INTRODUCTION

DEPARTMENT OF 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 Microscopic 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

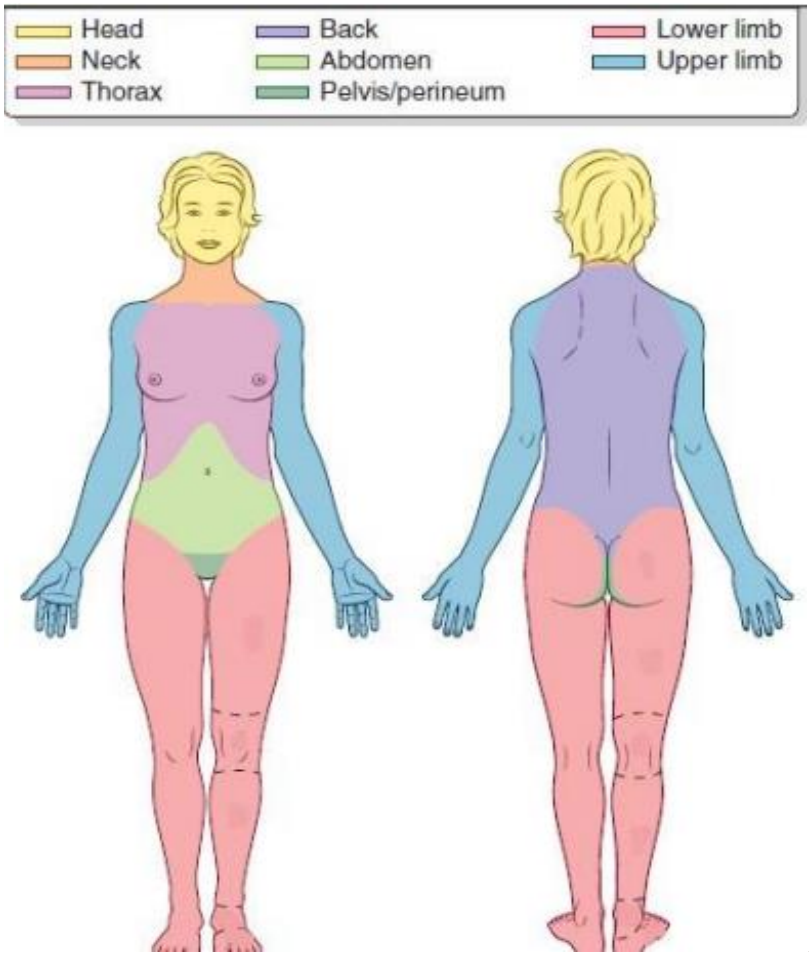
2. From front:

a- The thorax (chest)

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

• The upper limbs.

• The lower limbs.



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.

Microanatomy

The study of microscopic structures of cells, tissues, and organs, emphasizing structure-function relationships and clinical significance. Integrates histology with functional and pathological understanding.

Histology

The study of tissues and their microscopic structures. Focuses on identifying and classifying types of tissues using staining and light microscopy.

Cytology

is the scientific study of cells, including their origin, structure, function, and pathology

History of Microanatomy (Including Islamic & Arabic Contributions)

9th–11th Century – Islamic Golden Age

Hunayn ibn Ishaq: translated major Greek anatomical texts from Galen and Hippocrates, preserving anatomical terminology.

Al-Razi (Rhazes): Described detailed tissue inflammation and differentiation of pathological changes.

Ibn Sina (Avicenna): in The Canon of Medicine, proposed that disease begins at a minute structural level, suggesting invisible micro-components.

Ibn al-Nafis: discovered pulmonary circulation and hinted at subtle structures within lung tissues responsible for gas exchange.

14th Century – Optical Foundations

Ibn al-Haytham (Alhazen): developed principles of refraction and magnification with convex lenses. His Book of Optics later inspired European scientists to construct magnifying instruments.

1590s – Birth of the Microscope

Zacharias Janssen and others: created early compound microscopes, enabling the first magnified view of biological tissues.

1665–1700 – Discovery of Cells

Robert Hooke: published Micrographia and coined the term 'cell' after observing cork tissue.

Antonie van Leeuwenhoek: observed blood cells, spermatozoa, bacteria, and muscle fibers using refined single-lens microscopes.

1830s–1855 – Cell Theory Era

Matthias Schleiden and Theodor Schwann: declared that plants and animals are composed of cells.

Rudolf Virchow: later established that all cells arise from pre-existing cells, linking pathology to cellular change.

19th–20th Century – Staining & Electron Microscopy

Camillo Golgi: introduced silver staining, allowing visualization of neurons.

Paul Ehrlich: advanced aniline dyes to differentiate tissue types.

Ernst Ruska: developed the electron microscope in 1931, revealing ultrastructural elements like mitochondria and ribosomes.

Conclusion

Although Islamic scholars did not possess microscopes, their conceptual advancements in tissue theory and optical science laid the groundwork for microanatomy. When European scientists later developed microscopy, they unknowingly built upon centuries of preserved and refined Islamic scholarship. Today, microanatomy has evolved into molecular histology and AI-powered diagnostics, yet its intellectual roots reach back to the Golden Age of Islamic Medicine

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.

