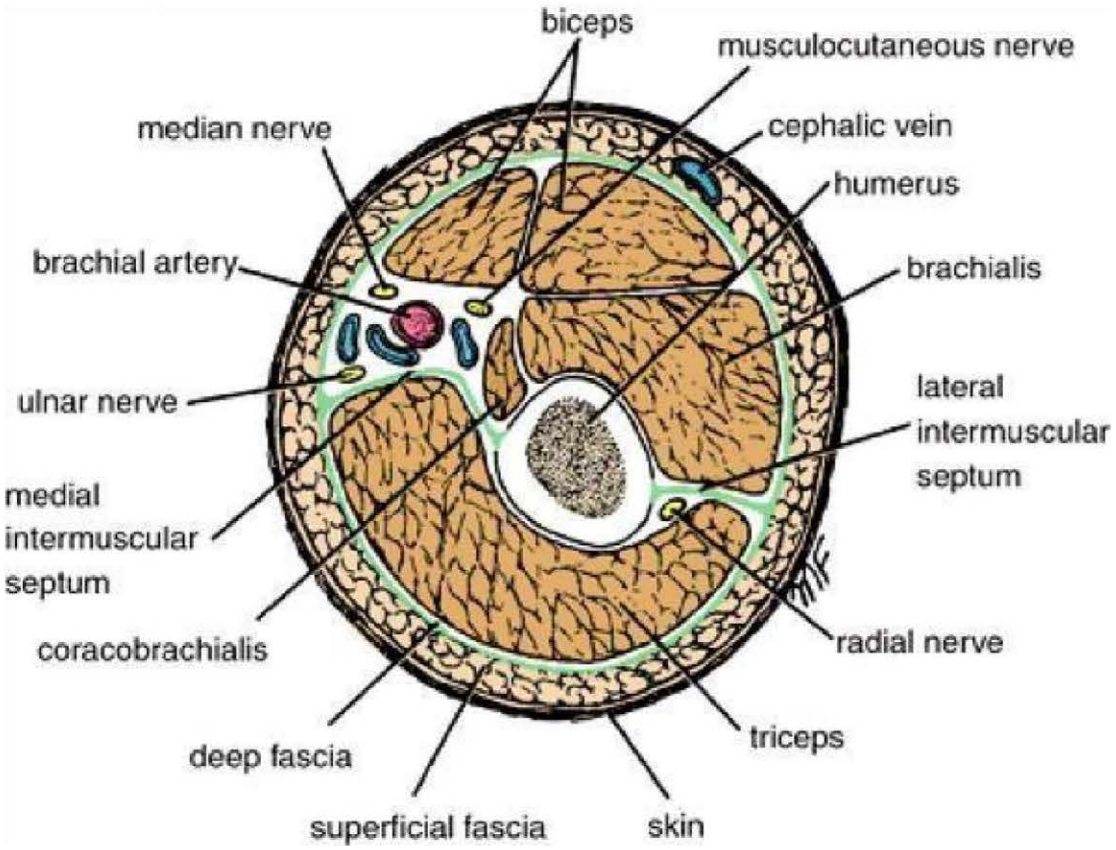

Figure 9: Section through the middle of the right arm showing the arrangement of the superficial and deep fascia. Note: The fibrous septa extend between groups of muscles, dividing the arm into fascial compartments.

II. DEEP FASCIA:

A membranous layer of connective tissue that invests the muscles and other deep structures (Figure 9).

Different forms and names of deep fascia:

- In some places, it splits to enclose structures as glands; submandibular & parotid glands.

- In anterior wall of axilla, it forms *clavipectoral fascia.*

- Extensions of the investing layer pass deeply to form *intermuscular septa* & sheaths for neurovascular bundles such as *axillary sheath.*

- In thorax and abdomen, it is merely a thin film of areolar tissue covering the muscles and aponeurosis. It is replaced by the membranous layer of superficial fascia (Scarpa's fascia).
- In thigh, it is called *fascia lata* and thickened on lateral side of the thigh to form *iliotibial tract*.

- In region of the joints, it is thickened to form bands (*retinacula*) to hold the underlying tendons in position or to serve as pulleys around which the tendons may move (Figure 10).

- Deep fascia, contracting muscles and venous valves work together as *musculo-venous pump* to return blood to heart, as in lower limbs where blood must move against pull of gravity.

- The layers of deep fascia have an important influence on tracking of pus and of body fluids so deep seated abscess may present at a position remote from the primary lesion. This is well seen in a *psoas abscess*.

III. SUBSEROUS FASCIA:

- Has varying amounts of fatty tissue
- Lies between internal surfaces of musculo-skeletal walls and serous membranes lining body cavities; *endothoracic, endoabdominal and endopelvic fascia*.
- Last 2 are called extraperitoneal fascia.

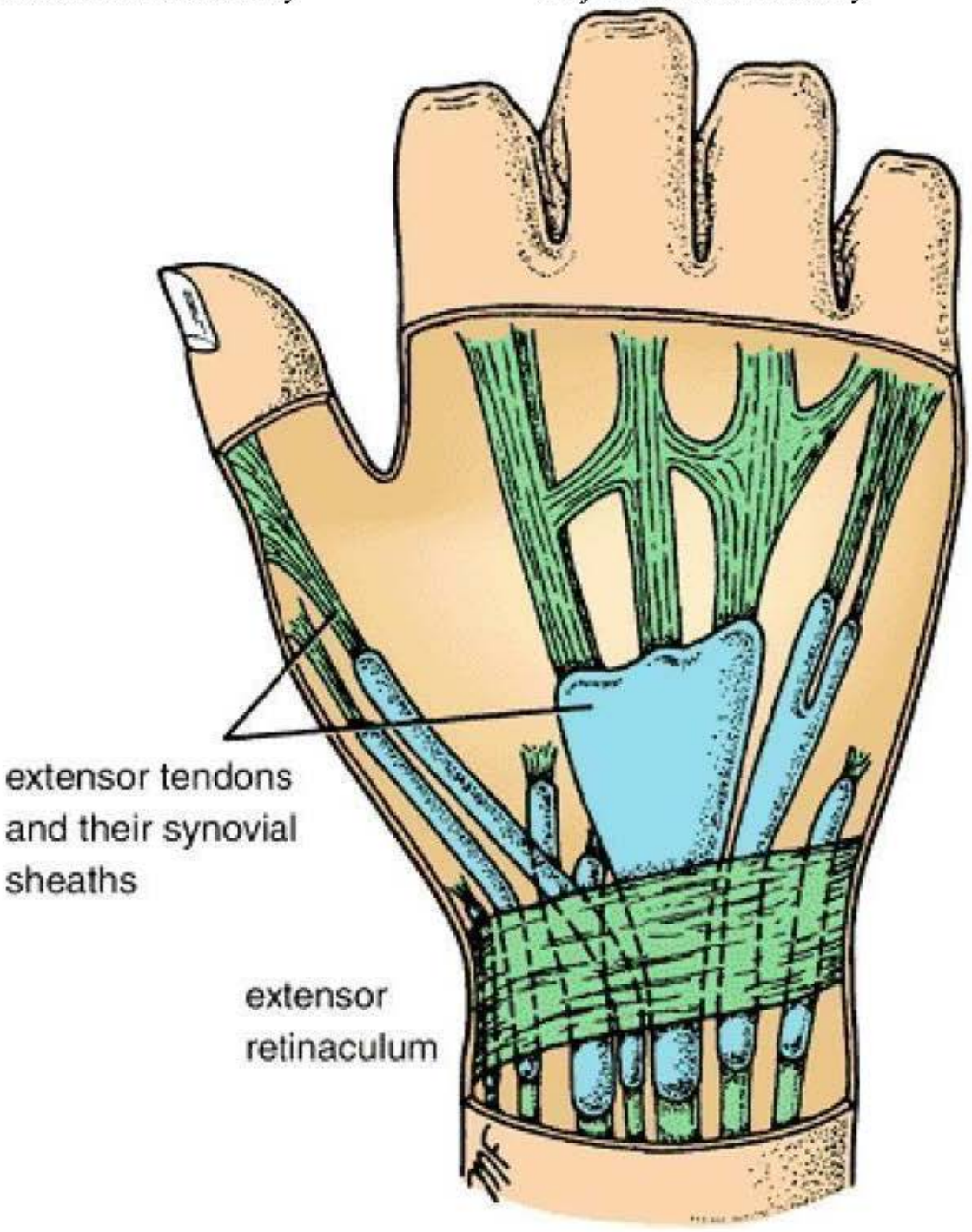

Figure 10: Extensor retinaculum on the posterior surface of the wrist holding the underlying tendons of the extensor muscles in position.

MUSCULAR SYSTEM

Muscles represent fleshy tissue of the body which have a power of contraction.

TYPES OF MUSCLES:

I. VOLUNTARY, SKELEAL, STRIATED:

1. Under control of well and desire.

- Controlled by special nerve or nerves which connect them to the central nervous system→ voluntary.

2. Attached; either origin or insertion to the skeleton→ skeletal.
3. Composed of groups of parallel bundles of muscle fibers→ striated or stripped.
4. Represent more than 40% of the whole body weight.
5. Their total number is 620 muscles all over the body.

Structure of Voluntary Muscles (Figure 11):

Origin: Begining part of the muscle
- Rigid and less mobile part
- Single or multiple

Insertion: Terminal mobile part
Attached to bone, skin, cartilage or contralateral muscle e.g. lumbricals, levator ani

Belly of the muscle: Fleshy part of the muscle

Tendon of the muscle:
Non-fleshy part by which the muscle is commonly inserted.

Forms of tendons (Figure 12):
1. Cord-like
2. Sheet-like (aponeurosis)
3. Raphe: interdigitate fibers

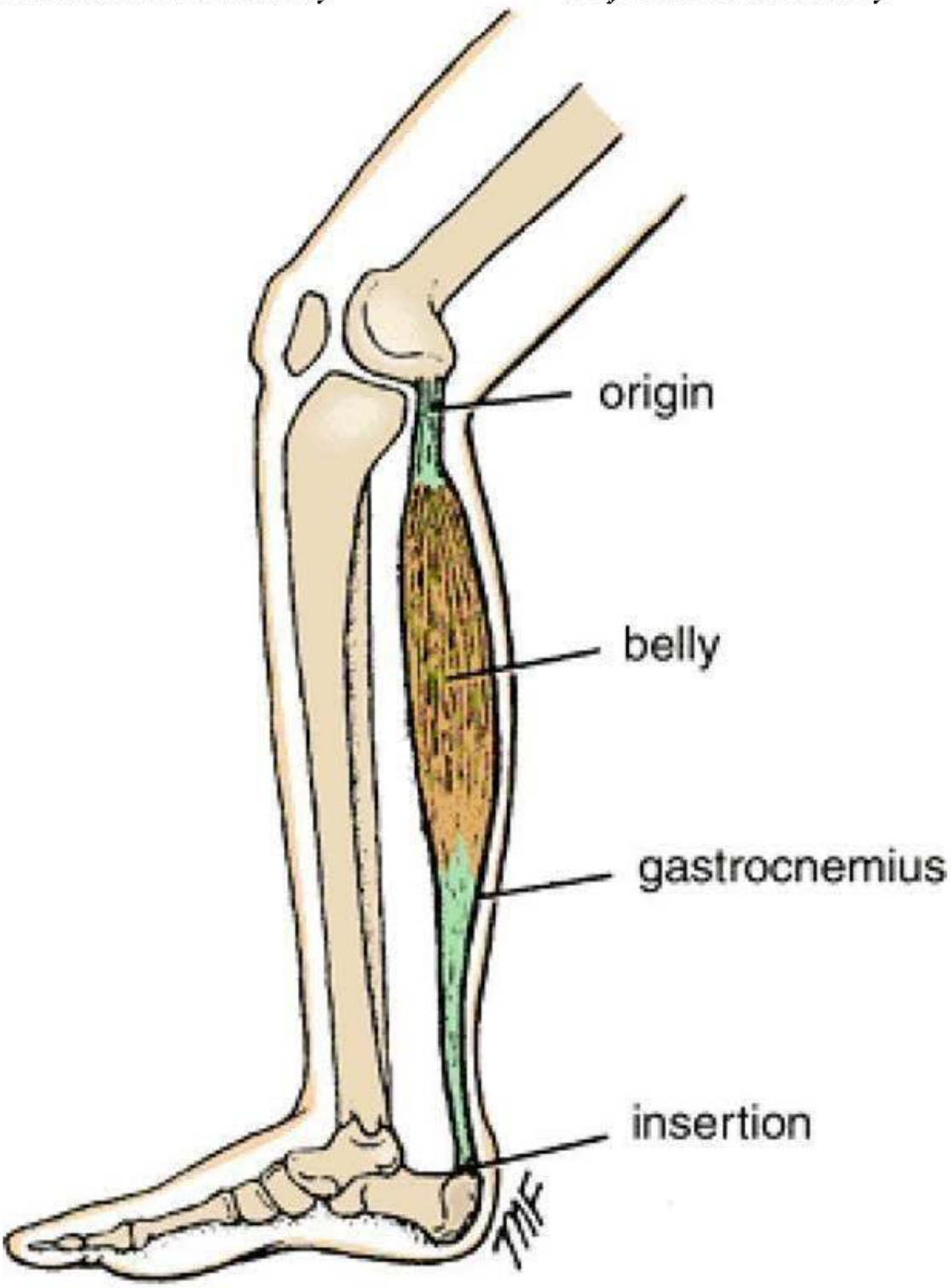

Figure 11: Origin, insertion, and belly of the gastrocnemius muscle

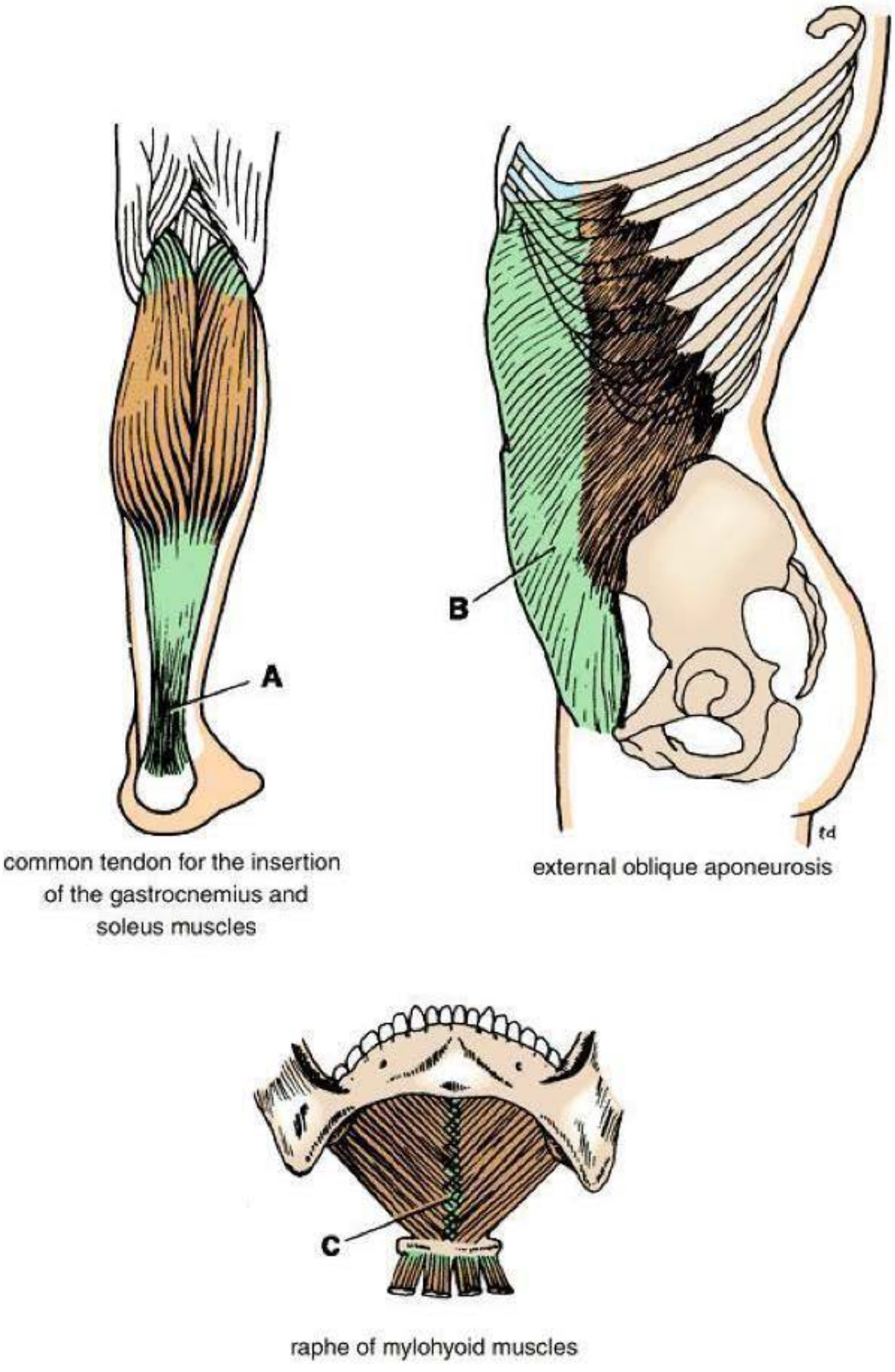

Figure 12: Examples of (A) a tendon, (B) an aponeurosis, and (C) a raphe

FORMS OF VOLUNTARY MUSCLES (Figure 13):

(According to shape and arrangement of fibers):-

1- Strap or parallel muscles: Parallel fibers e.g. sartorius

2- Quadrate muscle: Quadrangular in shape e.g. pronator quadratus

3- Triangular muscle: Triangular in shape e.g. temporalis

4- Fusiform muscle: Spindle-shaped e.g. biceps, flexor carpi radialis

5- Pennate muscle: The fibers are in oblique direction, feathery in shape and taking in many forms:-

a- Uni-pennate:

Its fibers come from one side of a tendon e.g. flexor pollicis longus

b- Bi-pennate:

Its fibers come from both sides of a tendon e.g. rectus femoris

c- Multi-pennate:

Series of bi-pennate fibers lie side by side e.g. deltoid muscle

d- Circum-pennate:

Fibers come out from central tendon in different directions e.g. tibialis anterior.

