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An Introduction to Human Anatomy

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What is Anatomy?

Anatomy is a descriptive science that studies the structure of living organisms. It includes two major branches: Gross anatomy and Microsopic anatomy.

A. Gross Anatomy: is the study of body structures visible to the naked eye. This can be approached in a *Systemic* Pattern where an entire system (like the respiratory system) is studied at different regions. It may also be studied in a *Regional* Pattern where the body is divided & studied in regions; each region containing parts of different systems. The study of anatomy in a comprehensive regional pattern is the most useful approach for medical students. For descriptive reasons, the body is divided into the following regions **[figure 1]**:

- The head & neck
- The trunk which consists of:

1. From behind: The back
2. From front: a- The thorax (chest)

   b-The abdomen: consisting of the abdomen proper and the pelvis.

- The upper limbs.
- The lower limbs.

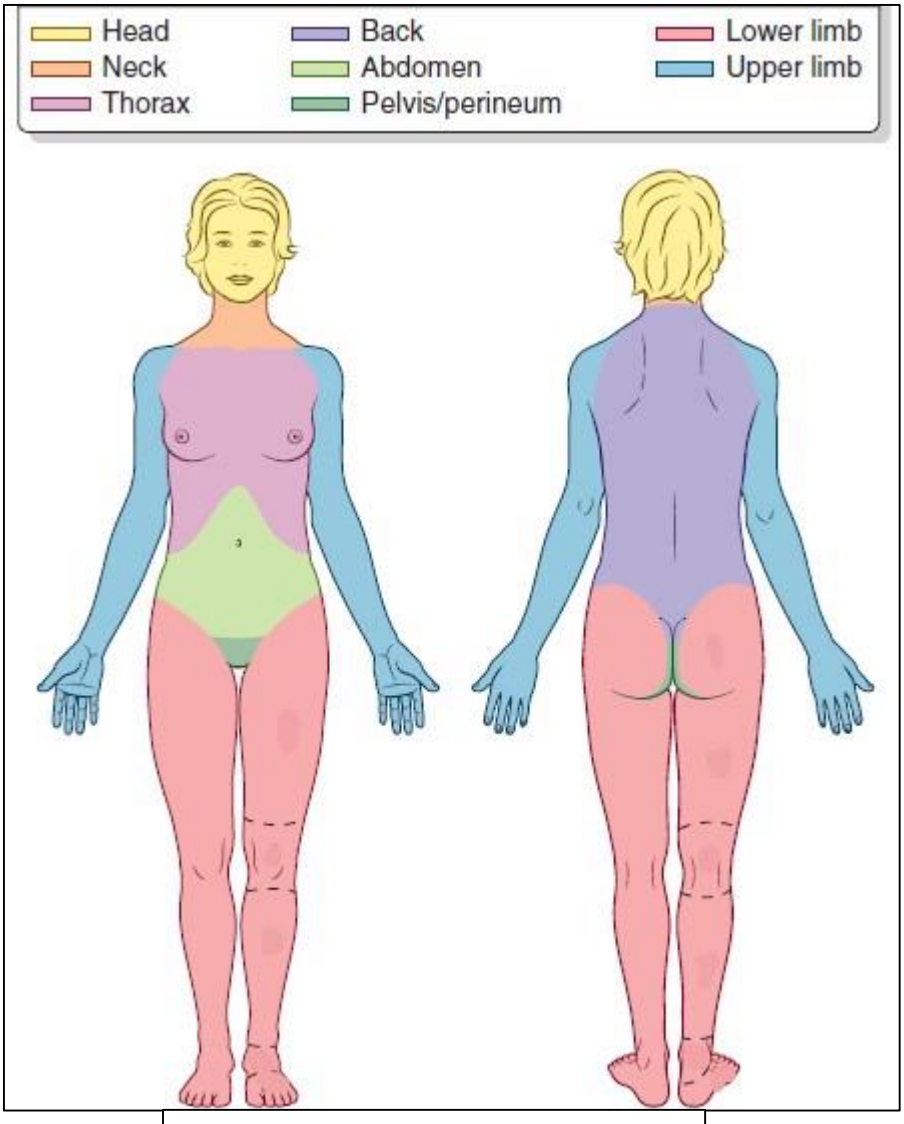


Figure 1: Regions of the human body

Sub-branches of gross anatomy include *Surface Anatomy* which describes the external body features & relates them to internal structures; and *Anatomic Imaging* which involves the use of different imaging techniques ***e.g.*** X-ray to reveal inner structures without dissection.

B. Microscopic Anatomy involves the study of tissues (*Histology*) & cells (*Cytology*) with the aid of a microscope.

Developmental anatomy traces structural changes that occur in the body throughout the life span. Embryology, a subdivision of developmental anatomy, concerns developmental changes that occur before birth.

Organization of the human body

Anatomy is always linked to *physiology*, the study of biological processes and functions in living organisms. The body is organized in such a way that the cell is the functional unit. Cells form tissues→ tissues make up organs → and organs which perform complementary fucntions form body systems. Body systems may fall in one of three functional categories:

1. **Systems of covering, support and movement:**
   a. Integumentary system (skin)
   b. Musculoskeletal system (Bones, cartilage, Joints and the muscles that move them)
2. **Systems of integration and interaction:**
   a. The nervous system and special senses.
   b. The endocrine system.
3. **Systems of maintenance, defence and continuity:**
   a. The digestive system.
   b. The respiratory system.
   c. The cardiovascular system.
   d. The urinary system.
   e. The immune system.
   f. The reproductive system.

How to Study Anatomy?

Studying anatomy involves lots of memorization. For instance, the human body contains 206 bones and over 600 muscles. Learning these structures requires time, effort, and good memorization skills. The following tips will help make learning and memorizing body structures easier:

Know the language. The most important thing to understand when studying anatomy is the terminology. Using standard anatomical terminology ensures that physicians have a common method of communicating to avoid confusion when identifying structures.

Use anatomy study aids. Anatomy is almost impossible to understand without visual aids. The more pictures, diagrams, flash cards & atlases you study, the more you'll grasp the subject.

Where to get resources?

1. Text book (Gray's Anatomy for students, 4th edition)
2. Supplementary lectures (like this one).
3. Atlas (Grant's Atlas)
4. Youtube video lectures (of your professors or others)
5. Use your time in the lab to review, link and ask for any unclear info.

The Language of Anatomy

(Anatomical Terminology)

Terms of Position

The anatomical position is a fixed position of the body (cadaver) taken as if the body is standing (erect) looking forward with the upper limbs hanging by the side, the palms facing forwards & the feet kept side by side **[figure.2]**. The importance of applying this position is to *keep* the position of a certain body structure and its relation to other structures *constant* whether the body is in the anatomical position or any other positions.

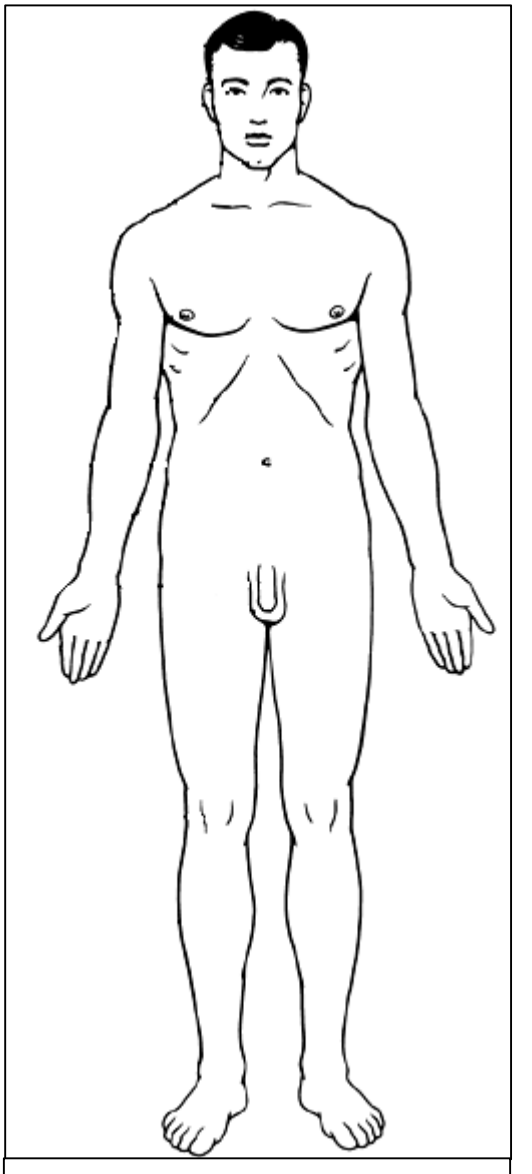


Figure 2: The anatomical position

The other positions are:

- The **prone** position: the body is lying on the face.
- The **supine** position: the body is lying on the back.
- The **lateral decubitus** position: the body is lying on one side.

Terms of direction, relation & Body Planes

Anatomical directional terms (of relation) are used to describe the position of each body structure & relate it to the positions of other structures. Just like one can argue that the scalp is the uppermost part of the body and it lies above the chin which is below or beneath the nose, it is more appropriate to use scientific terms to avoid the confusion of using adverbs. These terms are:

- ***Anterior*** is nearer the front of the body. In the trunk it may be replaced by ***ventral.*** In the hand it is replaced by ***palmar.***
- ***Posterior*** nearer the back. In the trunk & in the hand it is replaced by ***dorsal.***
- ***Superior*** is nearer the head. In the trunk it is replaced by ***cephalic*** *or* ***cranial***.
- ***Inferior*** is nearer the feet. In the trunk it is replaced by ***caudal*** and in the feet by ***plantar***.
- ***Proximal*** *is nearer* the root of a structure (usually the root of a limb or vessel) ***e.g.*** the arm is proximal to the hand.
- ***Distal*** is away from the root of the structure ***e.g.*** the hand is distal to the arm.
- ***Medial*** is nearer the midline of the body. In the forearm it is replaced by ***ulnar*** and in the leg by ***tibial.***
- ***Lateral*** is away from the midline. In the forearm it may be replaced by ***radial*** and in the leg by ***fibular.***