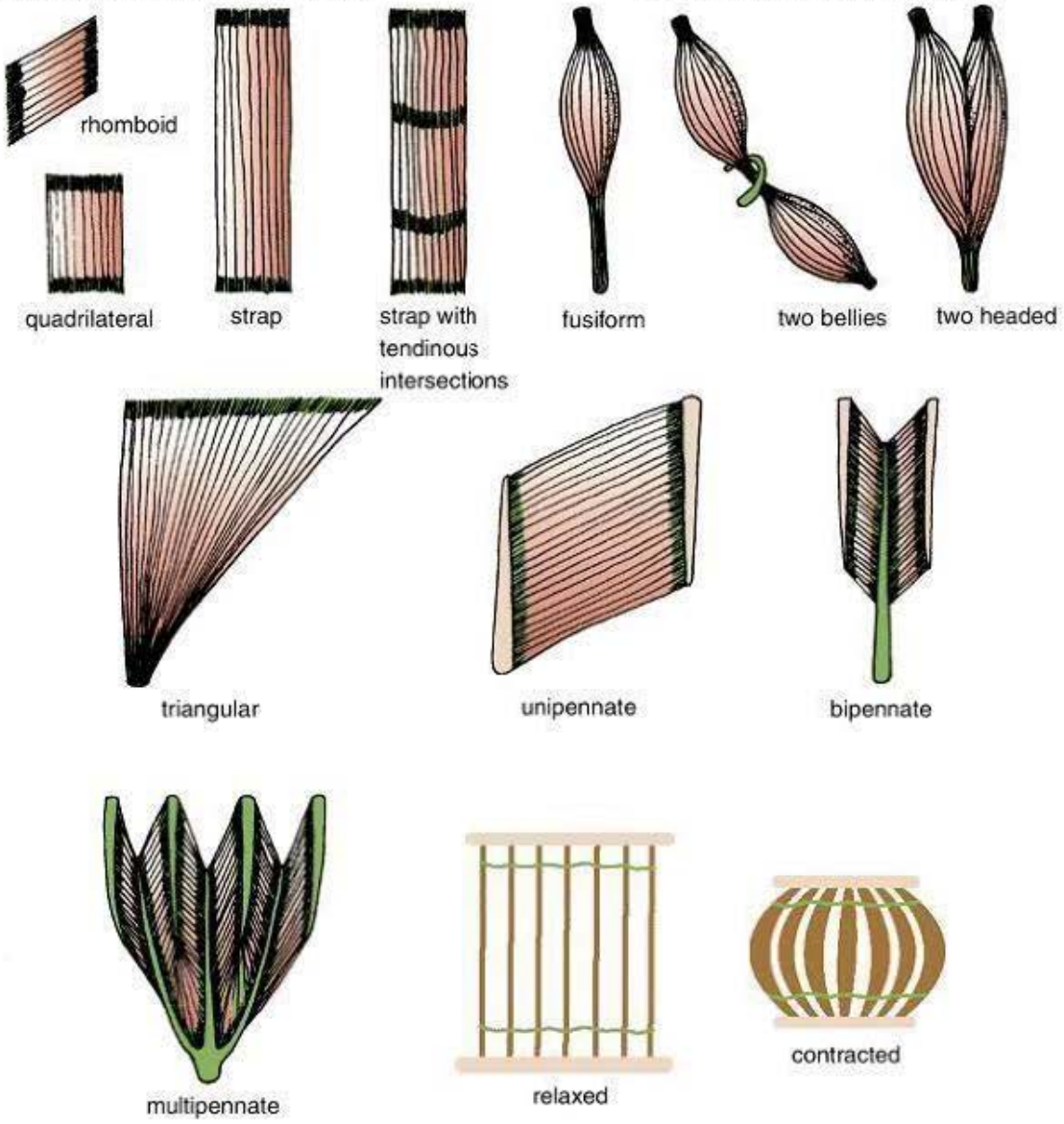

Figure 13: Different forms of the internal structure of skeletal muscle. A relaxed and a contracted muscle are also shown; note how the muscle fibers, on contraction, shorten by one third to one half of their resting length. Note: How the muscle swells.

MUSCLE TONE

- When resting, every skeletal muscle is in a partial state of contraction (muscle tone).
- Depends on integrity of monosynaptic reflex arc, composed of 2 neurons in nervous system.
- Degree of tension in muscle is detected by muscle spindle and tendon spindle.
- Nervous impulses travel in afferent neurons to spinal cord and synapse with anterior horn cells to give impulses along their axons (efferent) to muscle fibers.
- Cut reflex arc leads to paralysis of the muscle.

MOTOR UNIT:

Motor neuron and all the muscle fibers supplied by it.

- Gluteus maximus; motor neuron supplies about 200 muscle fibers.
- Small muscles of the hand, extrinsic muscles of the eyeball, one nerve fiber supplies few muscle fibers.

MUSCLE MOVEMENT:

All movements are the result of coordinated action of many muscles

Muscle Action; muscles may work in: (Figure 14):- 1.

Prime mover:

The chief muscle or a member of a chief group of muscles responsible for particular action e.g. quadriceps femoris is a prime mover in extension of the knee.

2. Antagonist:

Any muscle opposes action of prime mover e.g. biceps femoris oppose action of quadriceps femoris.

3. Fixator:

A muscle contracts isometrically (increase tone of the muscle but no movement) to stabilize action of prime mover. Muscles attaching to shoulder girdle to trunk contract as fixators to allow deltoid to act on shoulder

4. Synergist:

- To prevent unwanted movements in intermediate joints when the prime mover crosses number of joints before reaching the joint where its main action takes place.
- Flexor and extensor muscles of carpus contract to fix wrist joint to allow flexor and extensor muscles of fingers to work efficiently.

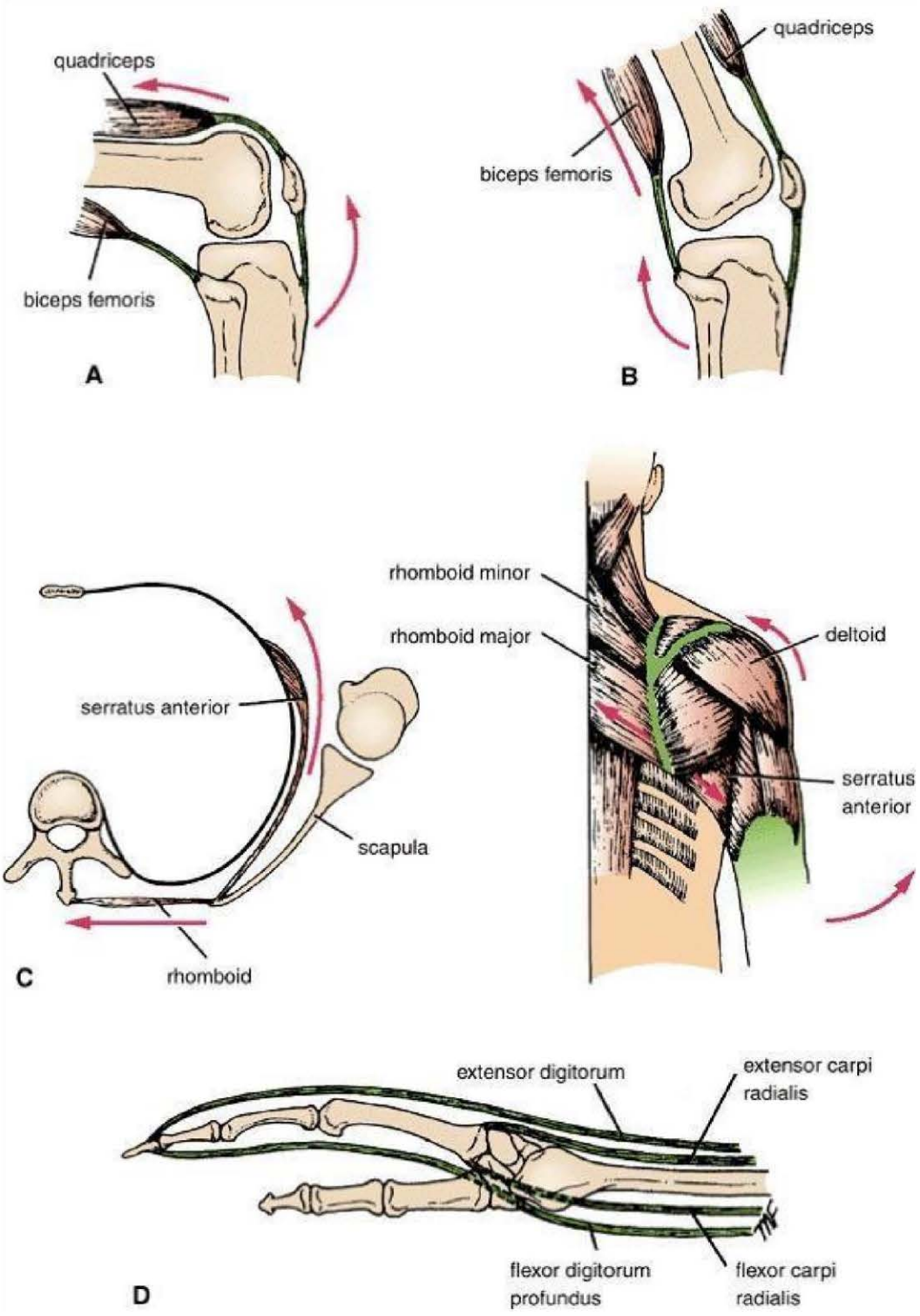

Figure 14: Different types of muscle action. A. Quadriceps femoris extending the knee as a prime mover, and biceps femoris acting as an antagonist. B. Biceps femoris flexing the knee as a prime mover, and quadriceps acting as an antagonist. C. Muscles around shoulder girdle fixing the scapula so that movement of abduction can take place at the shoulder joint. D. Flexor and extensor muscles of the carpus acting as synergists and stabilizing the carpus so that long flexor and extensor tendons can flex and extend the fingers.

MOTOR POINT:

Place of entrance of nerve to the muscle (about mid-point of its deep surface)

MOTOR END PLATE:

- Each motor fibre ends by dividing into branches.
- Each branch and the muscle fibers supplied by it are called motor end plate

II. UNVOLUNTARY, UNSTRIPPED, SMOOTH PLAIN GROUP:

Less common than voluntary

Characters of involuntary group:

1. Not controlled by well
2. Lies under control of autonomic nervous system
3. Not attached to bones
4. Their fibers are smooth, plane, not stripped
5. They contract and relax in ring fashion (peristalsis)

Examples: Smooth muscles in wall of gastrointestinal tract, respiratory tract, urinary and genital systems and wall of the blood vessels

III- THE CARDIAC MUSCLE:

Single and the most important muscle in the body

Characters of cardiac muscle:

1. Not voluntary
2. Not smooth
3. Single
4. Contracts in rhythmic fashion (pumping)

BONES

- Forms most of the adult skeleton (Figure 15).
- About 206 bones
- Solid living tissue.
- Vascularized dense connective tissue

TYPES OF BONES (Figure 16):

A- ACCORDING TO STRCTURE:

1. Compact Bone:

- Outer layer of flat, short bones and cylinders of long bones
- Solid and compact; regularly arranged compressed bone lamellae
- The arrangement is corresponding to distribution of blood vessels

2. Cancellous (Spongy) Bone:

- Diploe of flat bones (skull)
- Inner mass of short bones
- Terminal ends of long bones
- Thin irregularly arranged branching bone trabeculae (corresponding with lines of maximal tension), separated by bone marrow spaces.

B. ACCORDING TO SHAPE:

1. Long Bones:

- Ex: Clavicle, humerus, radius, ulna, femur, fibula, tibia
- Cylindrical in shape
- Has 2 ends (upper and lower) and shaft:-
- **Ends (epiphysis):** Have cancellous bone trabeculae covered by shell of compact bone
- **Shaft (diaphysis);** Compact bone, surrounds medullary cavity
- **Bone marrow:** Main blood forming organ in the body.
- The shaft is covered by periosteum (membrane covering bone), sensitive and contains blood vessels and nerves.
- Metaphysis: Part of diaphysis near epiphysis and separated from it by epiphyseal plate of cartilage.

2. Short Bones:

- Ex: Carpal and tarsal bones
- Different forms without bone marrow
- May contain red marrow in interstitial spaces; in-between the trabeculae.

3. Sesamoid Bones:

- Ex: Patella; the largest sesamoid bone.
- Special variety of short bones present in certain sites in the body
- Invested in tendons of some muscles
- Act to modify pressure and diminish friction at their origin.

4. Short Long Bones:

- Ex: Metacarpal, metatarsal and phalanges
- Short cylindrical with one end and bone marrow cavity

5. Flat Bones:

- Ex: Vault of the skull, ribs, scapula.
- Thin and broad bones
- Outer and inner plates of compact bones with intermediate cancellous bone

6. Irregular Bones:

- Ex: Vertebrae, hip bones
- Ill-defined shape due to presence of bony processes and extensions diverge in different directions.

7. Pneumatic Bones:

- Ex: Paranasal sinuses; found in some bones of face and around the nose (contain small air cavities inside them).
- **They are:-**
  1. Maxillary air sinuses
  2. Frontal air sinuses
  3. Sphenoid air sinus
  4. Ethmoid air sinuses

C. ACCORDING TO TYPE OF OSSIFICATION:

1. Cartilaginous Ossification:

- Cartilage is changed to bone
- Ex: Long bones

2. Intra-membranous Ossification:

- Membrane is changed to bone
- Ex: Flat bones
- Growth in thickness (sub-periosteal deposition of bone)

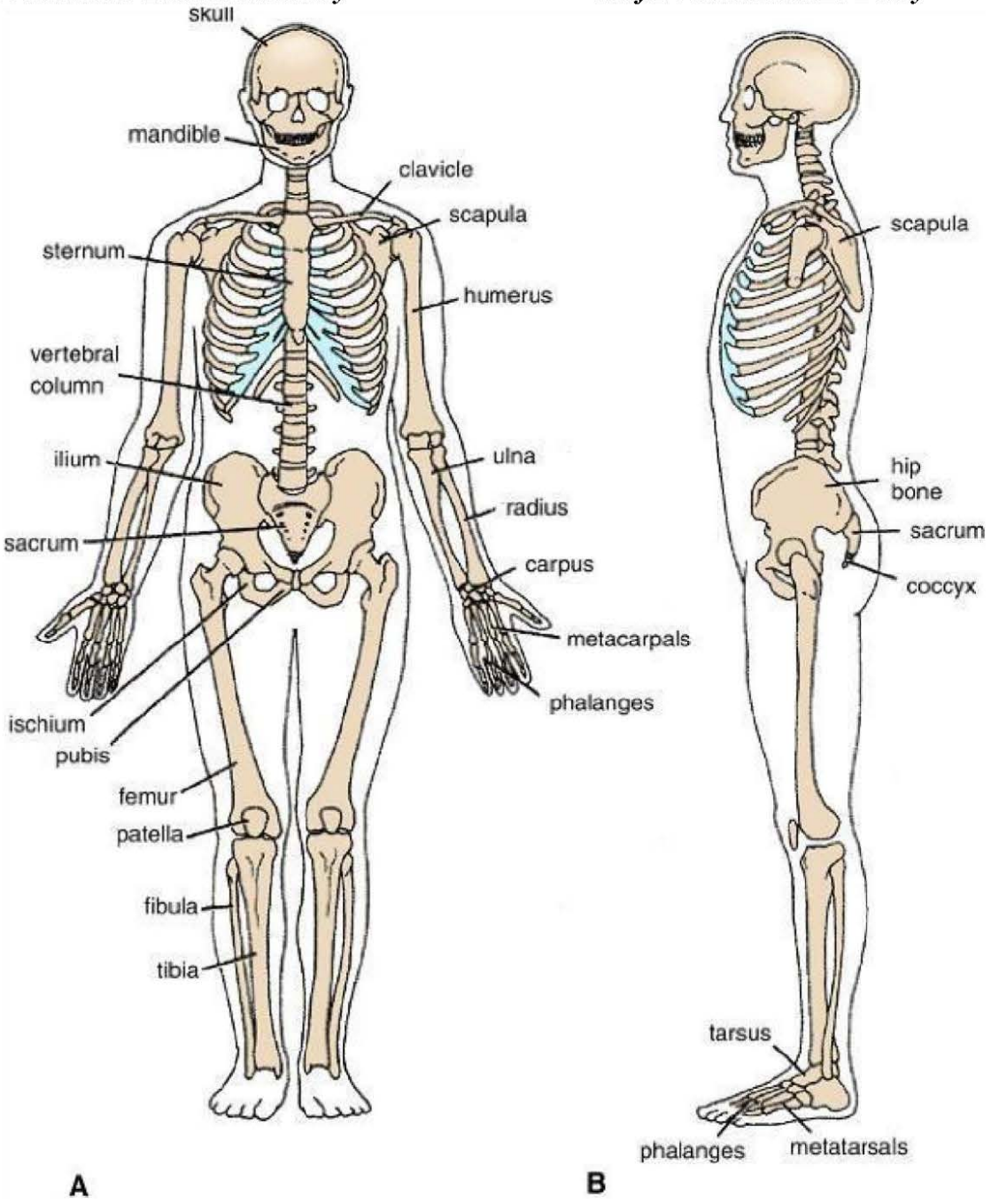

Figure 15: The skeleton. A. Anterior view. B. Lateral view.

BONE MARROW:

1. **Red bone marrow:** Forms red blood cells.
   - Lies in: Skull, vertebrae, ribs, sternum, hip, upper end of humerus, femur.

2. **Yellow (inert) bone marrow:**

• Composed of fatty tissue.

FUNCTIONS OF BONES:

1. Give the body its form, contour, defines its width.
2. Support overlying soft tissue
3. Protect important delicate and fragile internal organs; skull for brain, vertebrae for spinal cord, scapula and ribs for heart and lungs
4. Give areas for muscular attachment
5. 5. Act as levers during movements.
6. Help the body to assume different positions; standing up, seat down
7. Essential in walking, running, jumping, playing, upstairs
8. Stores for calcium salt to time to need; pregnancy, aging.
9. Production of R.B.C. via bone marrow.

BLOOD SUPPLY OF BONES (Figure 17):

1. **Nutrient artery:** Bone marrow, branches in metaphysis (its branches are end arteries).
2. **Epiphyseal artery:** Epiphysis
3. **Metaphyseal artery:** Metaphysis
4. **Periosteal artery:** Periosteum

N.B: Cartilagenous epiphysis hyaline cartilage has NO blood supply. As ossification begins, blood vessels penetrate epiphysis ossification centres

CARTILAGOUS OSSIFICATION:

Pre-existing hyaline cartilage model of bone gradually destroyed and replaced by bone.

Steps of cartilaginous ossification:-

1 Each bone is represented by small cartilaginous moulds in embryo

2 Primary centres of ossification appears in shaft of the cartilage during intra uterine life.

3. Secondary centres of ossification appear at the end of long bone epiphysis around birth.

4. Bone occupied whole cartilaginous mould except at epiphyseal plate of cartilage.

So, the long bone is composed of:-

a. Shaft (diaphysis)
b. Two ends (epiphysis)
c. Epiphyseal plate of cartilage
d. Metaphysis

AT puberty (14 – 16 years) adolescent:

- One epiphyseal plate ossifies and unites with the shaft (non-growing end)

At adult age (18 -21 years)

- Other epiphyseal plates ossify (growing end).
- No further growth in length later.

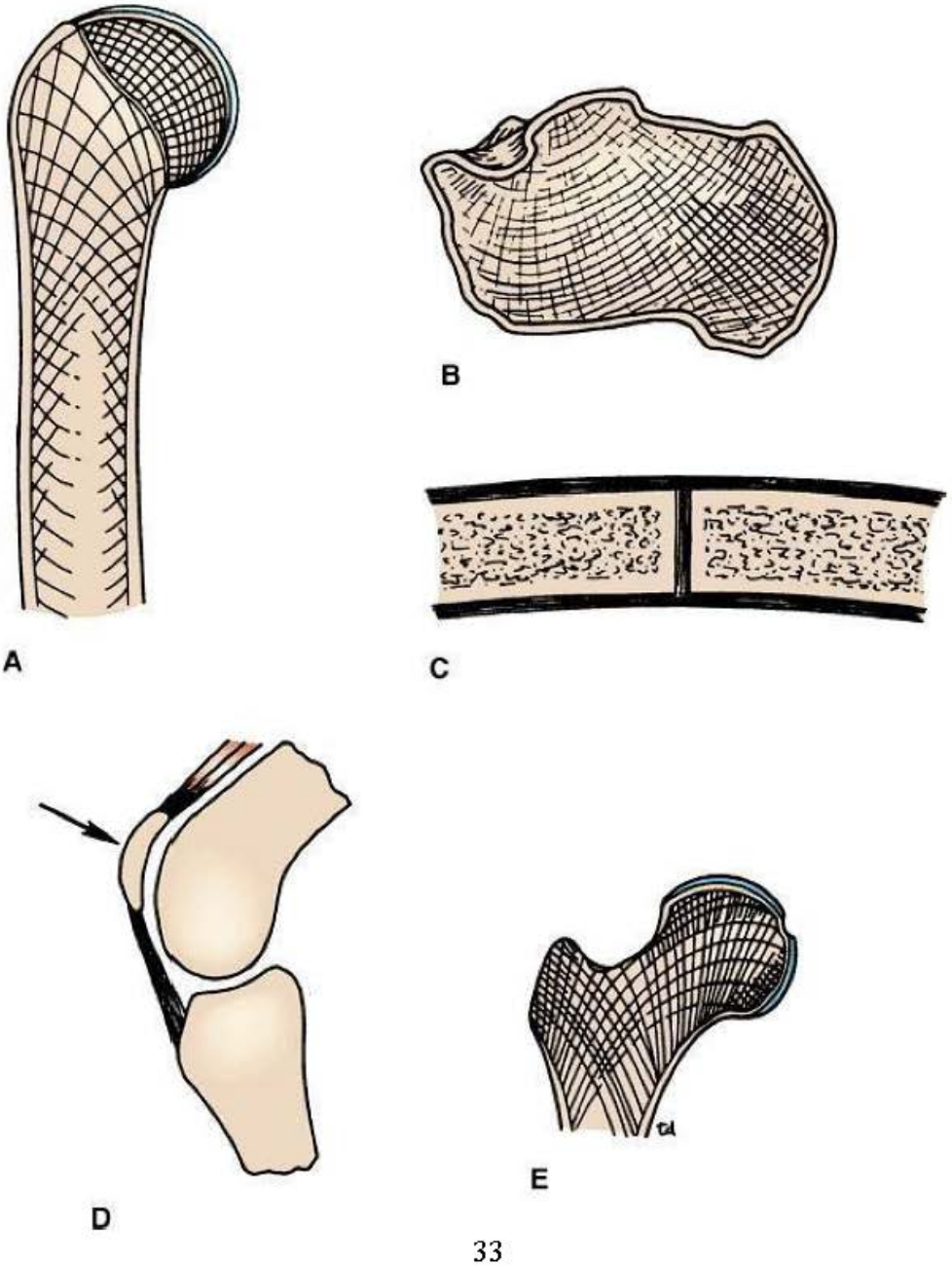

Figure 16: Sections of different types of bones. A. Long bone (humerus).
B. Irregular bone (calcaneum). C. Flat bone (two parietal bones separated by the sagittal suture). D. Sesamoid bone (patella). E. Note: Arrangement of trabeculae to act as struts to resist both compression and tension forces in the upper end of the femur.

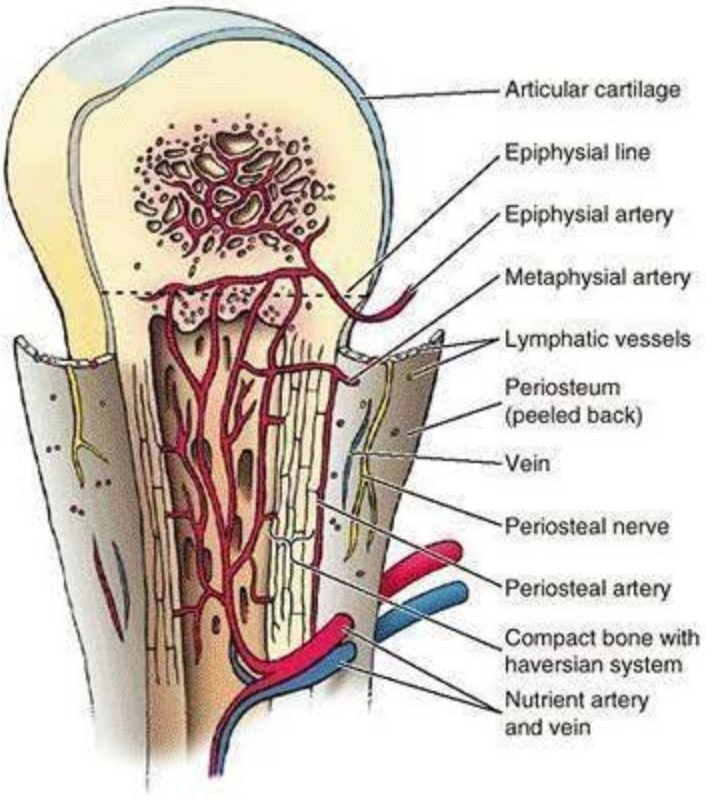

Figure 17: Vasculature and innervation of a long bone. Large nutrient artery (or arteries) supplies the marrow, spongy bone, and deeper compact bone of the diaphysis and metaphyses. Small branches from the periosteal arteries supply most of the compact bone from the superficial aspect. Haversian canal systems enable blood to penetrate the compact bone to nourish the osteocytes (bone cells). Epiphysial and metaphysial arteries supply the ends of long bones. The periosteum is also rich in sensory (periosteal) nerve.

Regional Classification of Bones

Region of Skeleton	Number of Bones
Axial skeleton	
Skull	
Cranium	8
Face	14
Auditory ossicles	6
Hyoid	1
Vertebrae (including sacrum and coccyx)	26
Sternum	1
Ribs	24
Appendicular skeleton	
Shoulder girdles	
Clavicle	2
Scapula	2
Upper extremities	
Humerus	2
Radius	2
Ulna	2
Carpals	16
Metacarpals	10
Phalanges	28
Pelvic girdle	
Hip bone	2
Lower extremities	
Femur	2
Patella	2
Fibula	2
Tibia	2
Tarsals	14
Metatarsals	10
Phalanges	28
Total	206

Bone Markings and Formations:

Bone markings appear wherever tendons, ligaments, and fasciae are attached or where arteries lie adjacent to or enter bones. Other formations occur in relation to the passage of a tendon (often to direct

the tendon or improve its leverage) or to control the type of movement occurring at a joint. The various markings and features of bones are:

- **Capitulum**: small, round, articular head (capitulum of humerus).
- **Condyle:** rounded, knuckle-like articular area, usually occurring in pairs (lateral femoral condyle).
- **Crest:** ridge of bone (iliac crest).
- **Epicondyle:** eminence superior to a condyle (lateral epicondyle of the humerus).
- **Facet:** smooth flat area, usually covered with cartilage, where a bone articulates with another bone (superior costal facet on the body of a vertebra for articulation with a rib).
- **Foramen:** passage through a bone (obturator foramen).
- **Fossa:** hollow or depressed area (infraspinous fossa of scapula).
- **Groove:** elongated depression, furrow (radial groove of humerus)
- **Head (L. caput):** large, round articular end (head of the humerus).
- **Line:** linear elevation (soleal line of the tibia).
- **Malleolus:** rounded process (lateral malleolus of the fibula).
- **Notch:** indentation at the edge of a bone (greater sciatic notch).
- **Protuberance:** projection of bone (external occipital protuberance).
- **Spine:** thorn-like process (spine of the scapula).
- **Spinous process:** projecting spine-like part (spinous process of a vertebra).
- **Trochanter:** large blunt elevation (greater trochanter of femur).
- **Trochlea:** spool-like articular process or process that acts as a pulley (trochlea of the humerus).
- **Tubercle:** small raised eminence (greater tubercle of the humerus).
- **Tuberosity:** large rounded elevation (ischial tuberosity).

CARTILAGE

- Dense irregular connective tissue
- Formed by living cells and intra-cellular matrix
- No blood vessels or lymph or nerves (insensitive)

Types of cartilage: (According to intra-cellular matrix composition)

I- Hyaline cartilage:

Ex: anterior part of most of ribs, articular cartilage of the synovial joints

II- Fibro-cartilage: Ex: symphysis pubis and intervertebral discs

III- Elastic cartilage: Ex: tip of nose, auditory tube and external ear.

JOINTS

Meeting, joining, union or connection between different parts of skeleton either bones or cartilage.

TYPES OF JOINTS (Figure 18):

A. FIBROUS JOINTS:

-The 2 bones are connected together by fibrous tissue.
-The tissue is mainly inelastic white fibers stretching between the 2 bony ends and tightly connects them together.
-No movement could be done ….fixed joints -The least common among all types of joints **Examples:**

1. Sutures of the skull (coronal, sagittal,.)
2. Gomphosis (dentoalveolar syndesmosis); between root of teeth and their sockets in gums.
3. Inferior tibio-fibular joint (Syndesmosis)

B. CARTILAGENOUS JOINTS:

-The 2 bones are connected by hyaline cartilage (1ry) or fibro-cartilage (2ry) that extends between the bony ends.
-Little or limited movement due to presence of a cartilaginous media. More common than flat bones.

I. Primary Cartilaginous Joints. (Synchondroses):

Hyaline cartilage is ossified later in life (transformed into bone at old age) **-Examples:**

1. Epiphyseal plate of long bones; between epiphysis and metaphysis).
2. Spheno-occipital (basi-spheoid) joint; between basilar part of occipital bone and body of sphenoid, at base of the skull, ossified at about 23years.
3. Between costal cartilage of first rib with manubrium sterni.

II. Secondary Cartilaginous Joints (Symphyses):

-Nature of articulation preserved all over the life.
-Examples:-

1. Intervertebral discs
2. Symphysis pubis
3. Manubrio-sternal joint (sternal angle, angle of Louis)

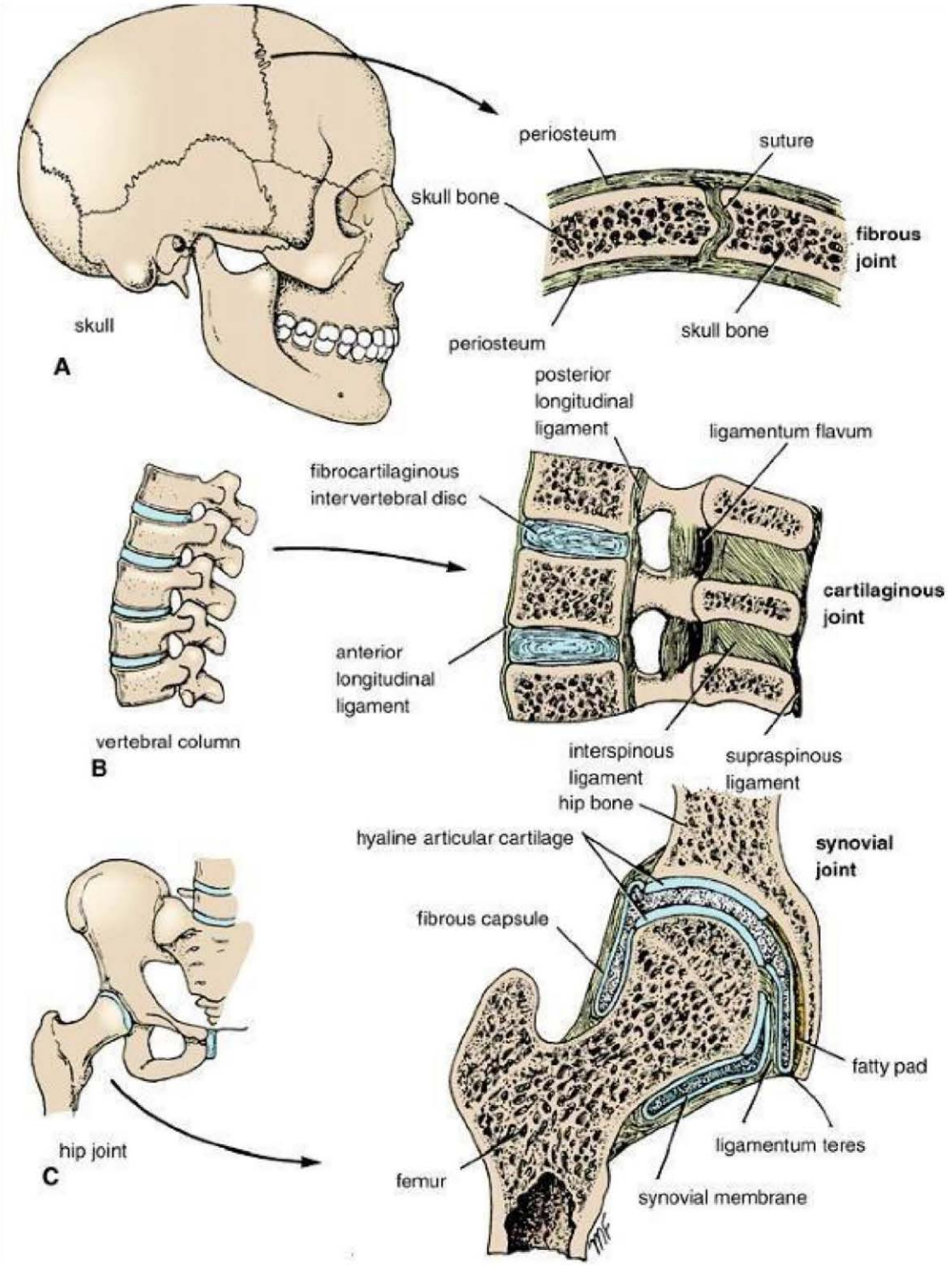

Figure 18: Examples of three types of joints. A. Fibrous joint (coronal suture of skull). B. Cartilaginous joint (joint between two lumbar vertebral bodies). C. Synovial joint (hip joint).