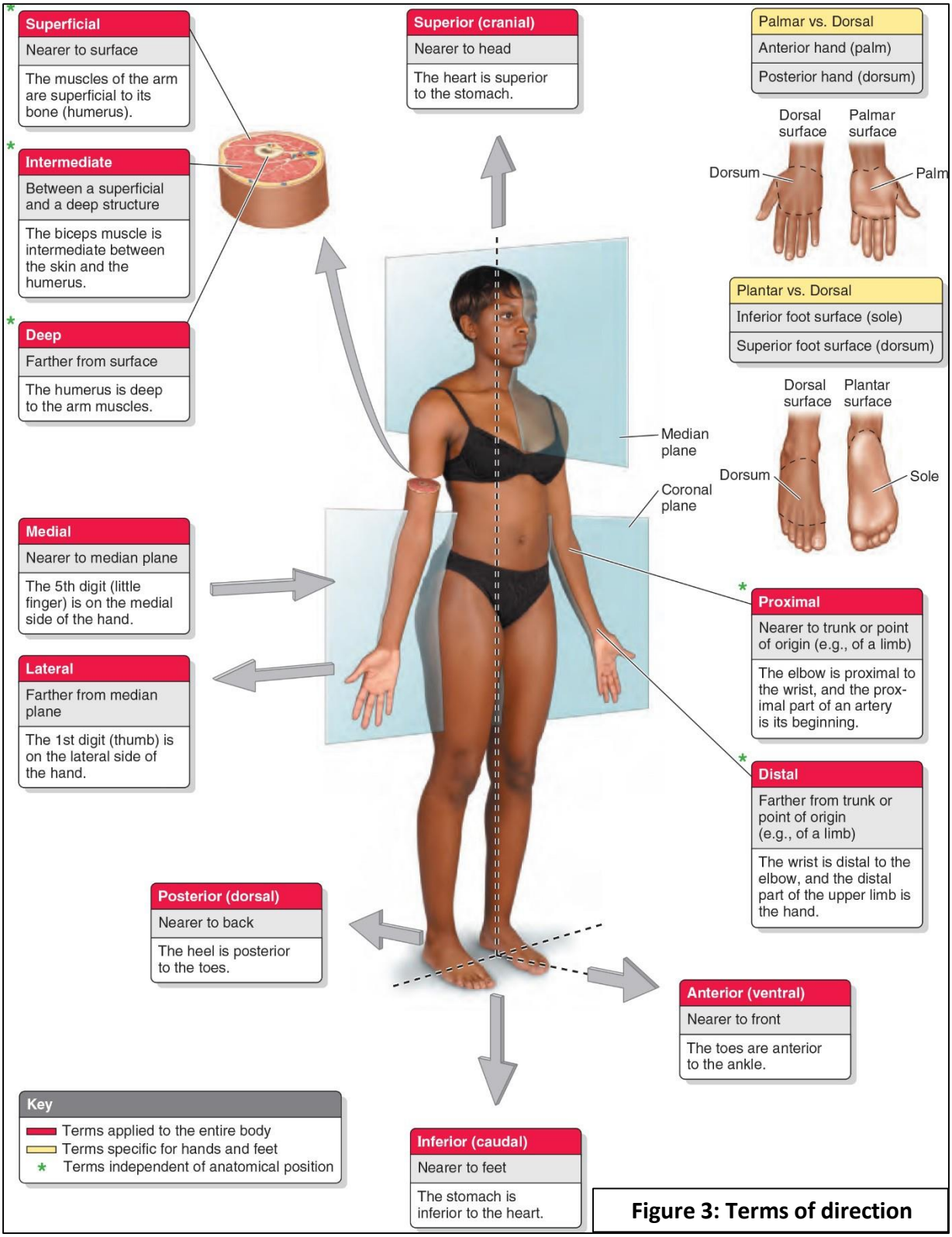


Figure 3: Terms of direction

- ***Superficial*** is nearer the skin.
- ***Deep*** is away from the skin.
- ***Middle (medius)*** indicates a position between superior & inferior or anterior & posterior.
- ***Intermediate*** usually describes a position between medial & lateral
- ***Internal & External*** are used to describe structures nearer or away from the interior of the body; respectively ***e.g.*** muscles are internal to the skin but external to bones. The terms are usually used to describe the position of a structure in relation to the wall of an organ, cavity or region ***e.g.*** internal iliac artery (inside the pelvis).

Just like the points of the compass, the above terms can be combined ***e.g.*** *anteromedial, posteroinferior, superolateral…..etc.*

All of these terms, and the terms of movements that will follow, are arranged around the three (imaginary) axis planes that divide the body into its different parts & regions **[figure.4]**. These body planes are:

A. <u>The median sagittal plane</u>: is the vertical plane that divides the body into *apparently* 2 equal halves, right & left. (*Apparently*: because some inner structures are not present on both sides of the body). The anterior edge of the plane is the *anterior median line* while its posterior edge is the *posterior median line*. <u>*The paramedian (parasagittal) planes*</u> are planes running parallel to the median plane

(to the right & to the left). Medial, lateral & intermediate are are arranged around this plane.

B. The coronal (Frontal) plane: is a vertical plane lying at right angle to the median plane dividing the body into front & back parts. Anterior & posterior are arranged around this plane.

C. The transverse (Horizontal) plane: lies at right angles to both the median & coronal planes and divides the body into upper & lower parts. Superior & inferior are arranged around this plane.

An oblique plane may be taken through any region at an oblique angle to one or more of the above planes.

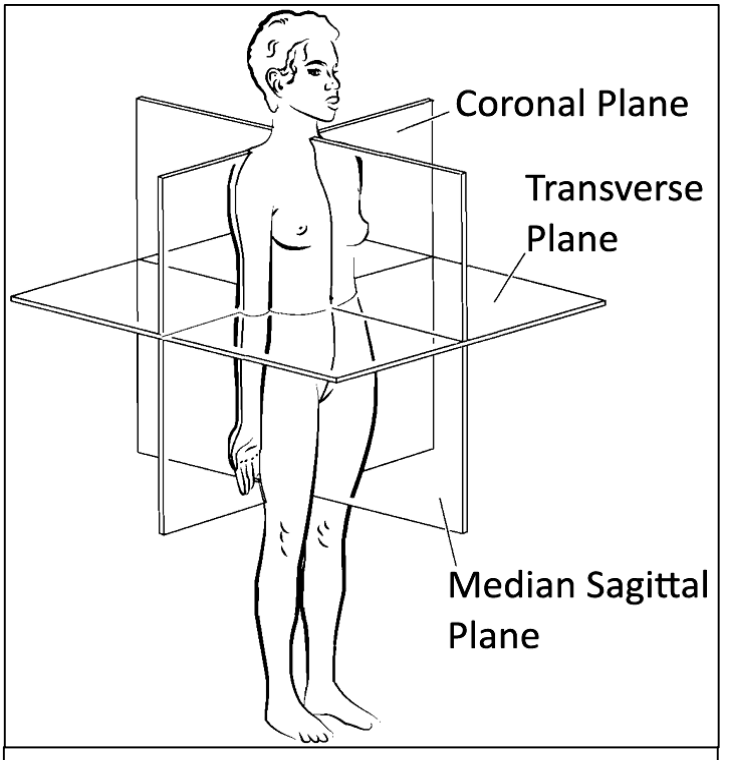


Figure 4: The body planes

Terms of Movements

Movements occur around joints and are referred to them ***e.g.*** Flexion of the shoulder. The following are the anatomical terms of movements:

- **Flexion & Extension:** to flex a joint is to fold it (i.e. decrease the angle) and to extend a joint is to unfold it (i.e. increase the angle). ***In the trunk*** and neck *lateral flexion* refers to bending the neck or trunk to the right or left.
- **Abduction and adduction:** to abduct is to move away from the median plane (increasing the angle) and to adduct is to move towards the median plane (decreasing the angle).
- ***Rotation*:** this movement occurs around a longitudinal axis either towards the midline (*Medial or Internal Rotation*) or away from the midline (*Lateral or External Rotation*). ***In the forearm*** medial rotation is substituted by *Pronation* and lateral rotation by *Supination.*
- **Circumduction:** is a conical rotatory movement creating an arc around a longitudinal axis and represents the combination of flexion, abduction, extension & adduction.

❖ ***Special movements At the wrist & hand:***

- ***In the wrist*** the term abduction may be replaced by *radial deviation* and adduction by *ulnar deviation.*
- ***In the hand***, the axis of the middle finger acts as the midline and to abduct the fingers is to spread them apart from the middle finger. Abduction of the thumb is moving it away from the fingers & palm so

that it makes right angles with the index (pointing finger) and the palm. To adduct the fingers is to bring them together to the line of the middle finger and to bring the thumb beside the index.

- ***In the hand***, to ***flex*** the ***fingers*** is to fold them in the palm and to ***flex*** the ***thumb*** is to bring it on the palm below the other fingers. To ***extend*** the ***thumb*** is to move it away from the palm making a right angle with the index finger but parallel to the palm.
- **Opposition**: is moving the thumb so its tip touches the tips of other fingers. **Reposition** is moving the thumb from opposition back to the neutral position.

❖ ***Special movements at the ankle:***

- ***Flexion*** is replaced by ***dorsiflexion*** and refers to upward movement of the foot while ***extension*** is replaced by ***plantar flexion*** and refers to downward movement of the foot (standing on the toes).
- ***Adduction*** is replaced by ***inversion*** while ***abduction*** is replaced by ***eversion***. ***In the foot*** the line of adduction and abduction of the toes is the second toe (the one next to the big toe).

❖ ***Other movements:***

- **Elevation** (Lifting up), **depression** (Pulling down), **Protraction or Protrusion** (sliding forward) and **Retraction or Retrusion** (sliding backward) occur at the scapula and jaw, respectively.

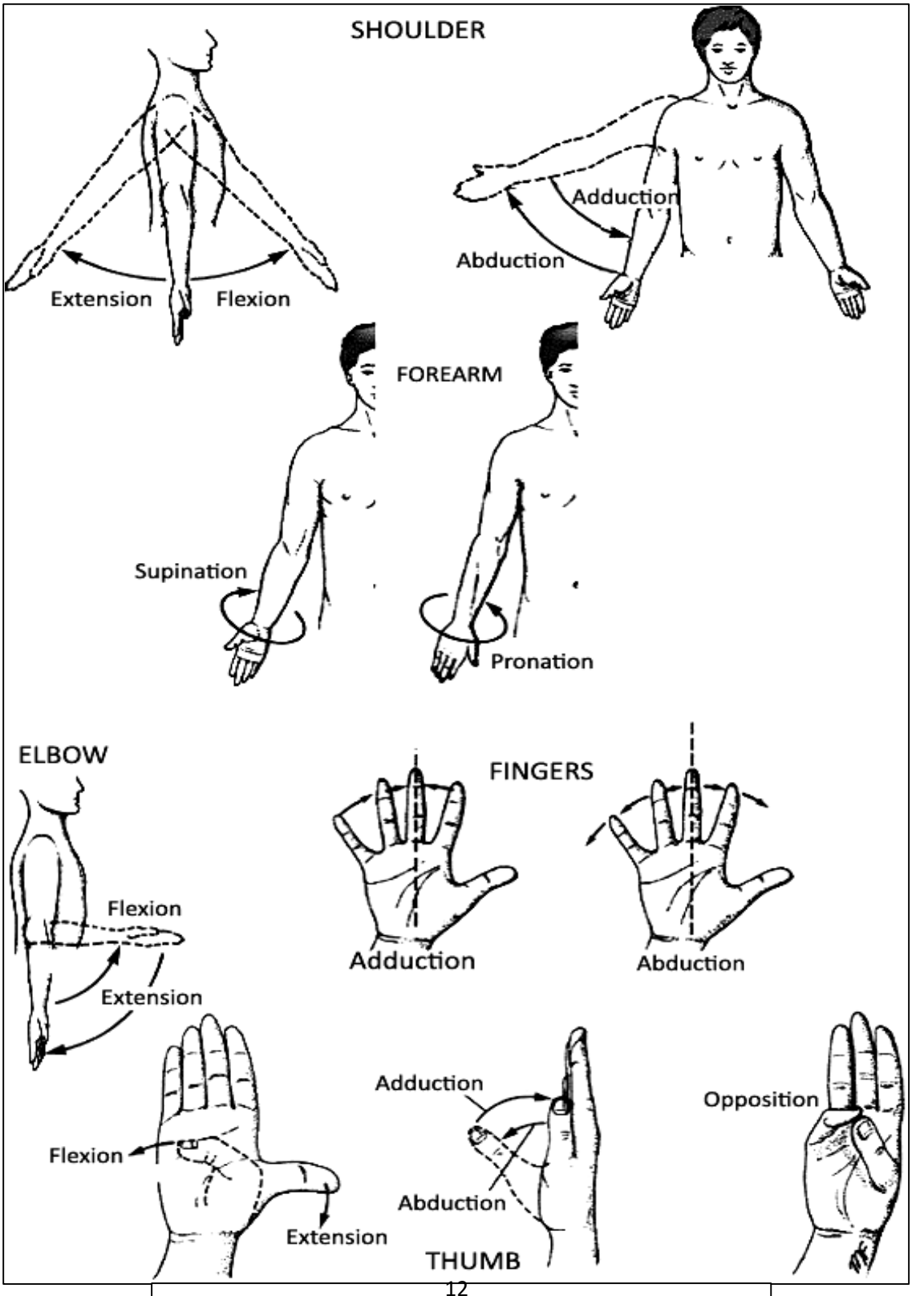


Figure 5: Some movements of the upper limb

Basic Anatomical Structures

The basic anatomical structures are structures that are met during dissection in almost every region of the body.