C. SYNOVIAL JOINTS:

-The most common type of joints in the body and the most movable one.

Structure of the synovial joint:

1. Bony articular ends: 2 or more bony ends, usually large in size

2. Articular cartilage:

- A thin smooth layer of hyaline cartilage covers the opposed articular surfaces of the bony ends.
- Gives a smooth surface for the surface of articulation.
- Gives a sort of flexibility between the articulating bones, so it facilitates the movements' in-between.

3. Fibrous capsule:

- Extends and connects the opposed bony ends sharing in the articulation together.
- May be thickened to form ligaments.
- May be weakened by the presence of openings in some sites.
- Sometimes, there are intra-capsular ligaments inside joint cavity.

4. Synovial membrane:

- A very thin highly vascular membrane
- Covers all the intra-capsular structures of the joint except the articular surfaces.
- Lines inner surface of the fibrous capsule.
- Contains the synovial cells which secrete the synovial fluid inside the joint cavity.

5. Synovial fluid:

- Acts as a lubricant to prevent friction between the opposed bones. Facilitates movements in-between the articulating bones • Plays an important role in nourishment of the articular cartilage.

Subsidiary structures inside the synovial joint:

1. Articular disc of fibro-cartilage (e.g. temporo-mandibular, sternoclavicular, acromio-clavicular, inferior radio-ulnar joints)
2. Intra-capsular ligaments as cruciate ligaments of knee joint
3. Menisci of cartilage that are present in the knee joint
4. Tendons of some muscles as long head of biceps brachii
5. Pads of fat inside the joint cavity

Blood supply:

Articular twigs that come from the surrounding vessels. They pierce the fibrous capsule to reach the joint.

Nerve Supply of Joints:

- Capsule and ligaments receive an abundant sensory nerve supply.
- A sensory nerve supplying a joint also supplies the muscles moving the joint and the skin overlying the insertions of these muscles, ***Hilton's law***.

STABILITY OF JOINTS (Figure 19):

- Depends on three main factors: the shape, size, and arrangement of the articular surfaces; the ligaments; and the tone of the muscles around the joint.

1. Articular Surfaces:

- Ball-and-socket arrangement of the hip joint (Fig. 19) and arrangement of the ankle joint are good examples of how bone shape plays an important role in joint stability.
- However, shape of the bones contributes little or nothing to the stability include acromioclavicular joint, calcaneocuboid joint and knee joint.

2. Ligaments:

- Fibrous ligaments prevent excessive movement in a joint (Fig. 19), but if the stress is continued for a long period, then fibrous ligaments stretch; ligaments of the joints between the bones forming arches of the feet will not by themselves support weight of the body. - Should tone of the muscles that normally support the arches become impaired by fatigue, then the ligaments will stretch and the arches will collapse, producing flat feet.
- Elastic ligaments, return to their original length after stretching. - Elastic ligaments of the auditory ossicles play an active part in supporting the joints and assisting in the return of the bones to their original position after movement.

3. Muscle Tone:

- In most joints, muscle tone is the major factor controlling stability. - Muscle tone of the short muscles around the shoulder joint keeps hemispherical head of the humerus in shallow glenoid cavity of the scapula; without the action of these muscles, very little force would be required to dislocate this joint.

- Knee joint is very unstable without tonic activity of quadriceps femoris.
- Joints between the small bones forming arches of the feet are largely supported by tone of the muscles of the leg, whose tendons are inserted into the bones of the feet (Fig. 19).

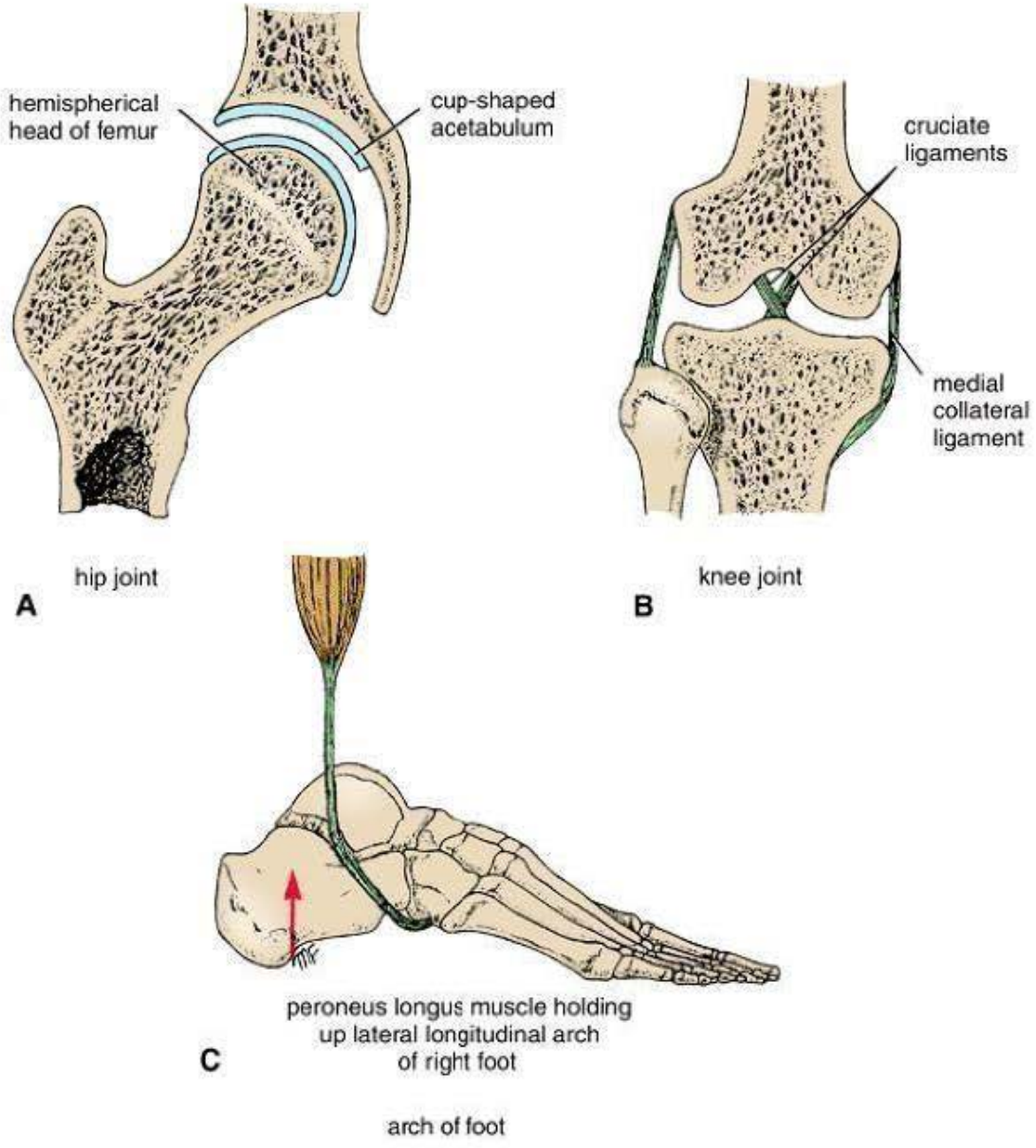

Figure 19: The three main factors responsible for stabilizing a joint. A. Shape of articular surfaces. B. Ligaments. C. Muscle tone.

CLASSIFICATION OF SYNOVIAL JOINTS (Figure 20):

A. ACCORDING TO AXIS OF MOVEMENTS:

1. Uni-axial joints:

They move around single axis, either transverse or longitudinal, e.g. elbow, ankle joints. The movements occur at these joints are e.g. flexion and extension.

2. Bi-axial joins:

They move around two axes e.g. wrist and ankle joints. Movements occur are flexion & extension and adduction & abduction.

3. Poly-axial joints:

They move in three axes, e.g. shoulder and hip joints. The movements at these joints are flexion and extension & adduction and abduction & medial and lateral rotations.

B. ACCORDING TO SHAPE OF ARTICULATING SURFACES:

1. BALL AND SOCKET TYPE:

Poly-axial, e.g. *shoulder and hip joints*

2. HINGE TYPE:

Uni-axial, e.g. *elbow, ankle, inter-phalangeal joints.*

3. SADDLE-SHAPED TYPE:

Bi-axial; the opposing surfaces are reciprocally concavo-convex, e.g. *carpo-metacarpal joint of thumb (1st carpo-metacarpal joint).*

4. GLIDING (PLANE) TYPE:

Has two smooth opposing surfaces, e.g. *inter-carpal, inter-tarsal and costovertebral joints.*

5. PIVOT TYPE:

Uni-axial; where a pivot turns around a longitudinal axis, e.g. *superior radio-ulnar and atlanto-axial joints*

6. CONDYLOID TYPE:

Bi-axial, where two convex condyles articulate with two concave condyles, e.g. *knee joint (modified hinge type).*

7. ELLIPSOID TYPE:

Bi-axial, where one convex surface articulates with an elliptical concave surface, e.g. *wrist joint.*

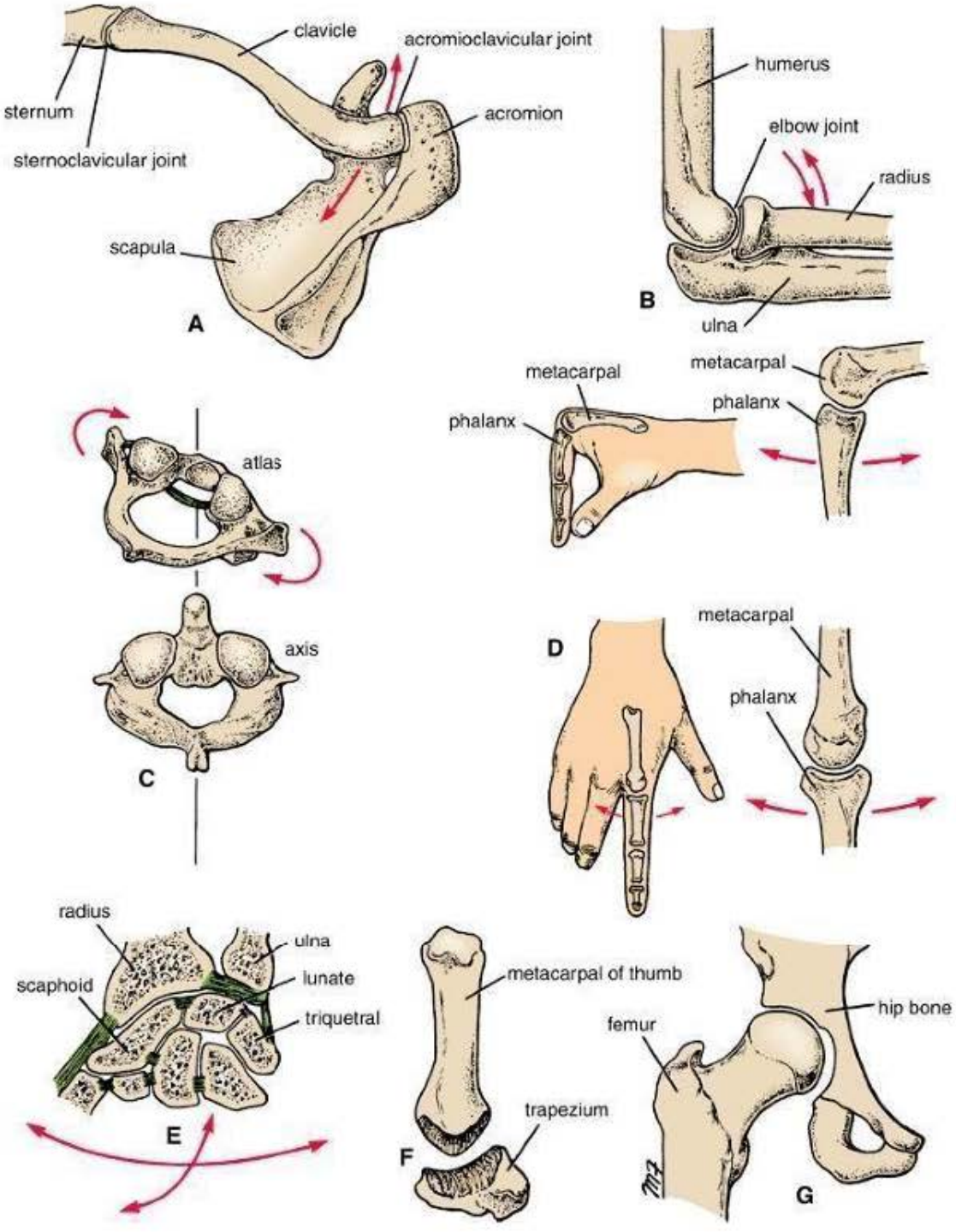

Figure 20: Examples of different types of synovial joints. A. Plane joints (sternoclavicular and acromioclavicular joints). B. Hinge joint (elbow joint). **C.** Pivot joint (atlantoaxial joint). D. Condyloid joint (metacarpophalangeal joint). E. Ellipsoid joint (wrist joint). F. Saddle joint (carpometacarpal joint of the thumb). G. Ball-and-socket joint (hip joint

Ligaments:

- Cord or band of connective tissue uniting two structures.
- Commonly found in association with joints, ligaments are of two types.
- Most are composed of dense bundles of collagen fibers and are unstretchable under normal conditions (iliofemoral ligament of the hip joint and collateral ligaments of the elbow joint).
- The second type is composed largely of elastic tissue and can therefore regain its original length after stretching (ligamentum flavum of the vertebral column and calcaneonavicular ligament of the foot).

Bursae:

- Lubricating device consisting of a closed fibrous sac lined with a delicate smooth membrane.
- Its walls are separated by a film of viscous fluid.
- Found wherever tendons rub against bones, ligaments, or other tendons.
- Commonly found close to joints where the skin rubs against underlying bony structures; prepatellar bursa (Fig. 21).
- Occasionally, the cavity of a bursa communicates with the cavity of a synovial joint; suprapatellar bursa communicates with the knee joint (Fig. 21) and subscapularis bursa communicates with the shoulder joint.

Synovial Sheath:

- Tubular bursa that surrounds a tendon.
- The tendon invaginates the bursa from one side so that the tendon becomes suspended within the bursa by a mesotendon (Fig. 21).
- Mesotendon enables blood vessels to enter the tendon along its course.
- In certain situations, when the range of movement is extensive, mesotendon disappears or remains in the form of narrow threads; vincula (long flexor tendons of the fingers and toes).
- Synovial sheaths occur where tendons pass under ligaments and retinacula and through osseofibrous tunnels.
- Their function is to reduce friction between the tendon and its surrounding structures.