The Skin

The skin is composed of two layers: the superficial avascular epidermis and the deeper dermis with blood vessels and fibers **[figure.6]**.

Anatomical importance of the epidermis:

A. According to the thickness of the epidermis (which varies from one part of the body to another) the skin is divided into:

1. Thick skin: which is present at any area subject to pressure or friction (i.e. tear & wear) like the palms, soles, back.
2. Thin skin: is specially present in highly sensitive areas like the lips, eyelids & genaitalia.

B. The epidermal appendages are structures derived from the epidermis but are invaginated into the dermis. They include:

1. Nails.
2. Hairs. (not all skin has hairs, e.g.: the palms, soles and lips are hairless).

3. Arrector pilli muscles (which cause hair erection in response to cold or fear; giving the skin a goose-flesh appearance).
4. Sebaceous glands are related to hairs and secrete an oily material (sebum) that moisturizes hair.
5. Sweat glands secrete excess water & electrolytes from the body.

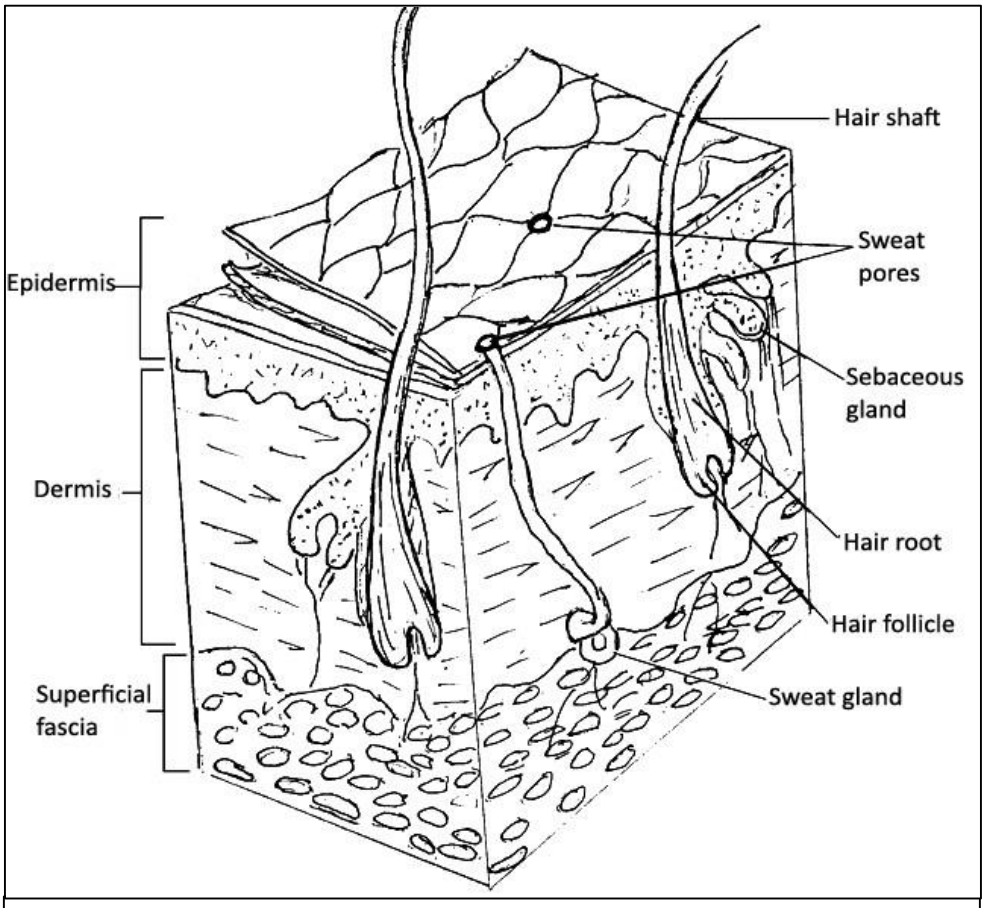


Figure 6: Cross section through the skin & subcutaneous tissue

Anatomical importance of the dermis:

A. The fibers of the dermis (collagen & elastic fibers) maintain its elasticity and strength. They break up with advancing age leading to the appearance of wrinkles. These fibers are arranged in parallel bundles at different directions all over the body. These directional bundles are called the tension (Langer's) lines of the skin and are of great importance in wound healing.

B. The dermis contains the nerve endings and receptors for skin (general) sensation. These receptors can detect five modalities of **cutaneous** sensation: touch, pressure, pain, temperature & vibration. These sensation are delivered to the nervous system by the nerves that supply the skin which ae called **cutaneous nerves**. If a cutaneous nerve is damaged, the are of the skin it supplies will lose sensation (anesthesia).

Exercise
1. TRY TO LEARN HOW BURNS ARE CLASSIFIED IN RELATION TO WHAT YOU HAVE LEARNED SO FAR REGARDING THE SKIN. 2. HOW CAN THE TENSION LINES OF THE SKIN AFFECT WOUND HEALING AND SURGICAL INCISIONS?

Fascia

Fascia is a connective tissue that surrounds the body and all its inner structures & is divided into 2 types:

1) Superficial fascia

This is also called the subcutaneous tissue or hypodermis because it lies immediately deep to the skin but it is NOT part of the skin. It is composed of loose areolar connective tissue rich with fat. It functions to store fat, insulate the body temperature & connect the skin above to the deeper structures below. In the male the superficial fascial fat tends to accumulate at certain areas like the abdomen and thighs but in females it is more evenly distributed. The superficial fascia contains veins called superficial veins, the cutaneous nerves passing to the dermis, superficial lymphatic vessels and occasionally skeletal muscles.

2) Deep fascia

This is a membranous connective tissue that surrounds and invests inner structures and takes its name according to the structure it surrounds. For example: deep fascia which separates muscles from each other into compartments is the ***septum*** (pl. septa), at joints deep fascia thickens and extends from one articulating bone to another and is called ***ligament***.

Muscles

There are three types of muscles: skeletal, smooth and cardiac.

- **Skeletal muscles**

These are voluntary striated muscles that have at least one attachment to the skeleton (whether bone or cartilage). Skeletal muscles are made up of bundles of striated fibers. The power of a skeletal muscle depends on the number & diameter of its bundle fibers.

A skeletal muscle is composed of the following parts **[figure.7]**:

- ***Origin*:** is the part that moves the least (almost fixed).
- ***Insertion*:** the part which moves the most (mobile).
- ***Belly*:** the fleshy part between the origin & insertion.
- ***Tendon*:** the fibrous band which attaches the muscle to the bone. The tendons of some muscles form a flat sheet called an **aponeurosis** that anchor the muscle to the skeleton.
- ***Neurovascular bundle:*** is composed of the nerve & vessels that supply the muscle. The nerve reaches the muscle at the neuromuscular junction.

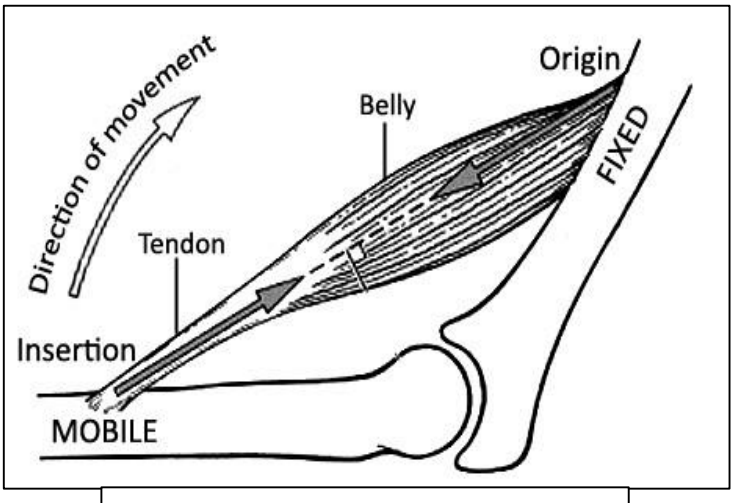


Figure 7: Parts of a skeletal muscle

In anatomical diagrams, the part of the bone which gives rise to the muscle origin is always colored in red, while the part to which the muscle is inserted is always colored in blue.

Skeletal muscles are named according to different categories. They may be named according to:

- Shape: *e.g.* Teres (round), Deltoid (triangular).
- Size: *e.g.* Minor (small), Major (Large), Longus (Long).
- Position: *e.g.* Brachii (in the arm).
- Depth: *e.g.* Profundus (Deep), Superficialis (Superficial).
- Action: *e.g.* Extensor (Performs extension).
- Nmber of heads: *e.g.* Biceps (two heads).
- Number of bellies: *e.g.* Digastric (two bellies).
- Points of attachments: *e.g.* Brachioradialis.

Many muscles are named in combinations, *e.g.* Abductor Pollicis Longus (The long abductor of the thumb).

- **Smooth muscles**

These are involuntary non-striated muscles related to internal structures ***e.g.*** arteries, gut, urinary bladder…etc. & are controlled by autonomic nerves &/or hormones. They're arranged in either of two forms:

- *Circular and longitudinal* fibers producing a combination of constrictive & propulsive action. This action produces *pulsation* in arteries and *peristalsis* in the gut & urinary tubes. Circular smooth

muscles may be thickened at the entrance or exit parts of some organs and form ***sphincters*** that control the emptying of these organs.

- *Interlacing fibers* in the wall of a hollow viscus ***e.g.*** uterus, urinary bladder; producing an *evacuatory* function.

- **The cardiac muscle**

This is the involuntary striated muscle of the heart that contracts on its own but under autonomic nervous control.

Exercise
1. IF A MUSCLE TAKES ORIGIN FROM THE FRONT OF THE THIGH AND IS INSERTED ONTO THE FRONT OF THE LEG, WHAT WOULD ITS ACTION BE ON THE KNEE? 2. A SKELETAL MUSCLE CAN PRONATE THE FOREARM AND IT IS ALSO ROUNDED IN SHAPE. WHAT DO YOU EXPECT IT TO BE CALLED? 3. THE SMOOTH MUSCLE OF YOU STOACH CONTRACTED PUSHING THE FOOD UPWARDS. WHATS HAPPENING TO YOU?

Blood Vessels

1. Arteries:

An artery is a blood vessel that carries blood (away) from the heart to all body tissues. Arteries are mostly deep vessels. According to their diameter, arteries may be Large, Medium-sized or small, most of which have rich smooth muscles in their walls making them capable of constriction and dilatation (i.e., *Pulsation*). When the small arteries reach a diameter of <0.1 mm, they are called *arterioles*. All arteries *branch* and re-branch as the run in the body. Eventually, arterioles break up into a *capillary network*. Therefore, each major artery has a point of beginning, a point of ending, a course & a number of branches it gives along its course.

Arteries usually communicate freely with each other through connecting channels called *anastomosis*. Anastomosis provides blood supply for tissues from an alternative path if one or more of the supplying arteries are blocked. This supportive circulation is called *collateral circulation*. Arteries which do not anastomose with each other are called *anatomical end arteries*. Arteries which anastomose with each other but whose connections are too weak to provide a sufficient collateral circulation; are called *functional end arteries.* ***In anatomical illustrations, arteries are always colored in red.***

2. Capillaries:

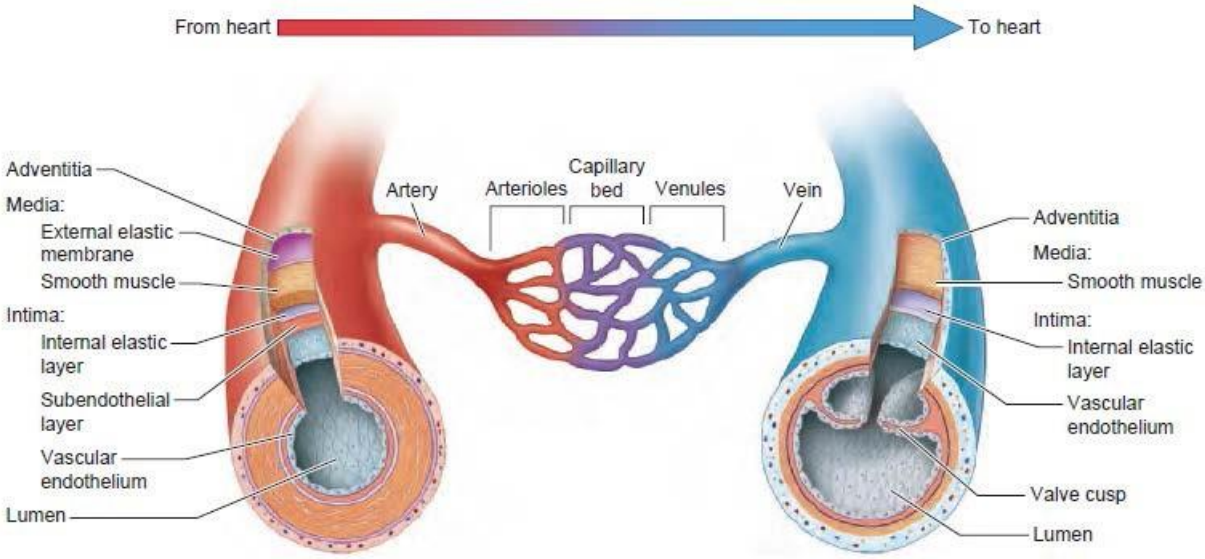
Capillaries are microscopical vessels having a diameter of 7-9 µm. They arise from the breakup of *pre-capillary arterioles* into capillary network. They're the site of exchange of nutrients, gases and waste products between blood and tissues. After blood has delivered O_2 & nutrients to the tissues and taken up CO_2 & other waste products, it is drained from the capillaries by *post-capillary venules*.

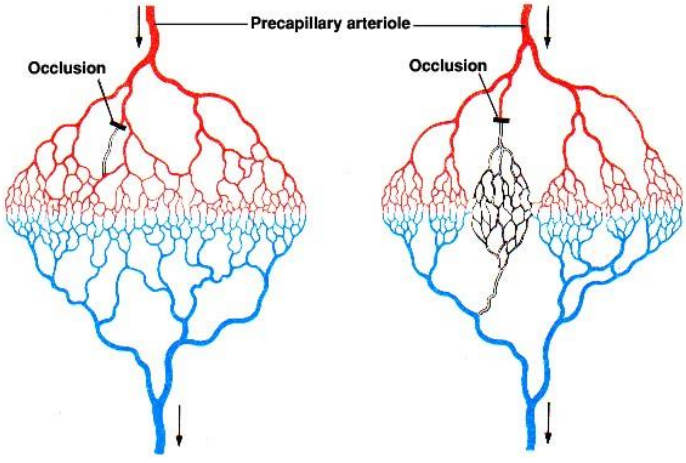
3. Veins:

A vein is a blood vessel that drains blood from the tissues towards or back to the heart. The venous side of the circulation starts at the *post-capillary venules* (<0.1 mm) which *join* other venules and receive *tributaries* along the way to form small, medium-sized and finally large veins. Therefore, veins begin where arteries end, and end where arteries begin. Veins do not have much smooth muscle in their walls and therefore cannot pulsate. Below the level of the heart this could result in retrograde flow of blood. To prevent this, veins are provided with *valves*. Sometimes, a given artery may have more than one accompanying vein. These veins are known as *venae commitantes*. Like arteries, veins communicate with each other through *venous plexuses*. Veins may be *deep* (accompanying the corresponding arteries) or *superficial.* Blood from superficial veins eventually empty their blood into deep veins. ***In anatomical illustrations, veins are always colored in blue.***

Exercise

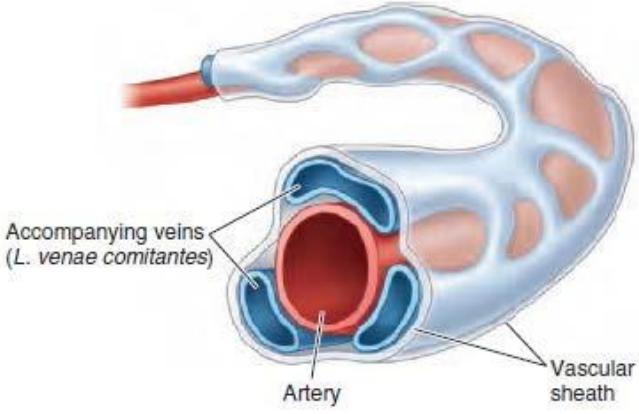
HOW MANY DIFFERENCES CAN YOU LIST BETWEEN ARTERIES AND VEINS?





A- Capillary bed supplied by anastomosing arteries

B- Capillary bed supplied by end arteries



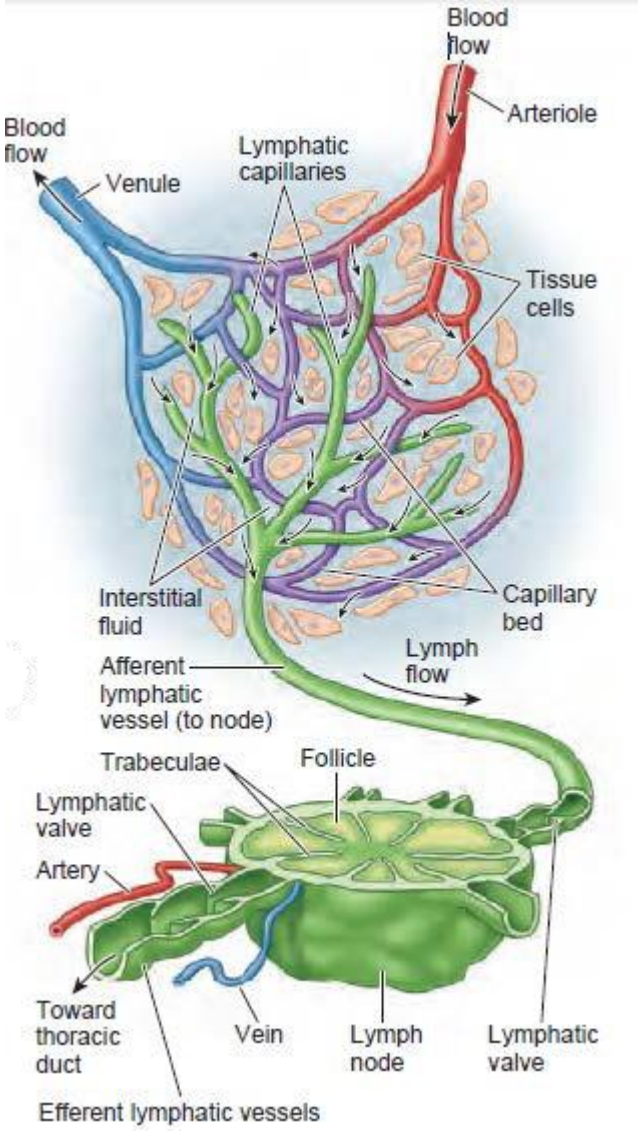
Lymph and lymph vessels

Plasma is filtered from blood capillaries to the spaces between cells (*interstitial space*) where it becomes the *interstitial fluid*. This fluid exchanges electrolytes, waste products & fats with the surrounding cells. It is then drained into lymphatic vessels as a clear fluid called the *lymph*.

Lymph has to be drained eventually back into the venous side of the circulation.

While in the lymphatic vessels, lymph has to pass through at least one *lymph node* which acts as a check-point that clears the lymph from any foreign bodies or microorganisms before it is returned to the venous circulation.

The lymph vessel which carries lymph towards the lymph node is called an *afferent lymphatic*. That which carries lymph away from the lymph node is called *efferent lymphatic*.



Lymph nodes are scattered throughout the body but they tend to aggregate at the roots of the limbs (*e.g.,* axilla), neck and around major blood vessels & internal viscera.

Bone

Bone is composed of connective tissue cells embedded in a calcium phosphate matrix. The connective tissue cells and fibers give bone its resilience while the calcium phosphate matrix gives it its strength & toughness. The deep fascia that surrounds bone is called **periosteum**. Bone surface is shaped by attachments of muscles & ligaments and surrounding vessels & nerves. It may be elevated, depressed, grooved, perforated or notched. The resulting bone markings are given different terms that are best learned gradually during the regional study of anatomy.