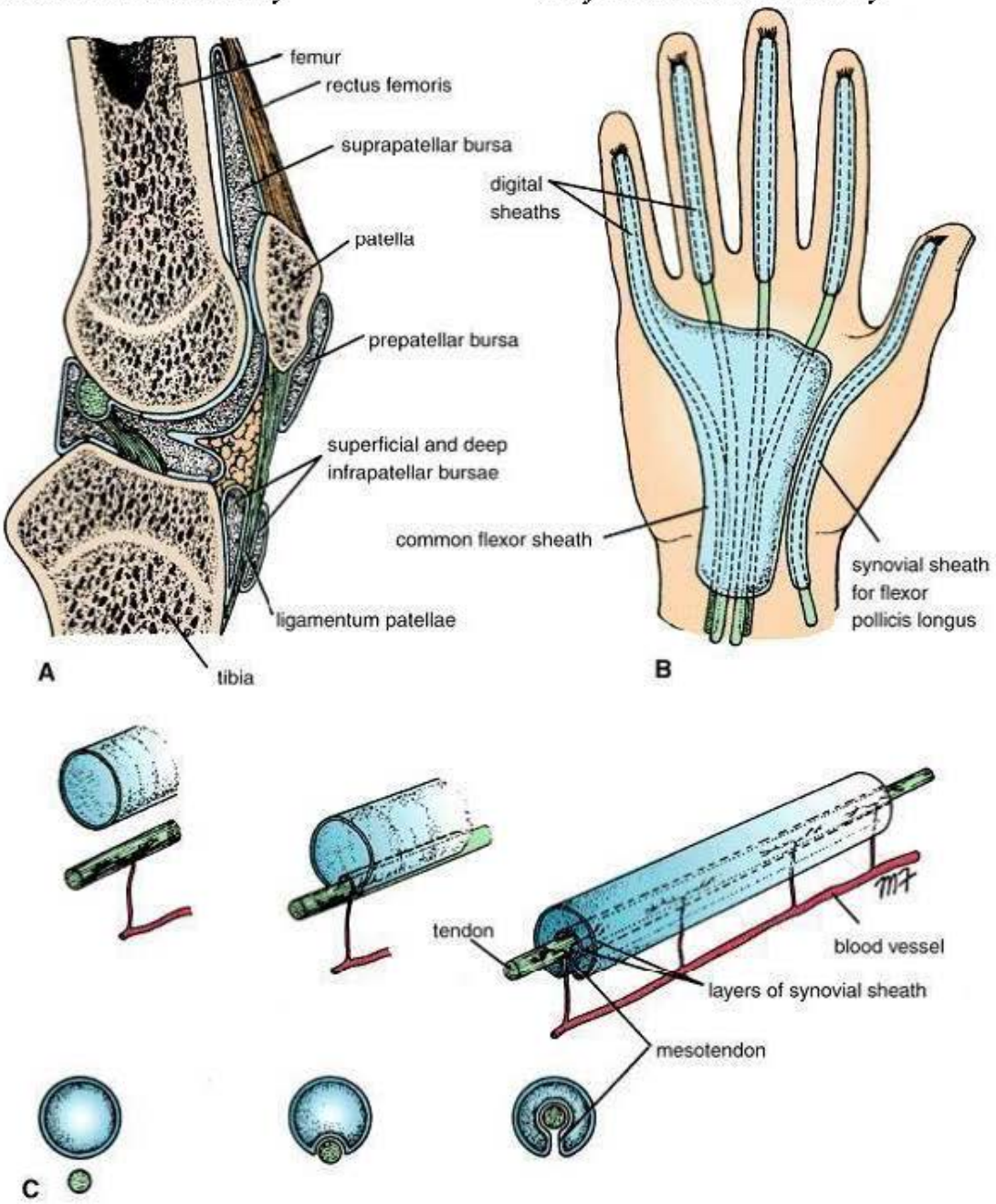

Figure 21: A. Four bursae related to the front of the knee joint. Note: suprapatellar bursa communicates with the cavity of the joint. B. Synovial sheaths around the long tendons of the fingers. C. How tendon indents synovial sheath during development, and how blood vessels reach the tendon through the mesotendon.

CARDIO-VASCULAR SYSTEM

It consists of (Figure 22):

1. Heart
2. Blood vessels: - Arteries - Veins - Capillaries

THE HEART:

- Pumps oxygenated blood to all parts of the body via arteries The arteries ramify and end in small minute arterioles.
- The arterioles open into a network of very small microscopic structures called capillaries.
- The capillaries form a capillary bed where interchange of oxygen, nutrients, waste products and other substances with the extra-cellular fluid occurs.
- Blood from the capillary bed passes into thin walled venules The venules join with one another to form veins.
- The veins unit with one another to form superior and inferior vena cava to return the blood again to the heart.

ARTERIES:

- The artery is a blood vessel carrying oxygenated blood from the heart to the periphery except pulmonary arteries.
- The pulmonary arteries carry non-oxygenated blood from the heart to the lungs.

TYPES OF ARTERIES:

I. Large Elastic (Conducting) Arteries:

- Have many elastic layers.
- Their elasticity enables them to expand when heart contracts.

Examples of large arteries:

1) Aorta
2) Aortic arch
3) Brachiocephalic artery
4) Left subclavian artery
5) Left common carotid artery
6) Pulmonary trunk
7) Pulmonary arteries

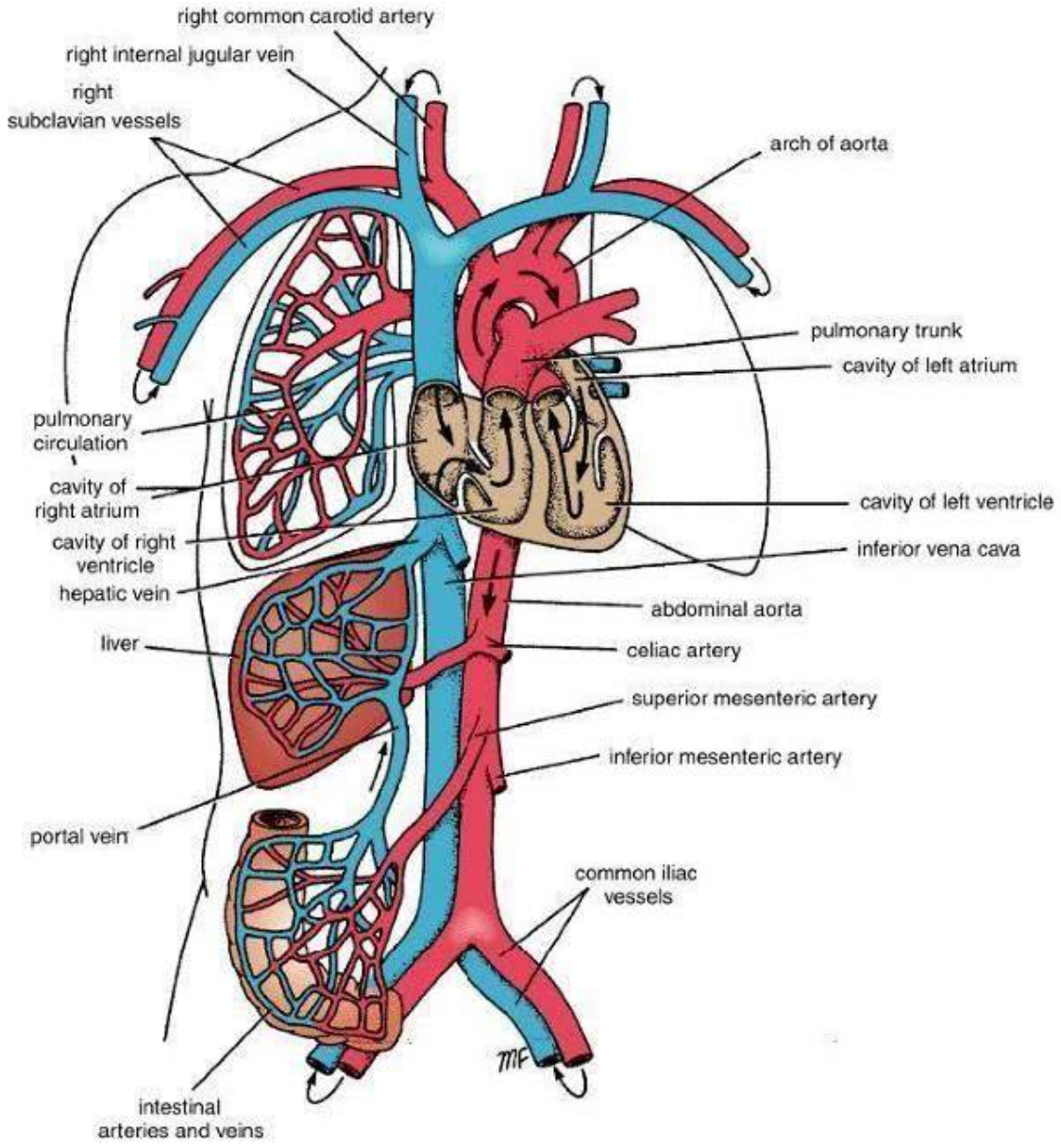

Figure 22: General plan of the blood vascular system.

II. Medium muscular (Distributing) Arteries:

- Have walls that consist chiefly of circularly smooth muscle fibres.
- Their ability to constrict regulates the flow of blood to different organs of the body as required by circumstance e.g. activity, thermoregulation.

Examples of medium arteries:

- Brachial artery
- Femoral artery

III. Small arteries and arterioles:

- Have relatively narrow lumina and thick muscular walls.
- The degree of filing of capillary beds and level of arterial pressure within vascular system are regulated mainly by degree of tonus in smooth muscle of arteriolar walls.

TORTOUS ARTERIES:

1) Superficial temporal artery
2) Facial artery
3) Lingual artery
4) Carotid arteries
5) Cerebral arteries
6) Coronary arteries
7) Splenic artery
8) Uterine artery

ARTERIAL ANASTOMOSES:

- Communications between branches of two or more arteries.
- They act to equalize pressure over areas they connect.
- Also, they provide an alternative channels of supply.
- All large arteries that cross over a joint are liable to be kinked during movements of the joint.
- However, the distal flow of blood is not interrupted because an adequate anastomosis is usually between branches of the artery that arise both proximal and distal to the joint.

Examples of sites of anastomoses:

1) Circulus arteriosus (Circle of Wills)
2) Around scapula
3) Around elbow
4) At wrist
5) Cruciate anastomoses at surgical neck of humerus
6) Cruciate anastomoses at neck of femur
7) At knee joint
8) At ankle join

END ARTERIES (Figure 23):

I. Anatomic End Arteries:

There is no anastomosis between their branches, so interruption or affection of their blood flow ends in serious complications which may lead to permanent damage or even death.

Examples of anatomic end arteries:

1) Central artery of the retina
2) Pulmonary artery
3) Renal artery
4) Splenic artery
5) Nutrient artery of bone

Occlusion to central artery of the retina leads to blindness.

II. Functional End Arteries:

- Arteries with ineffectual anastomoses supply segments of the brain, liver, kidneys, spleen and intestine.
- They may also exist in the heart.
- Coronary arteries (functional end arteries) if they become blocked by disease (coronary arterial occlusion), the cardiac muscle normally supplied by that artery will receive insufficient blood and undergo necrosis.
- Blockage of a large coronary artery results in death of the patient.

ARTERIAL PULSATION:

- The wall of the arteries pulsates with each cardiac beat.
- This pulsation can be felt in some arteries where they are superficial and pass upon a rigid substance as bone. **Examples of palpable pulsating arteries:**

1) Superficial temporal artery
2) Facial artery
3) Common carotid artery
4) Axillary artery
5) Brachial artery
6) Radial artery (the most commonly used)
7) Femoral artery
8) Popliteal artery
9) Dorsalis pedis artery

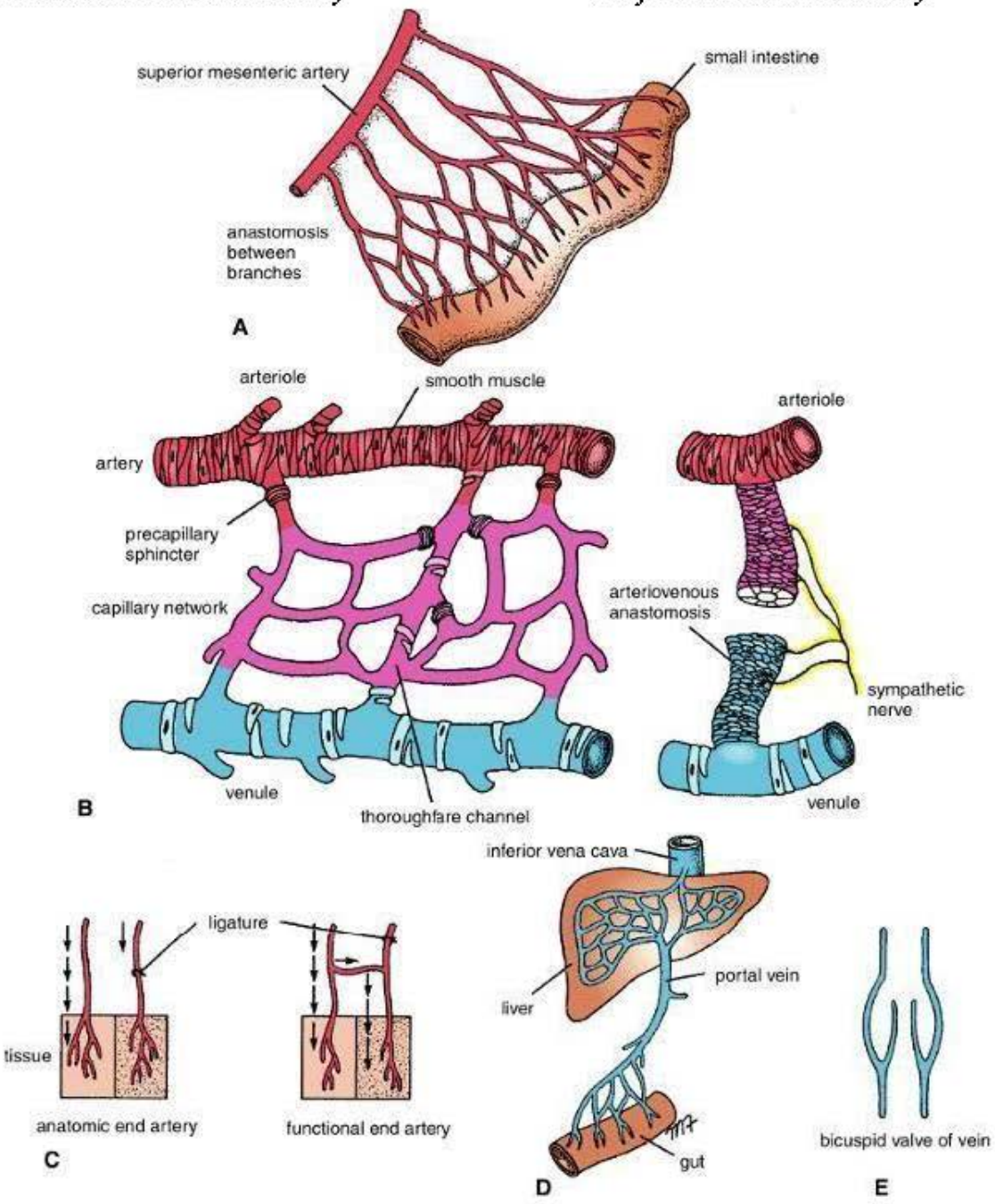

Figure 23: Different types of blood vessels and their methods of union.
A. Anastomosis between the branches of the superior mesenteric artery.
B. Capillary network and an arteriovenous anastomosis.
C. Anatomic end artery and functional end artery. D. A portal system. E. Structure of the bicuspid valve in a vein.

VEINS:

- Blood vessels carrying non-oxygenated blood from the periphery to the heart except pulmonary veins.
- The pulmonary veins carry well-oxygenated blood commonly called arterial blood) from lungs to the heart.

- Because of the lower blood pressure in the venous system, the walls (specially the tunica media) of veins are thinner than those of their companion arteries.
- The thin walls allow veins to have a large capacity to expand.
- Normally, veins do not pulsate and do not squirt or spurt blood when severed.

SIZES OF THE VEINS:

I. Venules: The smaller veins Drain capillary beds.

- Small veins are tributaries of larger veins that unite to form venous plexus, e.g. dorsal venous arch of the foot.
- Small veins are unnamed.

II. Medium veins:

- Drain venous plexuses and accompany medium arteries.
- In the limbs and in other locations, where flow of blood is opposed by the pull of gravity, the medium veins have valves to permit blood to flow toward the heart (Figure 23).

Examples of medium sized veins:

1) Cephalic vein
2) Great saphenous vein
3) Basilic vein
4) Small saphenous vein

III. Large veins:

- Characterized by wide bundles of longitudinal smooth muscle and a well-developed tunica adventitia.

Examples of large veins:

1. Superior vena cava
2. Inferior vena cava

VENAE COMITANTES (accompanying veins) (Figure 24):

- Two or more veins accompany medium sized deep arteries, surrounding them in an irregular branching network.
- This arrangement serves as a counter current heat exchanger, the warm arterial blood warming the cooler venous blood as it returns to the heart from a cold extremity.