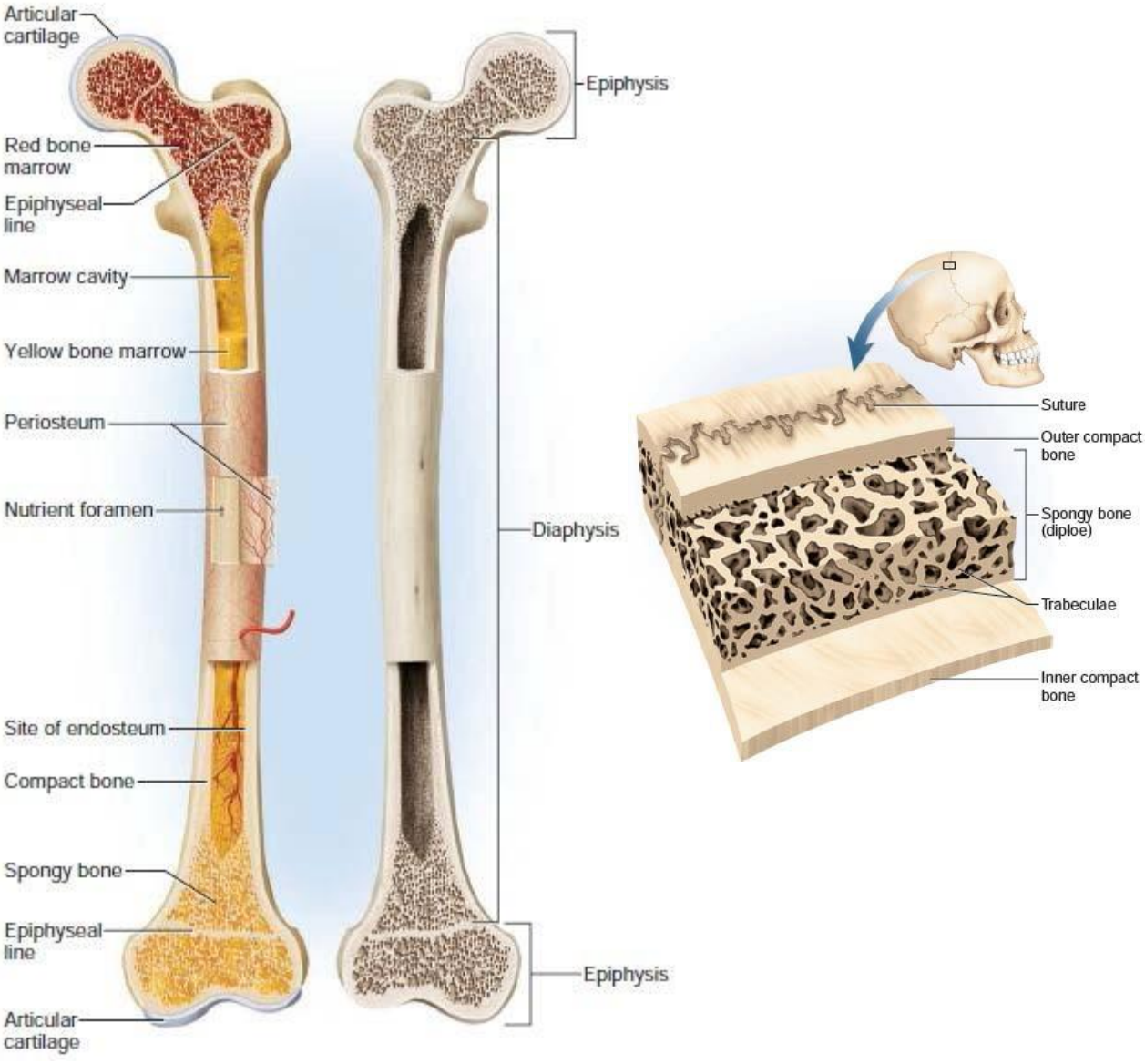
- ***Histologically, bones are of two types:***

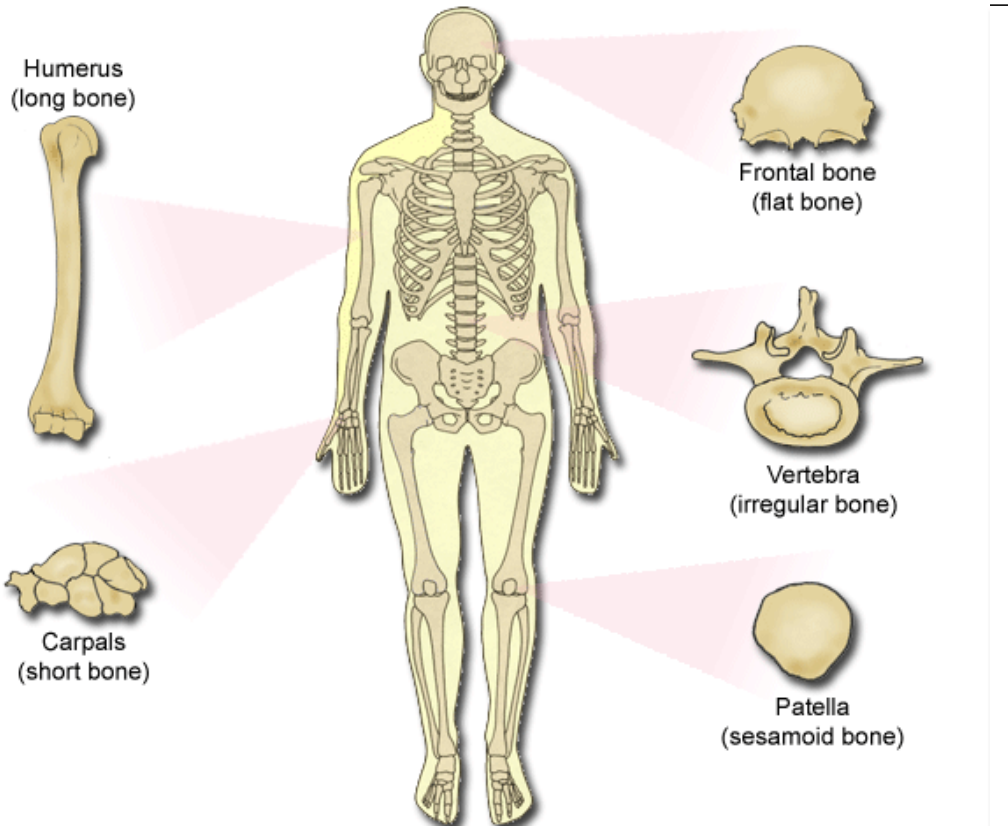
- **Compact (Haversian) bone** is composed of closely adherent dense plates of bone cells with little intervening spaces. In the shafts of long bones, a compact bone covering surrounds a large *medullary cavity* that is filled with the *Yellow Bone Marrow (fat store)*.
- **Spongy (cancellous) bone** is composed of branching meshes of bone cells with many spaces in between (like a sponge). The spaces of spongy bone are filled with the *Red Bone marrow* which is responsible for blood cell formation.

- ***Anatomically, bones are classified into 4 types according to their gross appearance:***

1. ***Long bones*** **(e.g., Humerus= arm bone**): consist of two ends called the *epiphyses* of cancellous bone with a compact bone covering, and a middle tubular *shaft* called the *diaphysis* of compact bone only (surrounding the medullary cavity). The small area between the epiphysis and the diaphysis is called the *metaphysis.*
2. ***Flat bones*** **(e.g., Scapula= shoulder blade):** consist of a cancellous bone center sandwiched between two plates of compact bone.
3. ***Short bones*** **(e.g., Carpal bones= wrist bones):** are almost as long as they are in width.
4. ***Irregular bones*** **(e.g., vertebrae= spine bones):** do not follow any regular shape as the other bones.

Figure 8: Structure of long bones (Left) and flat bones (Right).





Cartilage

Cartilage is composed of connective tissue cells & fibers embedded in a gel-like matrix giving it more resilience than bone. There are 3 types of cartilage: *Hyaline cartilage, Fibrocartilage & Elastic cartilage*.

Bones and cartilage form the human skeleton [Figure.9] which is divided into two main parts:

1. The axial skeleton: includes the skull, vertebral column and rib cage.
2. The appendicular system: includes the bones of the upper and lower limbs. The upper limb is attached to the axial skeleton by the shoulder girdle, while the lower limb is attached to the axial skeleton by the pelvic (hip) girdle.

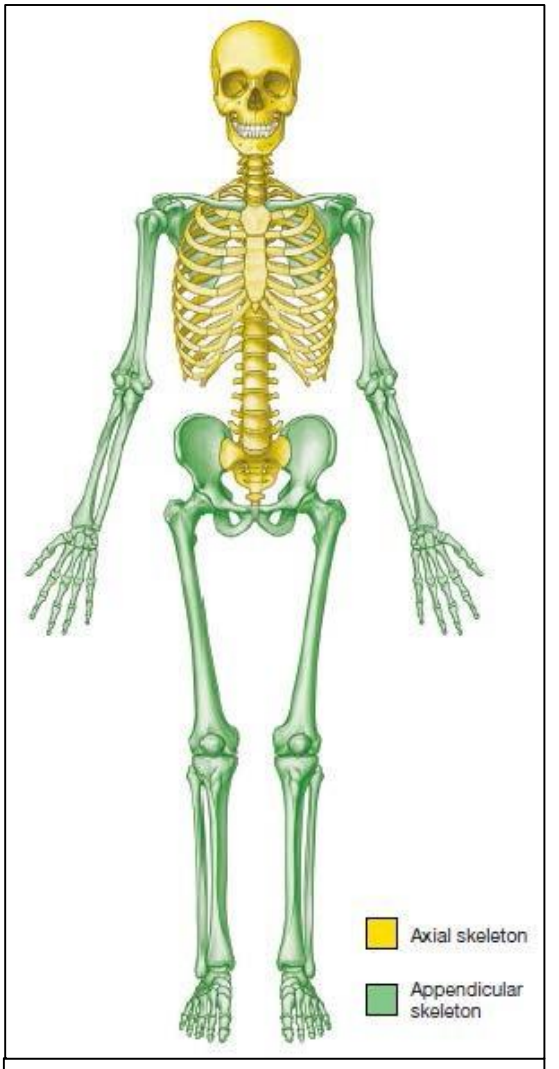


Figure 9: The skeleton

Joints

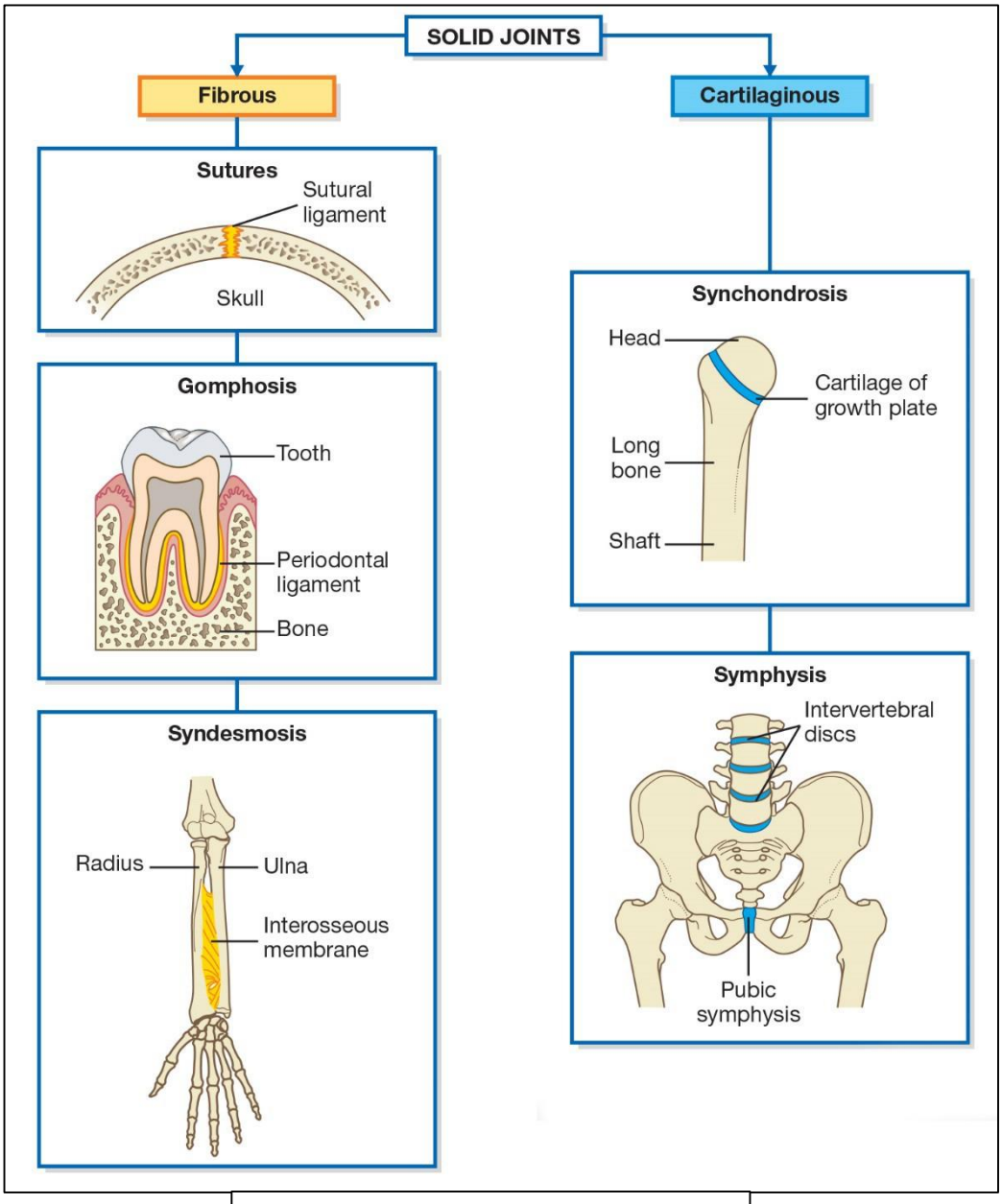
A joint is the area where two or more bones come in contact with each other whether there is movement or not between the bones. Joints are classified according to the presence or absence of a cavity between the articulating bones into two major types: Solid joints and Synovial joints.