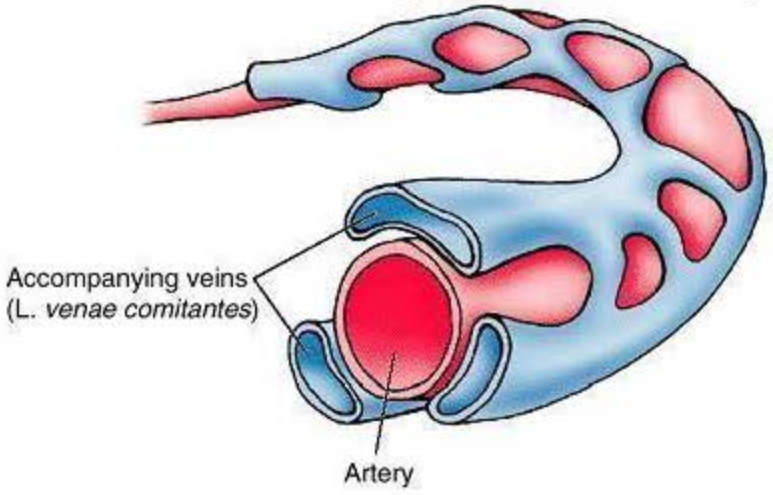

Figure 24: Accompanying veins (venae comitantes). Although most veins of the trunk occur as large single vessels, the veins in the limbs occur as two or more smaller vessels that accompany an artery in a common vascular sheath.

Examples of venae comitantes:

1) Venae comitantes of brachial artery
2) Venae comitantes of anterior tibial artery
3) Venae comitantes of posterior tibial artery

SINUSOIDS (CAPILLARY-LIKE VESSELS):

- They resemble capillaries in that they are thin-walled blood vessels, but they have an irregular cross diameter and are wider than capillaries.

Sites of sinusoids:

1. Bone marrow
2. Spleen
3. Liver
4. Some endocrine glands

ARTERIO-VENOUS ANASTOSES:

- Direct connections between the arteries and veins without intervention of capillaries.

Examples of arteriovenous anastomoses:

1. Tips of the fingers
2. Tips of the toes

LYMPHATIC SYSTEM

- Essentially a drainage system (Figure 25).
- There is no circulation.
- Essential for immunologic defences of the body against bacteria and viruses, absorption and transport of dietary fat.

Lymphatic (Lymphoid) Tissues:

A type of connective tissue that contains large amounts of lymphocytes.

Sites that produce lymphocytes:

1. Thymus
2. Lymph nodes
3. Spleen
4. Lymphatic nodules
5. Aggregated in walls of digestive tract
6. Myeloid tissue in red bone marrow

Lymphatic Vessels:

- Tubes that assist cardiovascular system in removal of tissue fluid from tissue spaces of the body then return the fluid to the blood.

They are present in all tissues and organs of the body EXCEPT:

1. Central nervous system
2. Eyeball
3. Internal ear
4. Epidermis of the skin
5. Cartilage
6. Bone

Lymph: Tissue fluid once it enters a lymphatic vessel.

Lymph Capillaries:

- A network of fine vessels that drain lymph from the tissues
- They are in turn drained by small lymph vessels, which unite to form large lymph vessels.
- The lymph vessels have a beaded appearance because of the presence of numerous valves along their course.

Lymph Nodes:

- Small masses of lymphatic tissue located along course of lymphatic vessels through it lymph is filtered on its way to venous system.

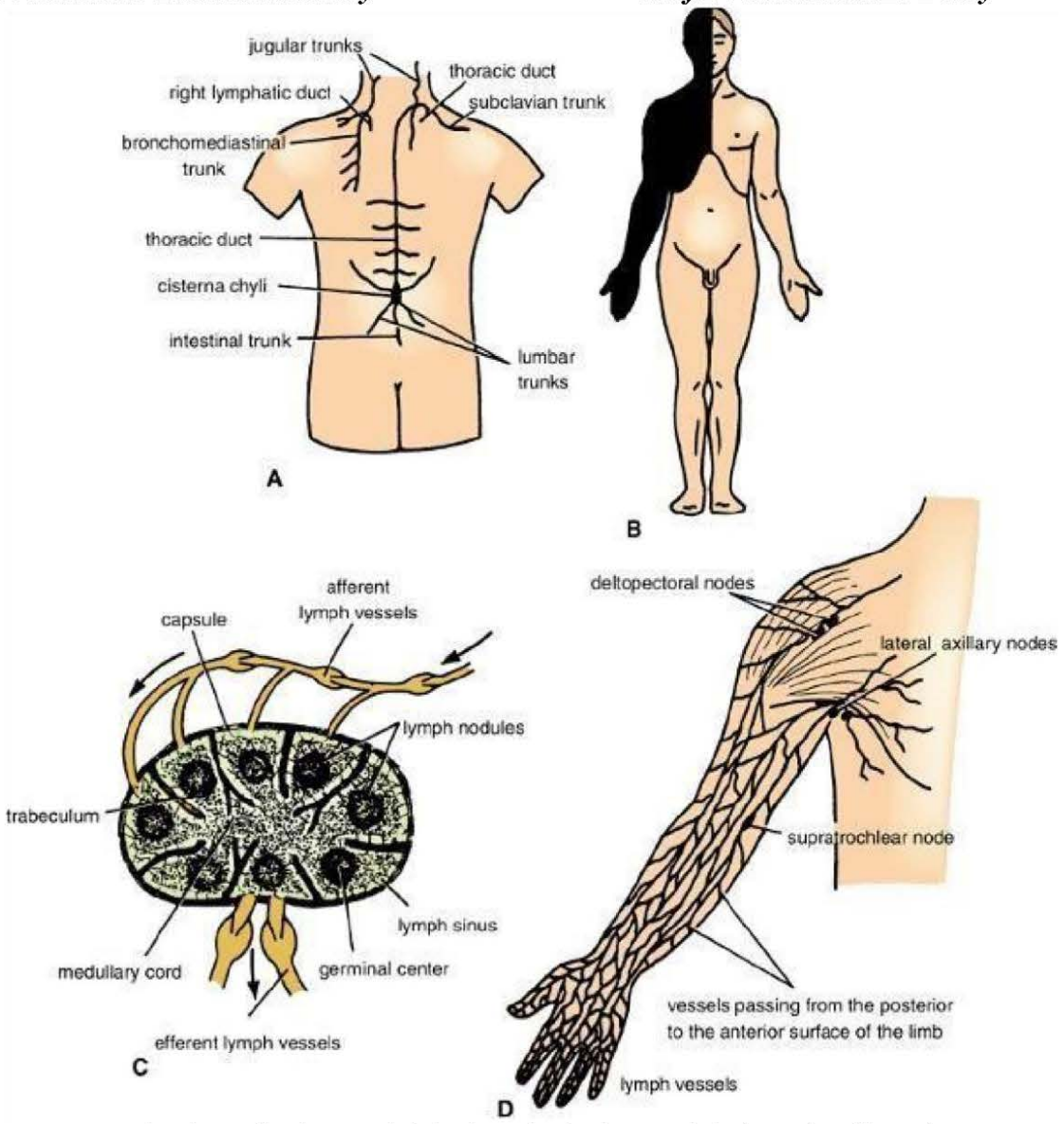

Figure 25: A. The thoracic duct and right lymphatic duct and their main tributaries. B. Areas of body drained into thoracic duct (clear) and right lymphatic duct (black). C. General structure of a lymph node. D. Lymph vessels and nodes of the upper limb.

Afferent Lymph Vessels: Lymph vessels carry lymph to lymph node

Efferent Lymph Vessels:

- Lymph vessels that transport lymph away from a lymph node

Right Lymphatic Trunk: Ends into junction of right venous angle

- Drains lymph from body's right upper quadrant.

Thoracic Duct: Drains lymph from remainder of the body.

- Ends into left venous angle (angle between left internal jugular vein and left subclavian vein.

NERVOUS SYSTEM

Divided into:

I. Central Nervous System (CNS): Consists of brain and spinal cord. **II. Peripheral Nervous System (PNS):** Consists of 12 pairs of cranial nerves and 31 pairs of spinal nerves and their associated ganglia.

Functionally, the nervous system can be divided into somatic nervous system which controls voluntary activities and autonomic nervous system which controls involuntary activities.

I. Central Nervous System:

Composed of large numbers of nerve cells and their processes and supported by neuroglia.

Neuron (Figure26): Nerve cell and its processes (dendrites and axon). Dendrites are short processes of cell body while the axon is its longest process

Interior of CNS: Organized into gray and white matter.
Gray matter: Consists of nerve cells embedded in neuroglia.
White matter: Consists of nerve fibers (axons) embedded in neuroglia.

II. Peripheral Nervous System:

Cranial nerves: 12 pairs of cranial nerves that leave the brain and pass through foramina in the skull.
All the nerves are distributed in the head and neck except the Xth (vagus nerve) which also supplies structures in the thorax and abdomen.

Spinal nerves (Figure 27): 31 pairs of spinal nerves that leave the spinal cord and pass through inter-vertebral foramina in the vertebral column. They are named according to region of vertebral column with which they are associated: 8 Cervical, 12 Thoracic, 5 Lumbar, 5 Sacral, 1 Coccygeal

Note: Lower end of spinal cord in adult: Opposite lower border of first lumbar vertebra

Cauda Equina (Horse's Tail): Roots of lumbar and sacral nerves below the level termination of spinal cord form a vertical bundle of nerves that resembles a horse's tail (Figure 27).

Note (Figure 28&29): Each spinal nerve is connected to the spinal cord by two roots: anterior root and posterior root, united to form trunk which divides into anterior and posterior rami and meningeal branches. Also, spinal nerves give rami communicantes (sympathetic) in thoracic region.

Anterior root (efferent): Bundles of nerve fibers carrying impulses away from CNS, go to skeletal muscles causing them to contract, (motor fibers). Their cells of origin lie in anterior grey horn of spinal cord.

Posterior root (afferent): Consists of bundles of nerve fibers carrying impulses to CNS, concerned with conveying information about sensations of touch, pain, temperature and vibration, so called sensory fibers.

Posterior root ganglion: Swelling on posterior root containing cell bodies of its sensory fibres.

Trunk of spinal nerve: Union of anterior and posterior roots of spinal nerves, so, mixed.

Anterior ramus: Continues anteriorly to supply muscles and skin over antero-lateral body wall and all muscles and skin of the limbs.

Posterior ramus: Passes posteriorly around vertebral column to supply muscles, skin of back

Meningeal branch: Supplies vertebrae & meninges (cover spinal cord)

Rami communicantes: Branches of thoracic spinal nerves those are associated with sympathetic part of autonomic nervous system.

Plexuses (Figure 27): At root of limbs, anterior rami join one another to form plexuses. Ex.: cervical, brachial, lumbar, sacral and coccygeal plexuses.

Dermatome (Figures 30&31): Unilateral area of skin innervated by the fibers of a single spinal nerve.

Myotome: Unilateral muscle mass receiving innervation from fibers conveyed by a single spinal nerve.

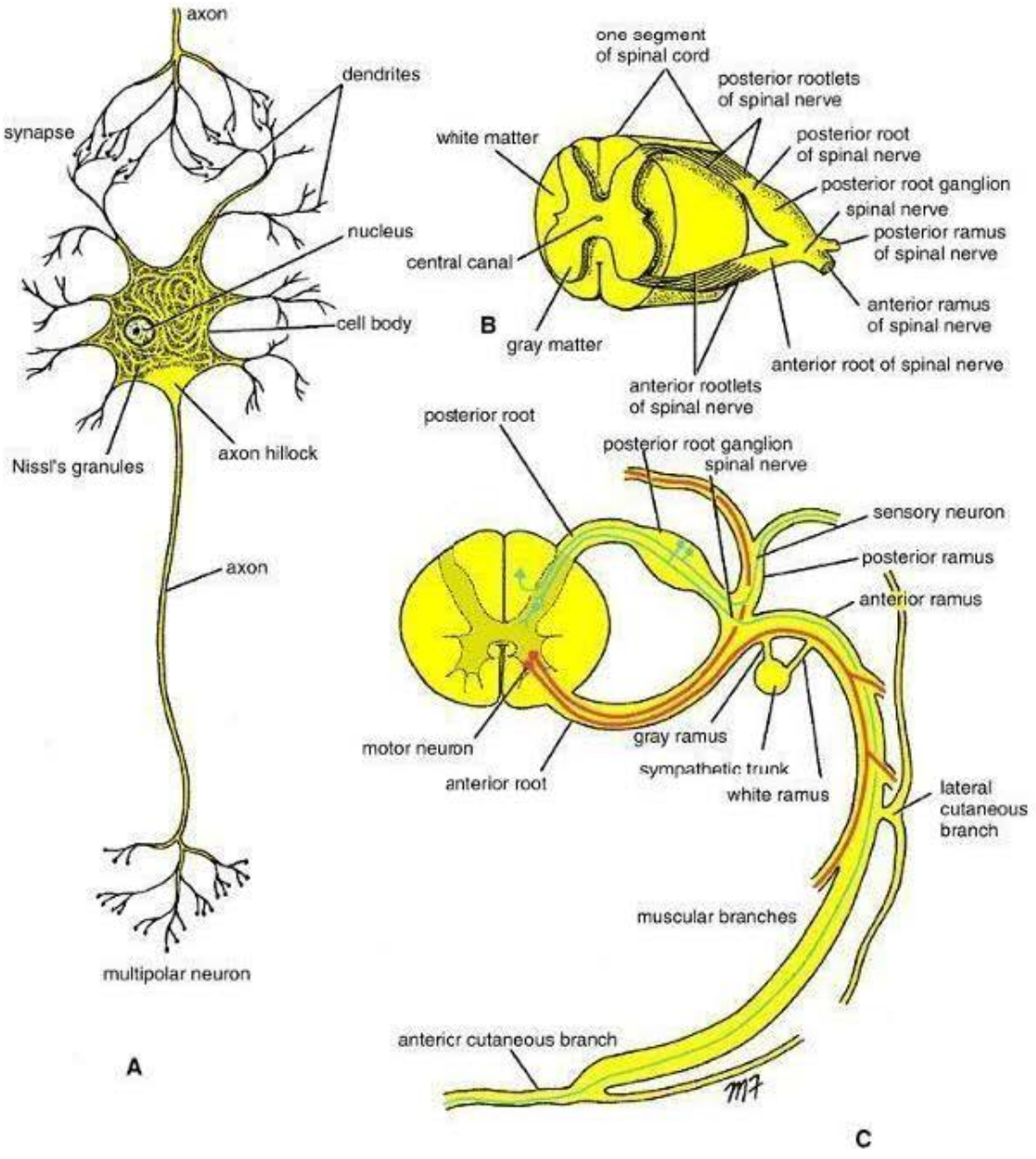

Figure 26: A. Multipolar motor neuron with connector neuron synapsing with it. B. Section through thoracic segment of spinal cord with spinal roots and posterior root ganglion. C. Cross section of thoracic segment of spinal cord showing roots, spinal nerve, and anterior and posterior rami and their branches.

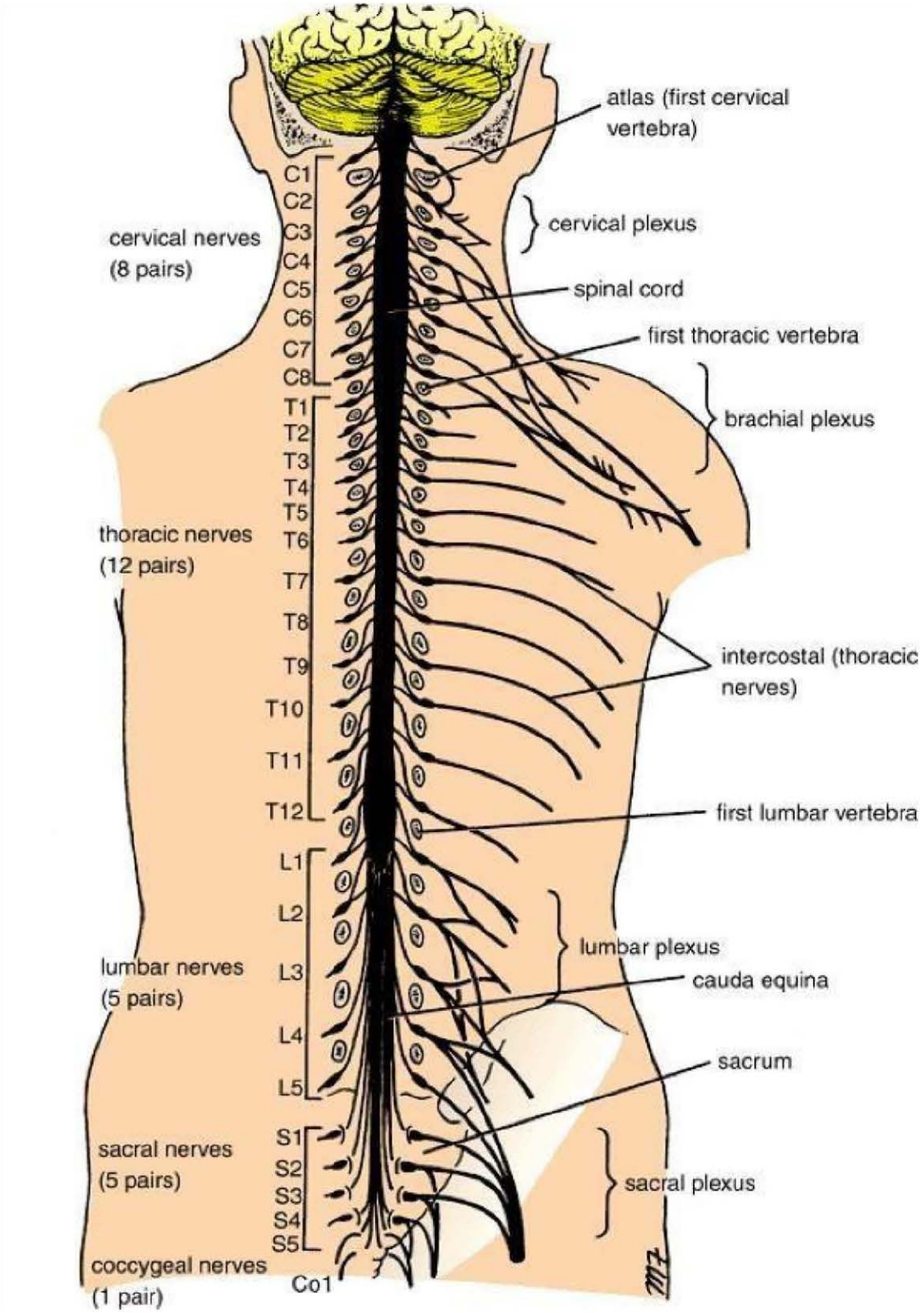

Figure 27: Brain, spinal cord, spinal nerves, and plexuses of limbs.