Articulating bones are linked together in solid joints by connective tissue, while in synovial joints they are separated from each other by a fluid-filled space.

1. **Solid Joints:** are classified into two categories according to the type of connective tissue that connects the articulating bones together:

A. **Fibrous joints:** In these joints, a fibrous connective tissue fills the space between the articulating bones allowing little or no movement at all ***e.g.,*** **sutures** of the skull & **gomphoses** of the teeth.

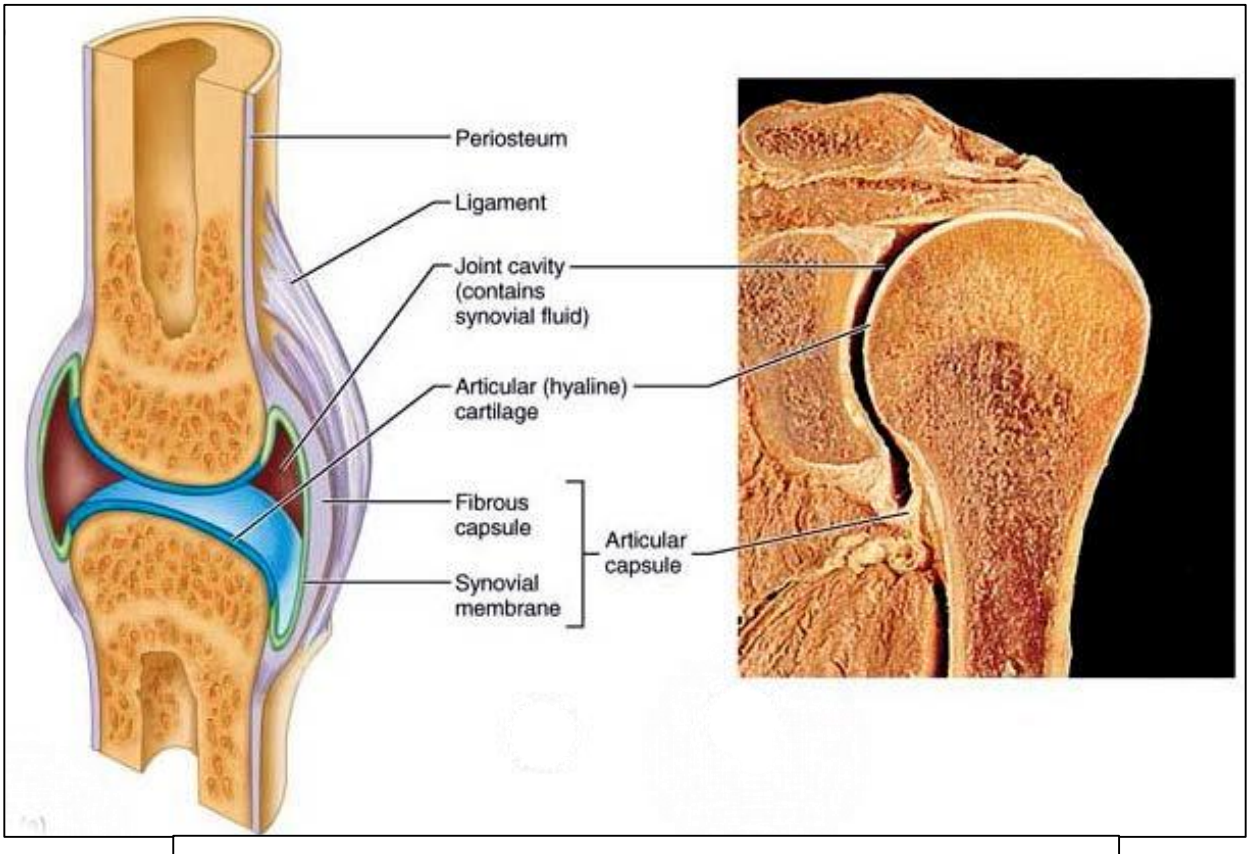
Cartilaginous joints: a cartilage fills the area between the articulating bones allowing some movement. If the cartilage is Hyaline the joint is called a Primary cartilaginous joint (Synchondrosis) like the sternomanuberial joint. If the cartilage is fibrocartilage, the joint is a Secondary cartilaginous joint (Symphysis) like the pubic symphysis. Cartilaginous joints are generally found at or close to the midline of the body, and they provide little but additive movement of related bones.



Types of solid joints

2. Synovial joints have the greatest range of movement.

The area between the articulating bones is occupied by the synovial cavity which is filled by a clear viscid synovial fluid (to lubricate movement & reduce friction) and surrounded by a synovial membrane (which produces the fluid). The synovial membrane is attached to the edges of the articular surfaces & is enclosed in a fibrous capsule that covers the whole joint & is continuous with the periosteum of adjacent bones. The synovial membrane & fibrous capsule together form the articular (joint) capsule. The articular surfaces are covered with a thin layer of hyaline

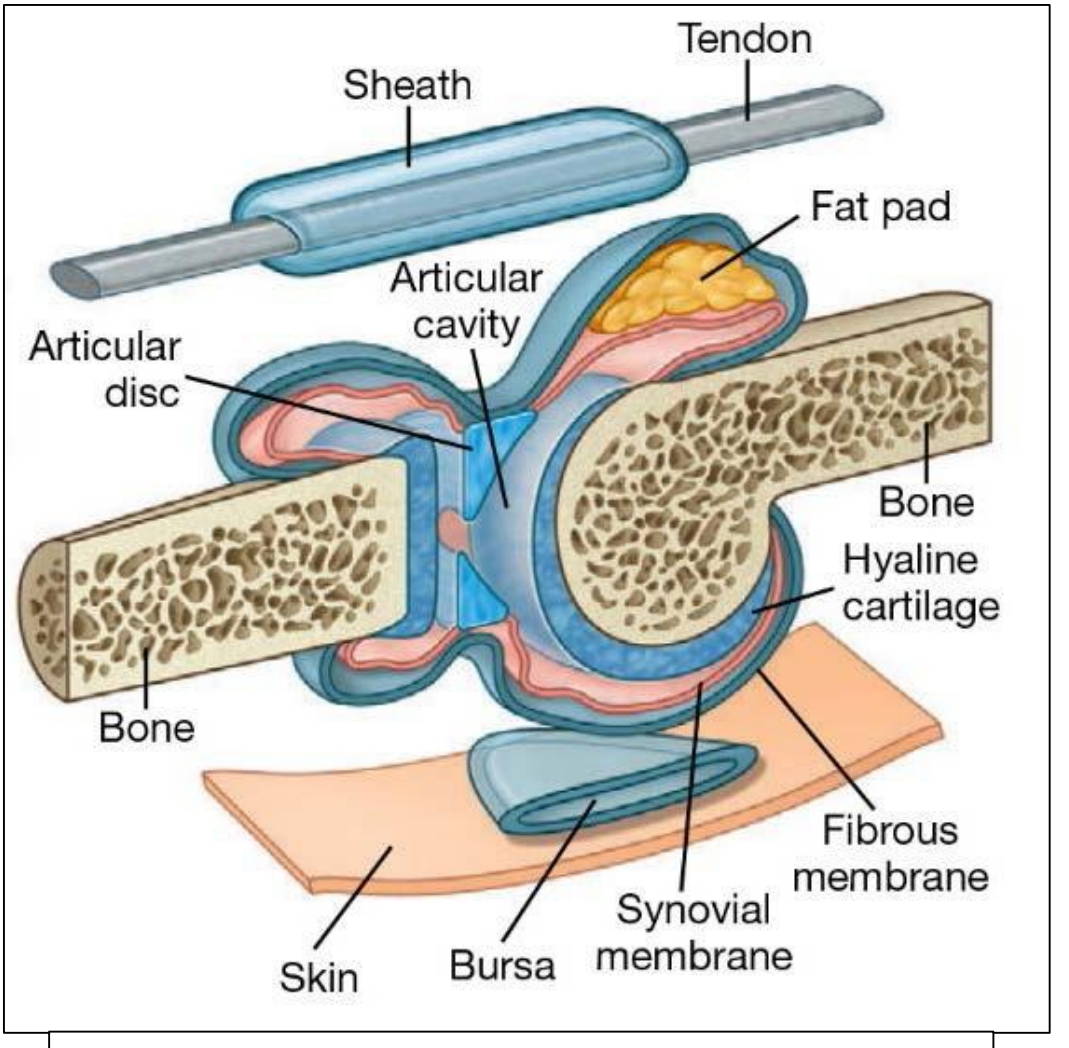


General structure of a synovial joint

Accessory structures associated with synovial joints

There are several accessory structures associated with synovial joints:

- **Bursa (pl. bursae)**: a bursa may be an extension of the synovial membrane or an isolated synovial sac filled with synovial fluid, found at areas where one structure frictions with another to reduce that friction ***e.g.,*** between skin& bone, or muscle tendon & joint…etc.
- **Tendon (synovial) sheath**: is a tubular extension of synovial membrane around muscle tendons which pass within or near the synovial joint cavity. It functions to lubricate the movement of tendons over each other & over boney structures.
- **Ligaments**: are cords of connective tissue holding the articulating bones together & giving support & stability to the joint. Most ligaments are thickenings of the fibrous capsule; some are thickenings of deep fascia around the joint. There are 2 types of ligaments: Fibrous ligaments (rich with collagen fibers with poor stretch & thus prevent excessive movement of the joint) and Elastic ligaments (rich with elastic fibers with good stretch that returns the joint to its resting position after movement).



Accessory structures associated with synovial joints

- **Retinacula**: a retinaculum is a thickening of deep fascia bridged between two or more bones and covering muscle tendons that pass over joints. the function of the retinaculum is to prevent long tendons passing over a joint from being sprung away during movement of that joint.

- **Articular discs:** (usually composed of fibrocartilage) absorb compression forces, adjust to changes in the contours of joint surfaces during movements, and increase the range of movements that can occur at joints.
- **Fat pads:** occur between the synovial membrane and the capsule and move into and out of regions as joint contours change during movement. Their function is to protect the articular cartilage.

The stability of any synovial joint depends on three factors:

1. The shape (&fit) of the articulating surfaces.

2. The number & strength of the surrounding ligaments.

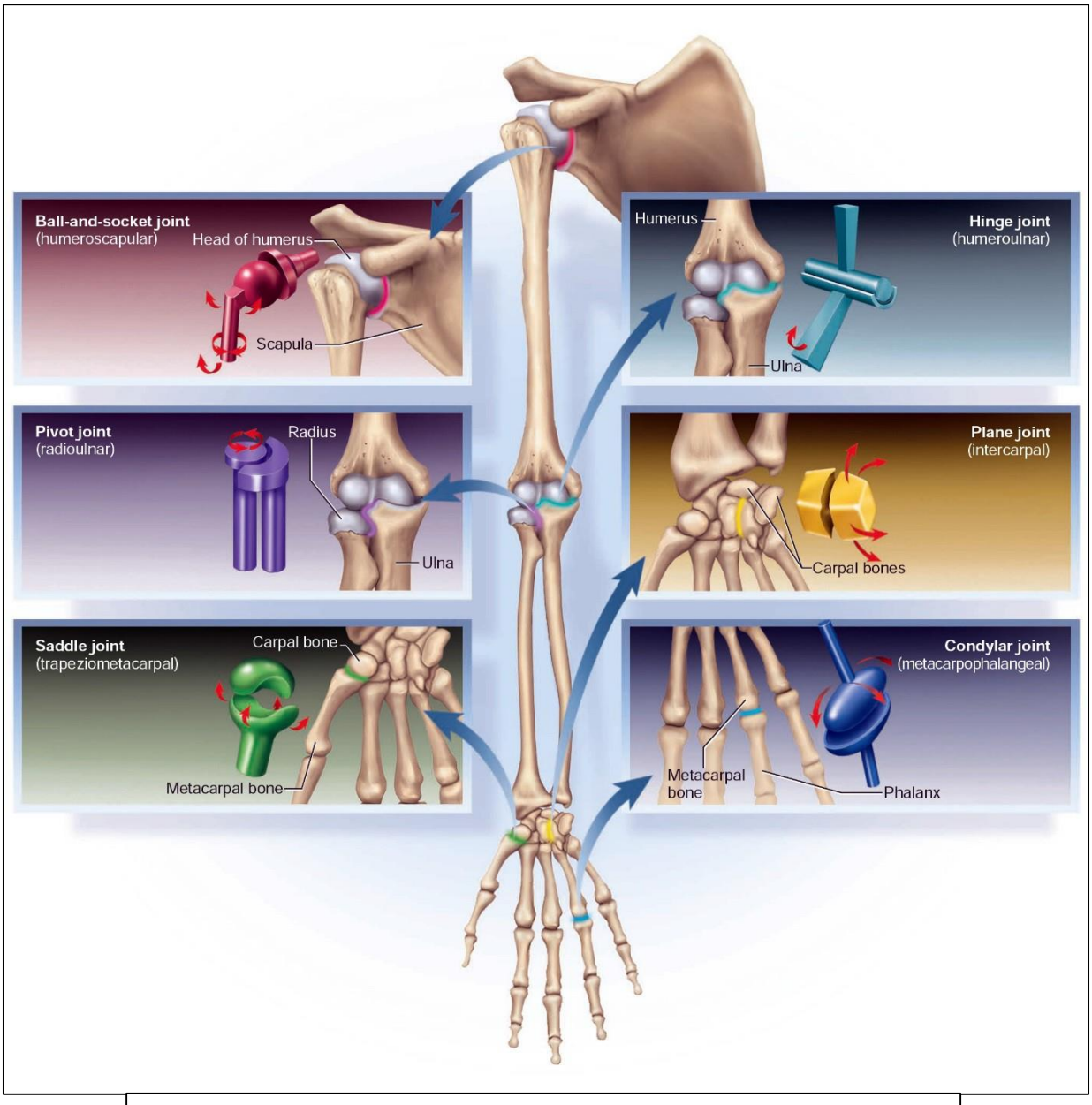
3. The bulk & strength of the surrounding muscles.

The greater the stability of a synovial joint the less is the range of movement & vice versa.

Types of synovial joints **[Figure 14]**

- Based on the **shape** of the articulating surfaces, synovial joints are described as plane (flat), hinge, pivot, condylar (ellipsoid), saddle, and ball and socket.
- Based on **movement**, synovial joints are described as uniaxial (movement in one plane), biaxial (movement in two planes), and multiaxial (movement in three planes).

Type	Shape of articulating bones	Possible movements	Example
Plane (Biaxial)	Flat	Sliding or gliding movements when one bone moves across the surface of another	Intercarpal joints
Ball-and-Socket (Multiaxial)	A spherical end fits a cup shaped cavity	**All movements** (flexion, extension, abduction, adduction, rotation & circumduction)	Shoulder joint
Hinge (Uniaxial)	A cylinder fits a longitudinal concavity (like a door hinge)	Allow movement around one axis that passes transversely through the joint permitting **flexion** & **extension**	Elbow joint
Pivot (Uniaxial)	One bony process rotates in another bony or ligamentous ring	Medial & lateral **rotation**	Proximal Radio-ulnar joint
Condylar/Ellipsoid (Biaxial)	An oval convex surface fits an oval concave surface	**Flexion**, **extension**, **abduction**, **adduction** and limited **circumduction** but no rotation	Wrist joint
Saddle (Biaxial)	A concavo-convex surface in one direction fits a convexo-concave surface in the opposite direction	**Flexion**, **extension**, **abduction**, **adduction**, **circumduction** & passive rotation.	Carpometacarpal joint of the thumb



Types of synovial joints with examples from the upper limb

Exercise

ARRANGE THESE JOINTS FROM MOST STABLE TO LEAST STABLE:
SHOULDER JOINT, ELBOW JOINT, WRIST JOINT, INTERVERTEBRAL JOINT.

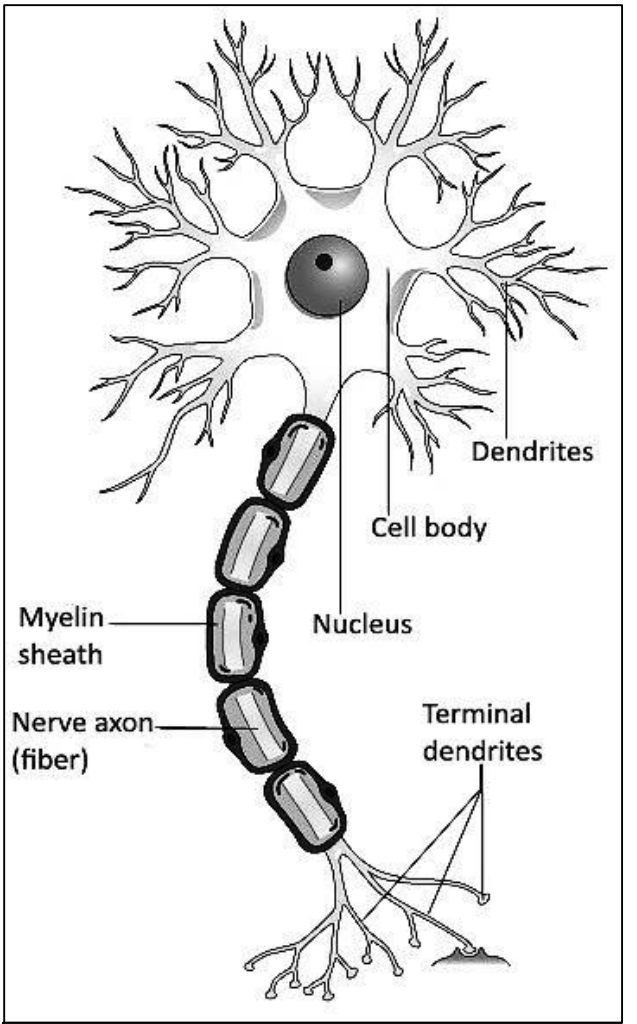
Glands

Glands are specialized epithelial structures which produce & secrete compounds that regulate different body functions. They are classified into two types:

- **Exocrine glands**: have *ducts* which deliver the gland secretions either to the *outside* of the body ***e.g.,*** sweat glands, or the *inside* of the body cavities ***e.g.,*** mucous glands in the lungs.
- **Endocrine glands**: have no ducts for delivery. Instead, they secrete their products (*hormones*) directly *into the blood stream* ***e.g.,*** thyroid gland.

General arrangement of the nervous system

The nerve cell or *neuron* is the functional unit of the nervous system. It is composed of a large *cell body* that has numerous branches called the *dendrites*. One of these is the longest and is called the *axon*, which ends by further branching into *terminal dendrites*. Nerve signals or impulses always travel from the cell body along the axon towards the terminal dendrites. Nerve cells communicate with each other at their ends by *synapses*. Each axon represents a *nerve fiber*. Most axons are surrounded by special isolating cells called *Schwan cells* that form a *myelin sheath* around the axons. Such axons are called *myelinated nerve fibers* and appear white in color forming *the white matter* of the nervous system. The axons which are not surrounded by myelin sheath are called *unmyelinated or grey nerve fibers.*

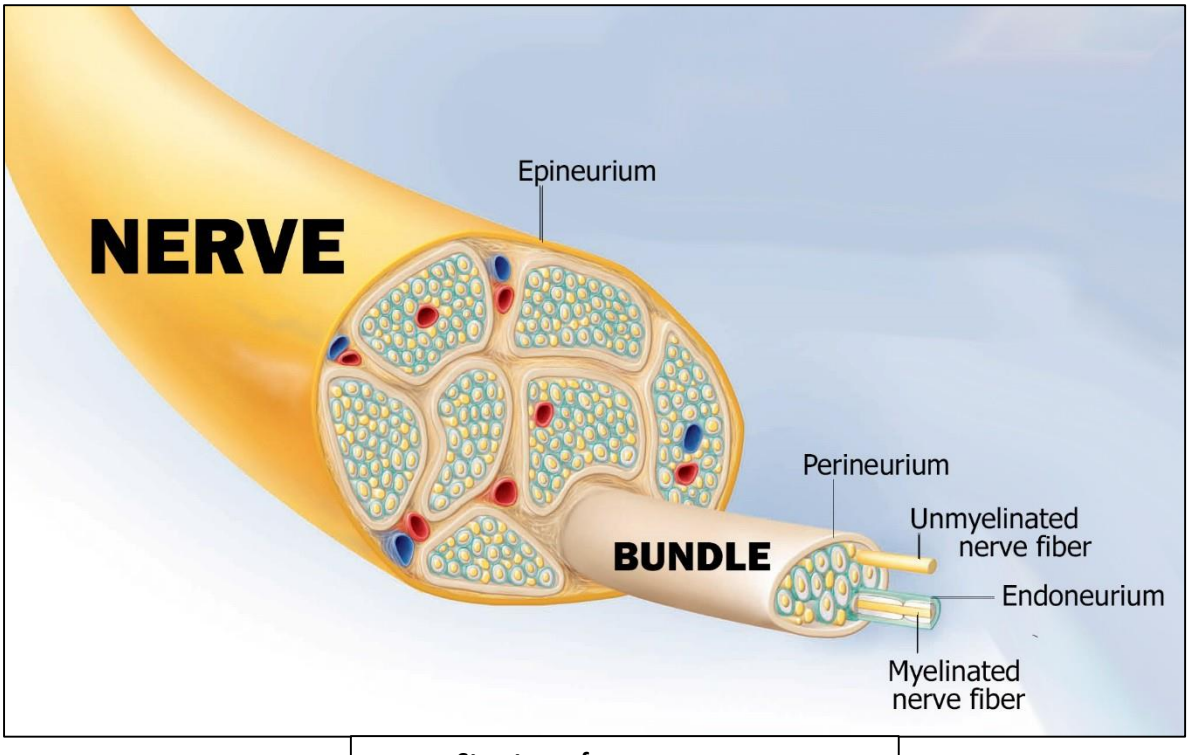


Typical nerve cell structure

Nerve cell bodies are never myelinated. Nerve cell bodies & unmyelinated nerve fibers form *the grey matter* of the nervous system.