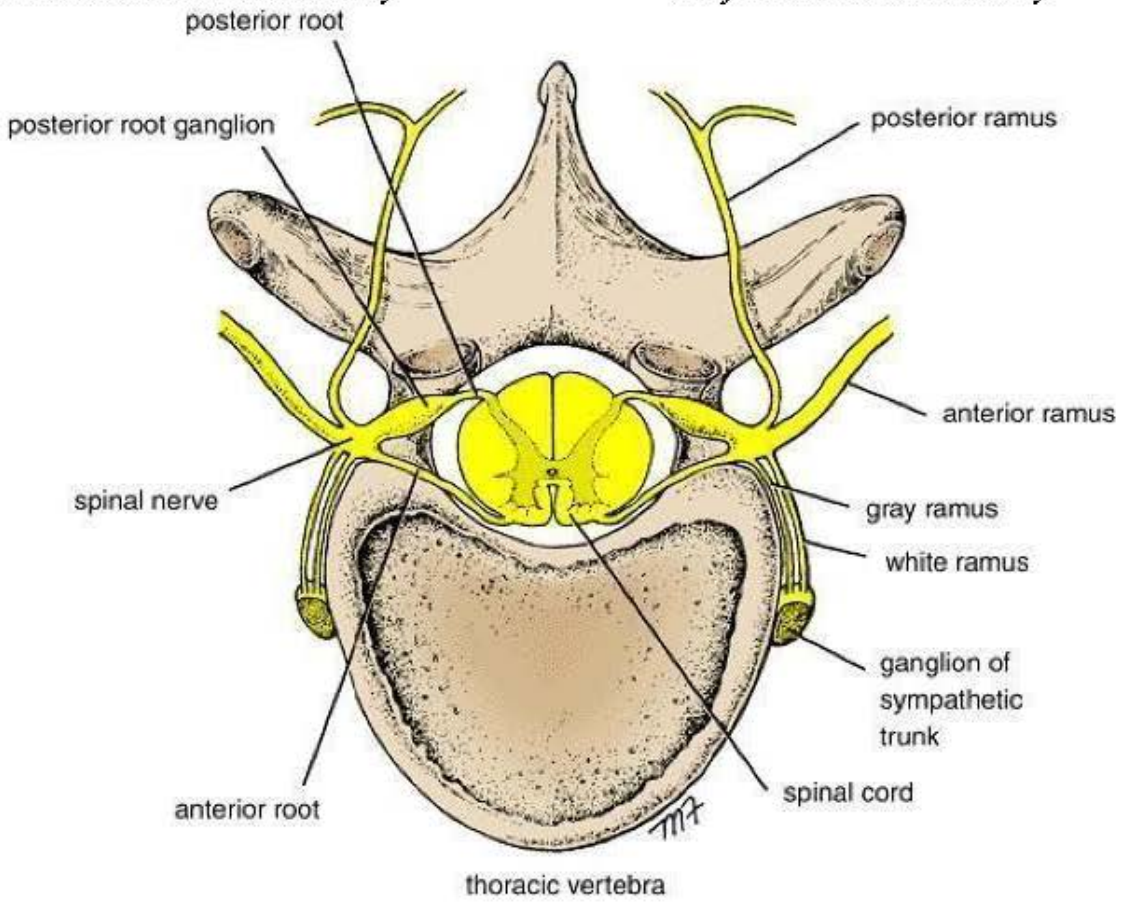

Figure 28: Association between spinal cord, spinal nerves, and sympathetic trunks.

Autonomic Nervous System:

Concerned with innervation of involuntary structures such as heart, smooth muscles and glands throughout the body. It is distributed throughout CNS and PNS.

Autonomic nervous system is divided into (Figures 32&33):- I . Sympathetic:

Efferent fibers are located in gray matter of spinal cord from first thoracic to second or third lumbar segment (thoraco-lumbar).

II. Parasympathetic:

Efferent fibers are located in brain (III, VII, IX and X) and sacral segments (2, 3, and 4) of spinal cord (cranio-sacral).

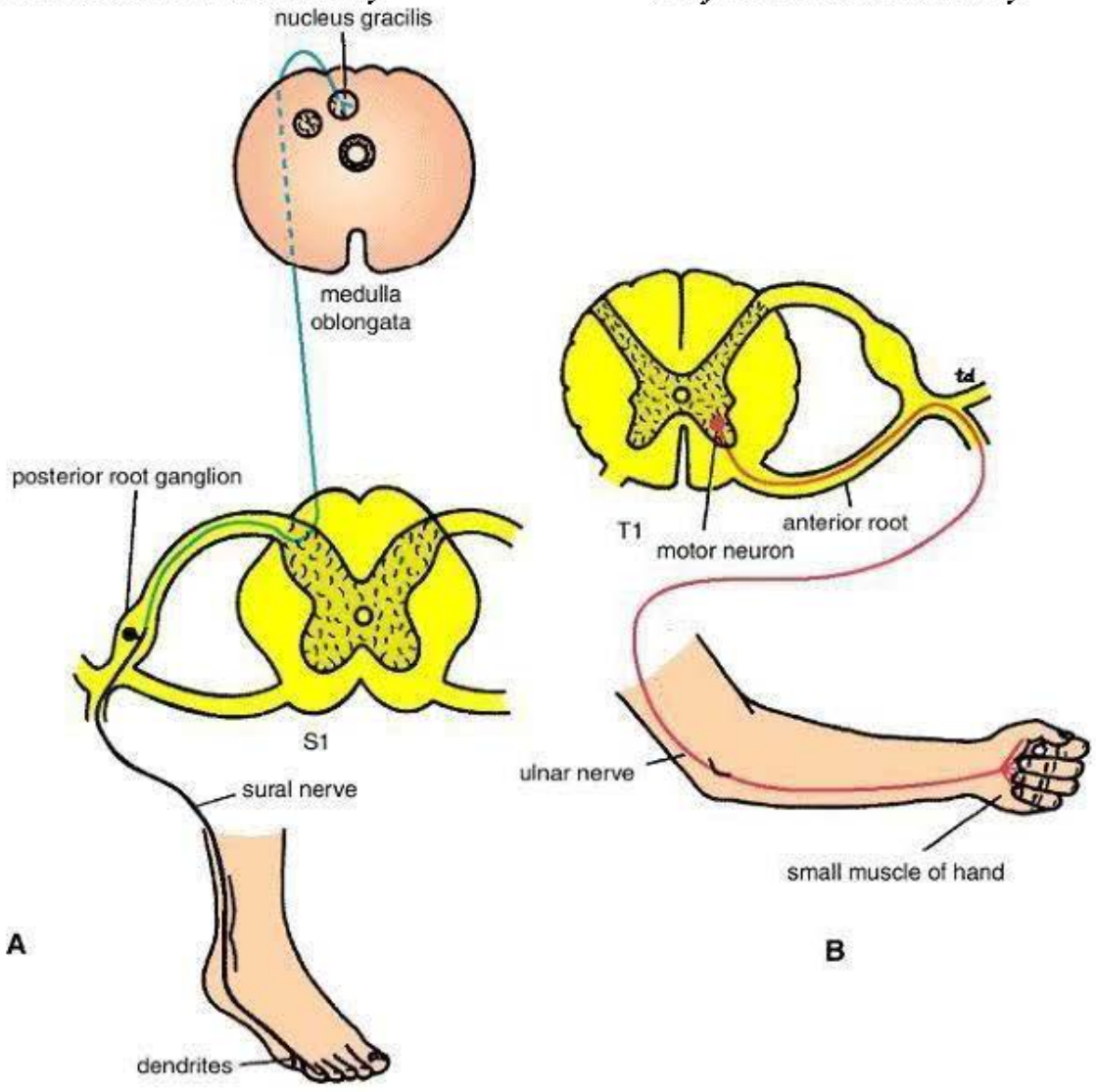

Figure 29: Two neurons that pass from the central to the peripheral nervous system. A. Afferent neuron that extends from the little toe to the brain. B. Efferent neuron that extends from the anterior gray horn of the first thoracic segment of spinal cord to the small muscle of the hand.

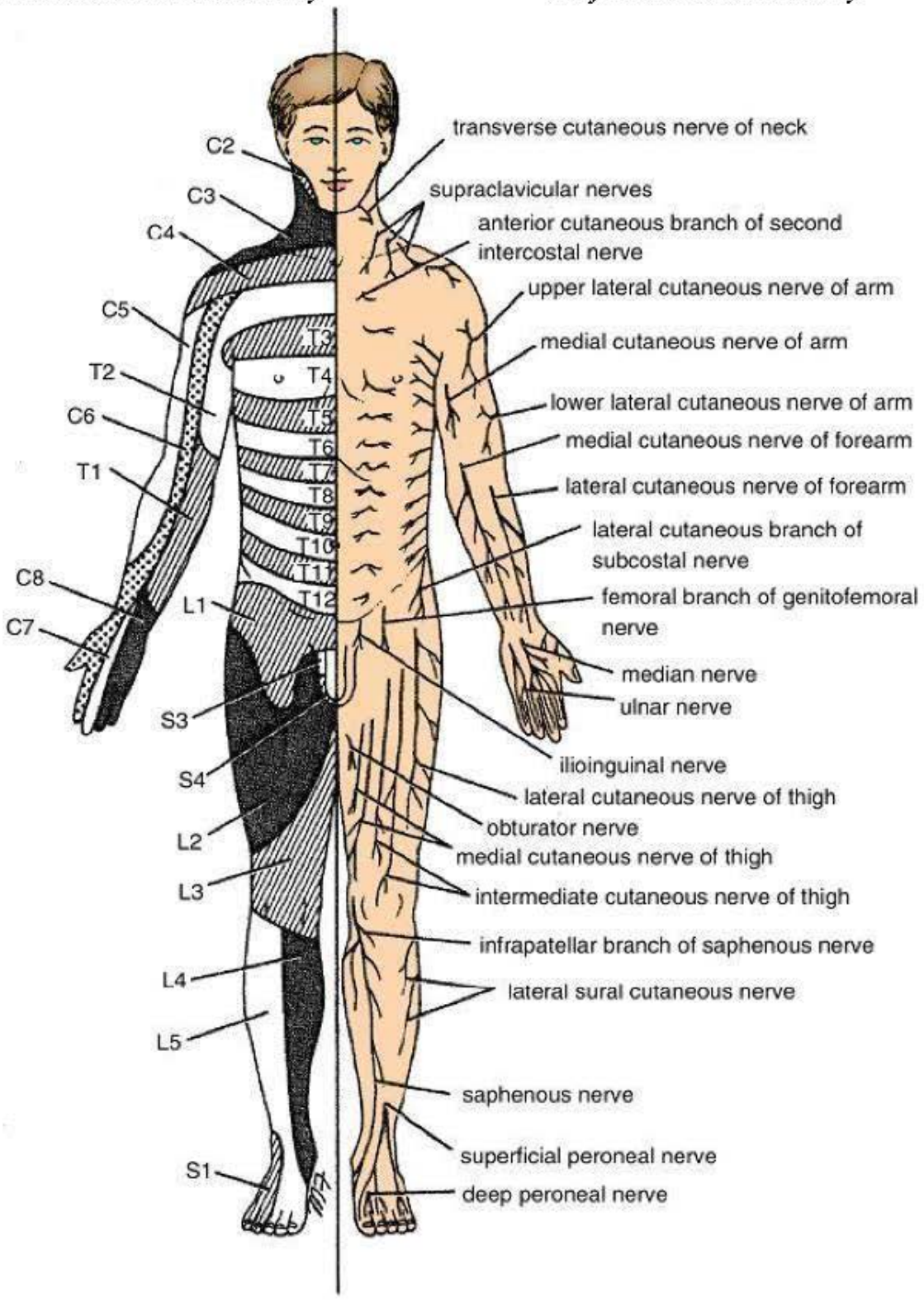

Figure 30: Dermatomes and distribution of cutaneous nerves on the anterior aspect of the body.

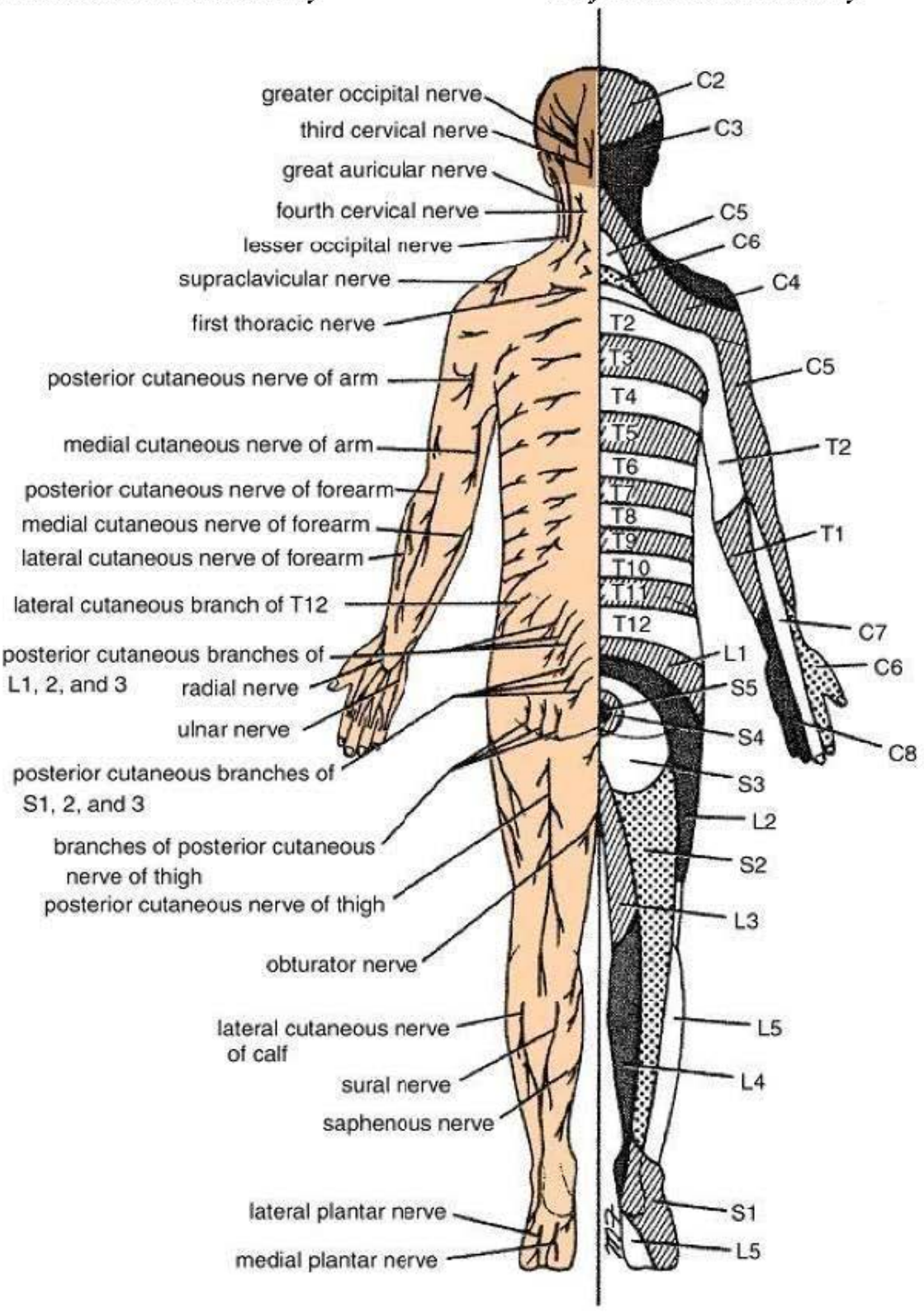

Figure 31: Dermatomes and distribution of cutaneous nerves on the posterior aspect of the body.

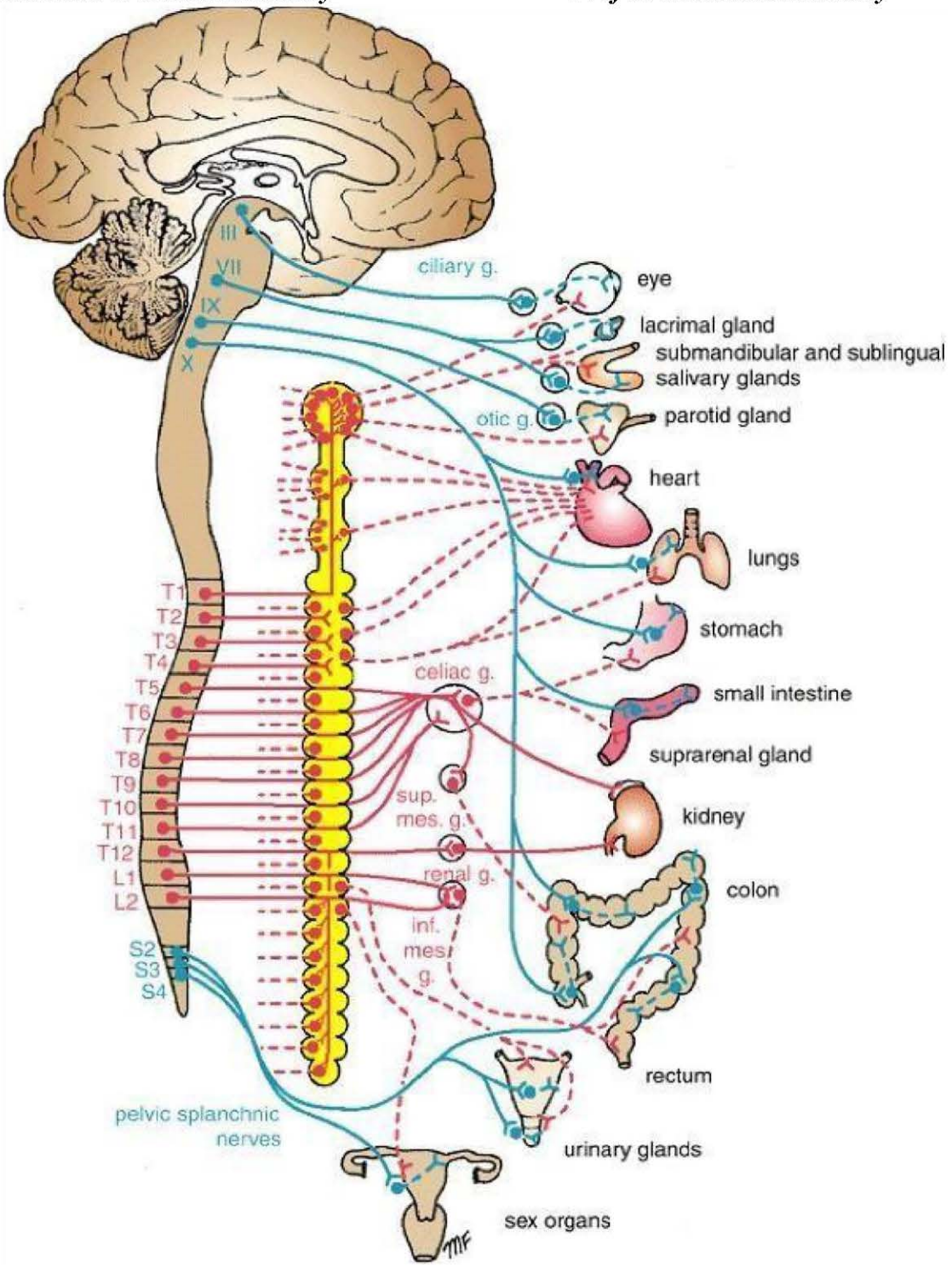

Figure 32: Efferent part of autonomic nervous system. Preganglionic parasympathetic fibers shown in solid; postganglionic parasympathetic fibers, in interrupted blue. Preganglionic sympathetic fibers are shown in solid; postganglionic sympathetic fibers, in interrupted.

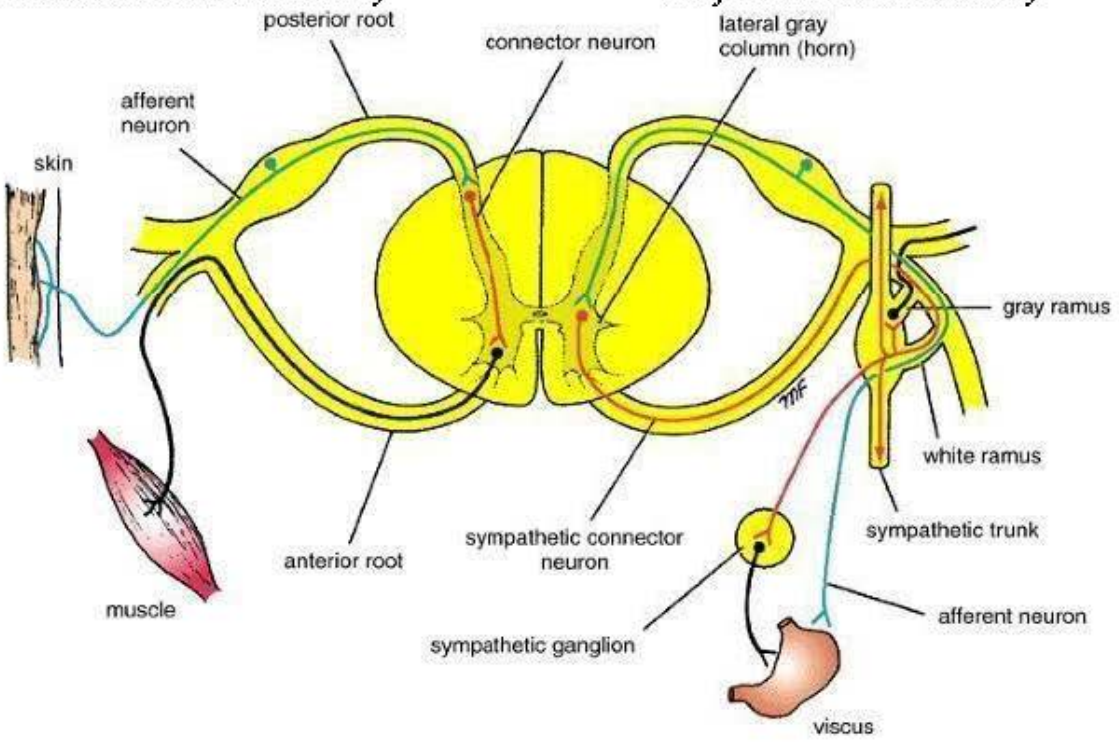

Figure 33: General arrangement of somatic part of nervous system (left) compared to autonomic part of nervous system (right).

Note:

- Learning segmental innervation of all the muscles of the body (myotomes) is an impossible task. So, segmental innervation of following muscles should be known because they can be tested by doing simple muscle reflexes in the patient (Figure 34):

- **Biceps brachii tendon reflex**: C5 and 6 (flexion of the elbow joint by tapping the biceps tendon)
- **Triceps tendon reflex:** C6, 7 and 8 (extension of the elbow joint by tapping the triceps tendon)
- **Brachioradialis tendon reflex:** C5, 6 and 7 (supination of radioulnar joints by tapping the insertion of the brachioradialis tendon)
- **Abdominal superficial reflexes** (contraction of underlying abdominal muscles by stroking the skin): Upper abdominal skin T6 to 7, middle abdominal skin T8 to 9, and lower abdominal skin T10 to 12
- **Patellar tendon reflex (knee jerk):** L2, 3 and 4 (extension of the knee joint on tapping the patellar tendon)
- **Achilles tendon reflex (ankle jerk):** S1 and S2 (plantar flexion of the ankle joint on tapping the Achilles tendon)

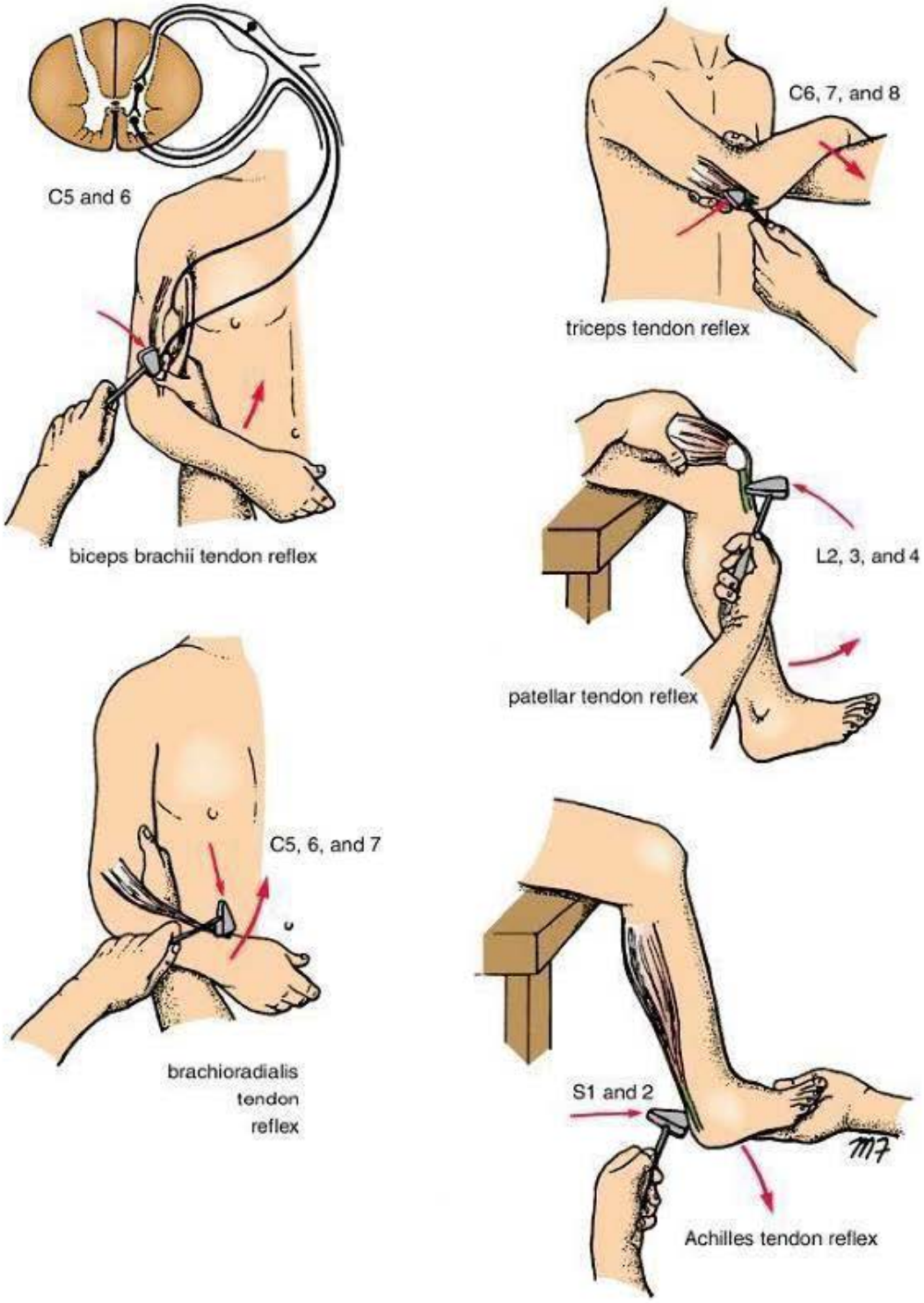

Figure 34: Some important tendon reflexes used in medical practice.

MUCOUS MEMBRANES

- The name given to the lining of organs or passages that communicate with the surface of the body.
- Mucous membrane consists essentially of a layer of epithelium supported by a layer of connective tissue, the lamina propria.
- Smooth muscle, called muscularis mucosa, is sometimes present in the connective tissue.
- Mucous membrane may or may not secrete mucus on its surface.

SEROUS MEMBRANES

- Line the cavities of the trunk and are reflected onto the mobile viscera lying within these cavities (Figure 35).
- Consist of a smooth layer of mesothelium supported by a thin layer of connective tissue.
- Serous membrane lining wall of the cavity is called the parietal layer and that covering the viscera is called visceral layer.
- **Narrow, slit-like interval that separates these layers forms:**
  1. Pleural cavities
  2. Pericardial cavity
  3. Peritoneal cavity
  4. Tunica vaginalis testes cavities.
- It contains a small amount of serous liquid, the serous exudate.
- **Serous exudate:** Lubricates the surfaces of the membranes and allows the two layers to slide readily on each other.
- **Parietal layer:** Developed from the somatopleure (inner cell layer of mesoderm) and is richly supplied by spinal nerves.
- It is therefore sensitive to all common sensations such as touch and pain.
- **Visceral layer**: Developed from the splanchnopleure (inner cell layer of mesoderm) and is supplied by autonomic nerves.
- It is insensitive to touch and temperature but very sensitive to stretch.

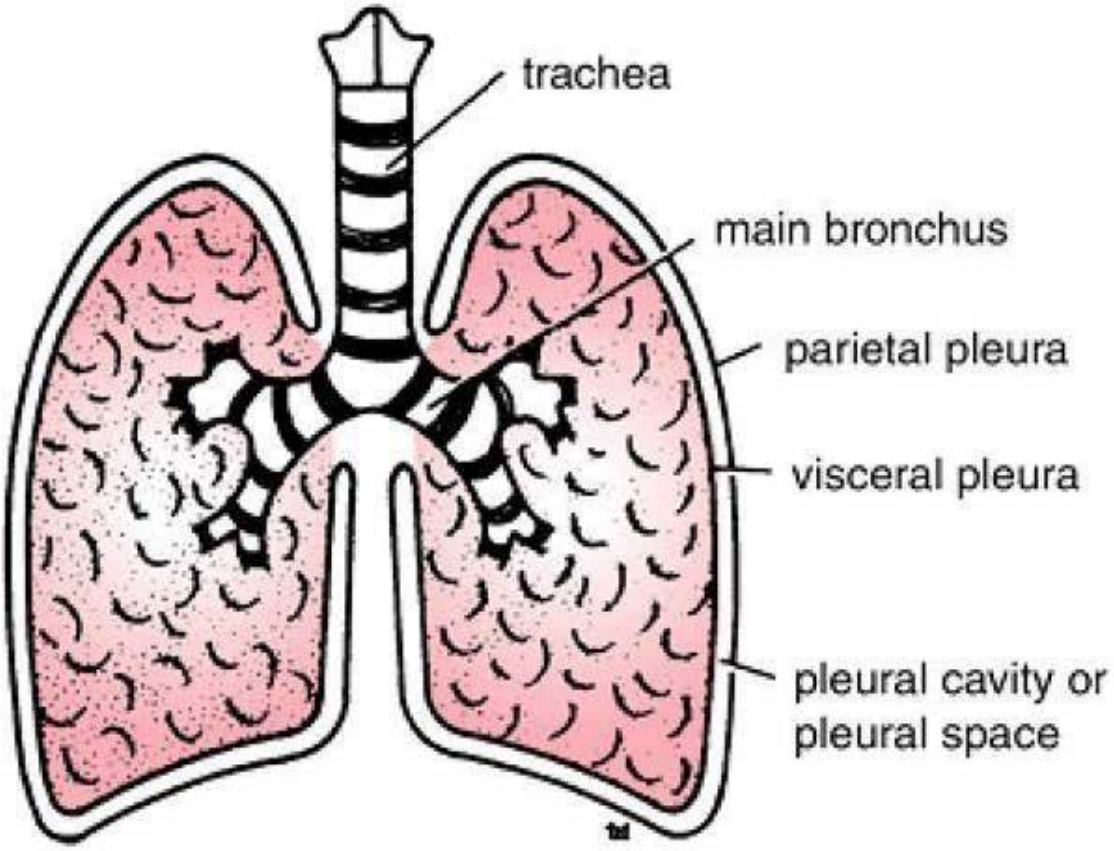

Figure 35: Arrangement of pleura within the thoracic cavity. Note that under normal conditions the pleural cavity is a slit like space; the parietal and visceral layers of pleura are separated by a small amount of serous fluid.

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