A nerve appears as a whitish strong cord that is composed of bundles of nerve fibers (i.e., neuronal axons) embedded in connective tissue and surrounded by deep fascial coverings.

Each nerve fiber consists of the axon of a nerve cell (which may be myelinated or unmyelinated). This fiber is surrounded by a membrane called *endoneurium*. The fibers are arranged in *bundles* and each bundle (fascicle) is surrounded by a membrane called the *perineurium*. The group of nerve fiber bundles making up the whole nerve cord is surrounded by deep fascial membrane called the *epineurium.*



Structure of a nerve

Anatomical arrangement of the nervous system

Anatomically, the nervous system is divided into the *Central Nervous System* (CNS) and *Peripheral Nervous System* (PNS). The CNS consists of the brain (enclosed in the cranium of the skull) and the *spinal cord* (enclosed in the *vertebral canal* of the *vertebral column*). The PNS is composed of 12 pairs of *cranial nerves* (which emerge directly from the brain through openings in the skull) and 31 pairs of *spinal nerves* (which emerge from the spinal cord at the *intervertebral foramina* between each two vertebrae).

Nerves (Spinal or cranial) can be divided into two types according to the direction of the flow of impulses they carry:

- **Afferent nerves:** carry *sensory* impulses from the periphery of the body to the central nervous system. An example is the cutaneous nerves that carry sensory information from the skin.
- **Efferent nerves:** carry *motor / effector* impulses from the central nervous system to different body organs. An example is the motor nerves that supply skeletal muscles.

The Cranial Nerves

The 12 cranial nerves are given Roman numerals & names related to their function or structure.

The Spinal Nerves

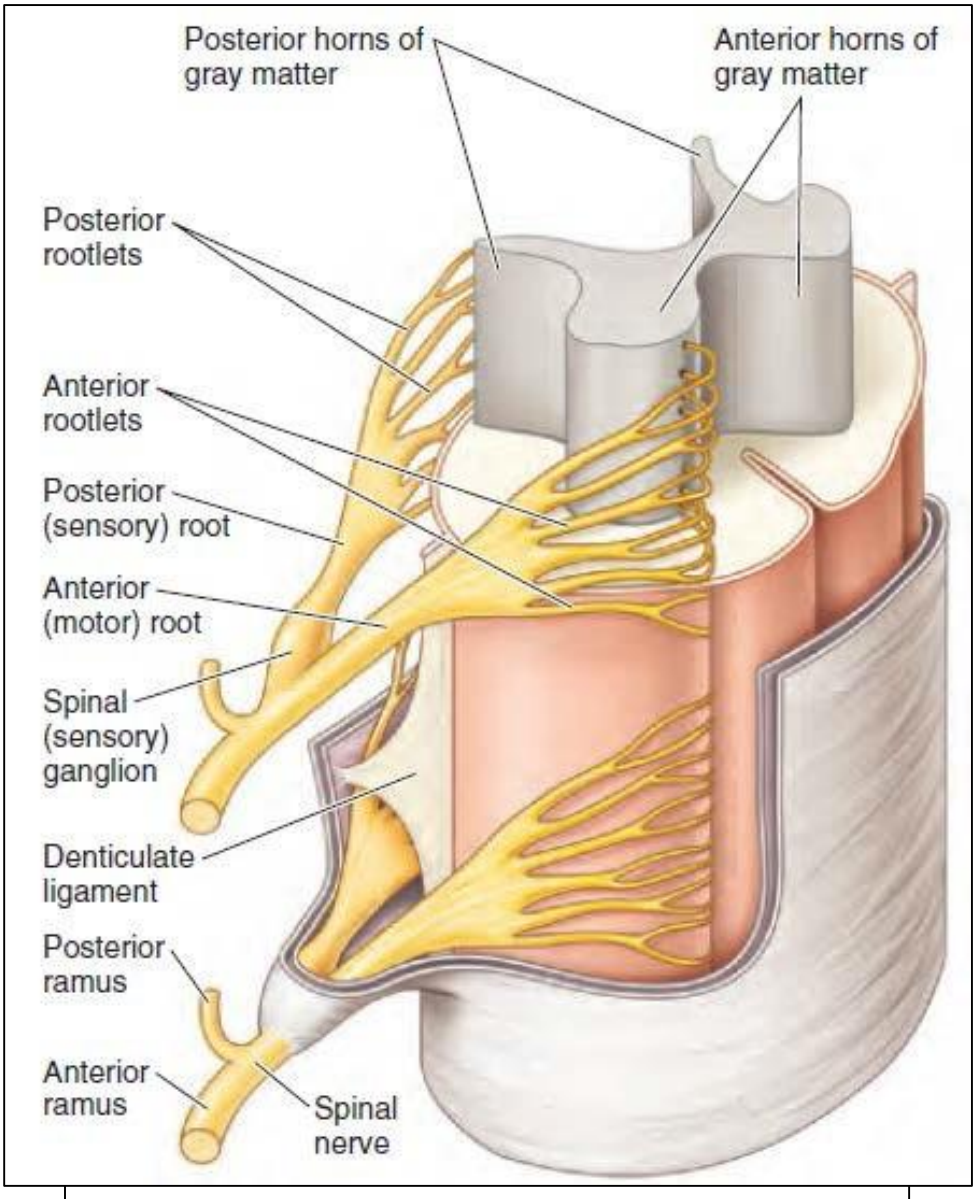
The vertebral column is composed of 30 vertebrae divided into five regions:

7 *cervical* [C] (in the neck), 12 *thoracic* [T] (in the chest), 5 *lumbar* [L] (in the abdomen), 5 *sacral* [S] (in the pelvis) and one *coccygeal* [Co] (made up of 3-4 fused small vertebrae but counted as one). The spinal cord is divided into functional segments that correspond to the vertebrae. Each segment gives rise to one pair of spinal nerves. However, there are 31 spinal segments and 31 pairs of spinal nerves. This is because of the fact that all spinal nerves emerge inferior to their corresponding vertebrae except the cervical nerves which emerge superior to their corresponding vertebrae. The intervertebral foramen between C7 & T1 vertebrae allows the C8 spinal nerve to emerge. Therefore, there are 7 cervical vertebrae but 8 cervical spinal nerves.

A cross section in the spinal cord shows that it is composed of a butterfly-shaped *grey matter* (cell bodies) surrounded by *white matter* (i.e., myelinated fibers). The grey matter has *anterior horn* cells (motor) and *posterior horn* cells (sensory). Each spinal nerve arises from the spinal cord by 2 roots: an *anterior root* composed of pure efferent motor fibers carrying impulses from the anterior horn cells, and a *posterior* root composed of pure afferent sensory fibers carrying impulses to the posterior horn calls. The posterior root shows a swelling called the *spinal (sensory) ganglion* where sensory nerve cell bodies aggregate. The two roots unite to form the *spinal nerve trunk* where there will be mixing of the motor and sensory fibers. The spinal nerve trunk lies at the *intervertebral foramen* & as soon as it leaves the foramen, it divides into *anterior & posterior rami* (i.e., branches). Each ramus consists of mixed afferent & efferent fibers. The anterior ramus is larger, longer and supplies more muscle mass and skin area.

The area of skin supplied by a single spinal nerve is called a dermatome. The muscle mass that is supplied by a single spinal nerve is called a myotome.

At the roots of the upper and lower limbs, the spinal nerves communicate with each other extensively through *Nerve Plexuses* which give rise to many branches to supply the many structures of the limbs ***e.g.,*** Brachial plexus at the root of the upper limb.



The spinal cord & spinal nerves

Functional arrangement of the Nervous System

Functionally, the nervous system can be divided into *Somatic* nervous system (nerves concerned with sensory skin perception and voluntary motor muscular action) and the *Autonomic Nervous System* (ANS) which include the sympathetic and parasympathetic systems. The ANS is concerned with visceral sensory perception and control of involuntary structures ***e.g.,*** glands, heart.

The Sympathetic System

The sympathetic system is called the thoracolumbar system because its fibers arise from the spinal segments between T1 & L2-L3.

These efferent fibers must relay their orders at an adaptor-like structure called the sympathetic ganglion. The sympathetic ganglia are interconnected to form the sympathetic trunk. Thus, the sympathetic trunk may be defined as a raw of ganglia connected by nerve fibers extending from the base of the skull to the coccyx on each side outside the vertebral column, in close relation to the anterior rami & trunks of the spinal nerves.

The efferent sympathetic fibers leave the spinal cord with the anterior root of each spinal nerve (preganglionic fibers). Then they pass from the anterior root to the sympathetic ganglion.

At the ganglion the efferent fibers synapse with second order neurons which then leave the ganglion as to be distributed through the anterior & posterior rami of the corresponding spinal nerve (postganglionic fibers).

Sympathetic fibers pass to involuntary structures and prepare the body for dangerous situation (causing sweating, contraction of arrector pilli muscles & goose-flesh, constriction of blood vessels, rise in blood pressure, increase in heart rate, dilatation of eye pupil…etc.). The sympathetic fibers reach these organs by passing through *all* the spinal nerves, *three* cranial nerves (IX, X, XII) or *around arteries* (as sympathetic plexuses).

Because of this arrangement preganglionic sympathetic fibers are shorter than postganglionic fibers.

The Parasympathetic System

The efferent fibers of this system pass from cell bodies located in the brain and the sacral segments S2, S3, S4 of the spinal cord (therefore it is also called the craniosacral system). The cranial part supplies structures in the head, neck, thorax & upper abdomen while the sacral part supplies structures in the lower abdomen and pelvis. The effects of parasympathetic stimulation are opposite those of sympathetic

stimulation (i.e., dilatation of blood vessels, decrease in blood pressure & heart rate…etc.). The parasympathetic fibers reach their target organs by passing through *four* cranial nerves (III, VII, IX & X) and *three* spinal nerves (S2, S3, S4). They do not travel along arteries. Unlike the sympathetic ganglia, the parasympathetic ganglia are located near the target organs. Therefore, the preganglionic parasympathetic fibers are longer than the postganglionic fibers.