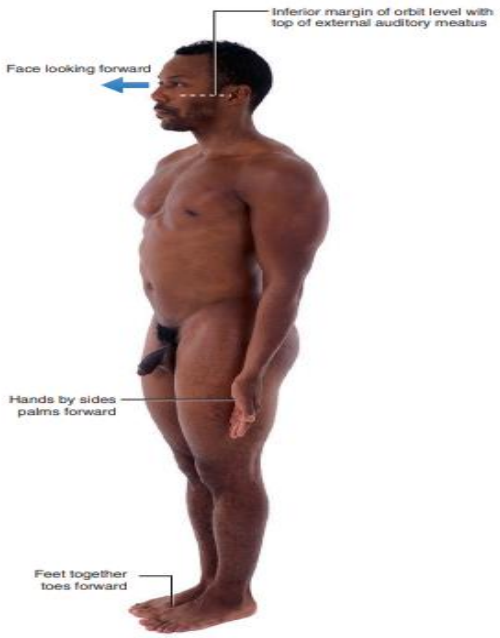
The most important thing to understand when studying anatomy is terminology. Using standard anatomical terminology ensures that physicians have a common method of communicating to avoid confusion when identifying structures.

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.

Important anatomical terms

The anatomical position



Anatomical position is the standard reference position of the body used to describe the location of structures. The body is in an anatomical position when standing upright with feet together, hands by the side and face looking forward. The mouth is closed, and the facial expression is neutral. The bone rim under the eyes is in the same horizontal plane as the top of the opening to the ear, and the eyes are open and focused on something in the distance. The palms of the hands face forward with the fingers straight and together and with the pad of the thumb turned 90° to the pads of the fingers. The toes point forward.

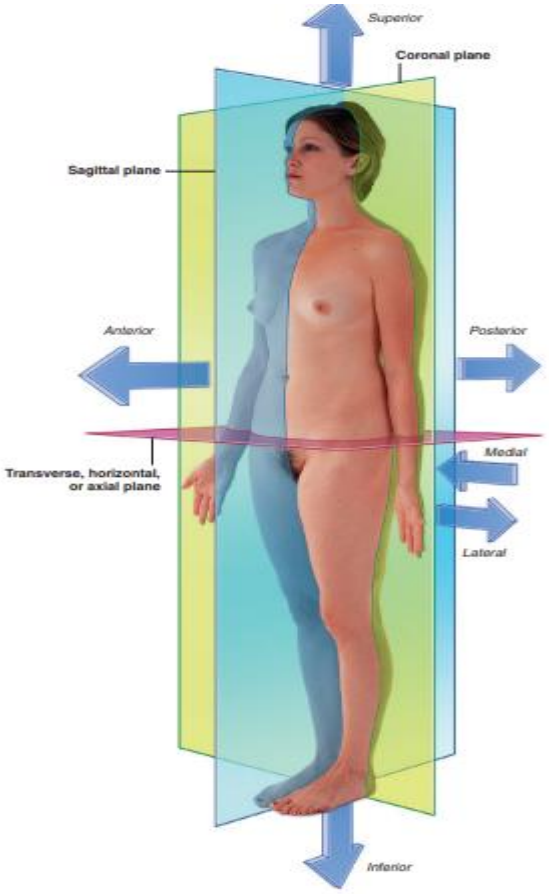
The other positions are:

• **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.

Anatomical planes



Three major groups of planes pass through the body in anatomical position

■ **Coronal planes** are oriented vertically and divide the body into anterior and posterior parts.

■ **Sagittal planes** also are oriented vertically but are at right angles to the coronal planes and divide the body into right and left parts. The plane that passes through the center of the body dividing it into equal right and left halves is termed the median sagittal plane.

■ **Transverse, horizontal, or axial planes** divide the body into superior and inferior parts.

Terms to describe location

Anterior (ventral) and posterior (dorsal), medial and lateral, superior and inferior

Three major pairs of terms are used to describe the location of structures relative to the body as a whole or to other structures.

■ **Anterior (or ventral) and posterior (or dorsal)** describe the position of structures relative to the "front" and "back" of the body. For example, the nose is an anterior (ventral) structure, whereas the vertebral column is a posterior (dorsal) structure. Also, the nose is anterior to the ears and the vertebral column is posterior to the sternum.

■ **Medial and lateral** describe the position of structures relative to the median sagittal plane and the sides of the body. For example, the thumb is lateral to the little finger. The nose is in the median sagittal plane and is medial to the eyes, which are in turn medial to the external ears.

■ **Superior and inferior** describe structures in reference to the vertical axis of the body. For example, the head is superior to the shoulders, and the knee joint is inferior to the hip joint.

Proximal and distal, cranial and caudal, and rostral

Other terms used to describe positions include proximal and distal, cranial and caudal, and rostral.

■ **Proximal and distal** are used with reference to being closer to or farther from a structure's origin, particularly in the limbs. For example, the hand is distal to the elbow joint. The glenohumeral joint is proximal to the elbow joint. These terms are also used to describe the relative positions of branches along the course of linear structures, such as airways, vessels, and nerves. For example, distal branches occur farther away toward the ends of the system, whereas proximal branches occur closer to and toward the origin of the system.

■ **Cranial (toward the head) and caudal (toward the tail)** are sometimes used instead of superior and inferior, respectively.

■ **Rostral** is used, particularly in the head, to describe the position of a structure with reference to the nose. For example, the forebrain is rostral to the hindbrain.

Other terms

• **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 above terms can be combined e.g. anteromedial, posteroinferior, superolateral…..etc.

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:

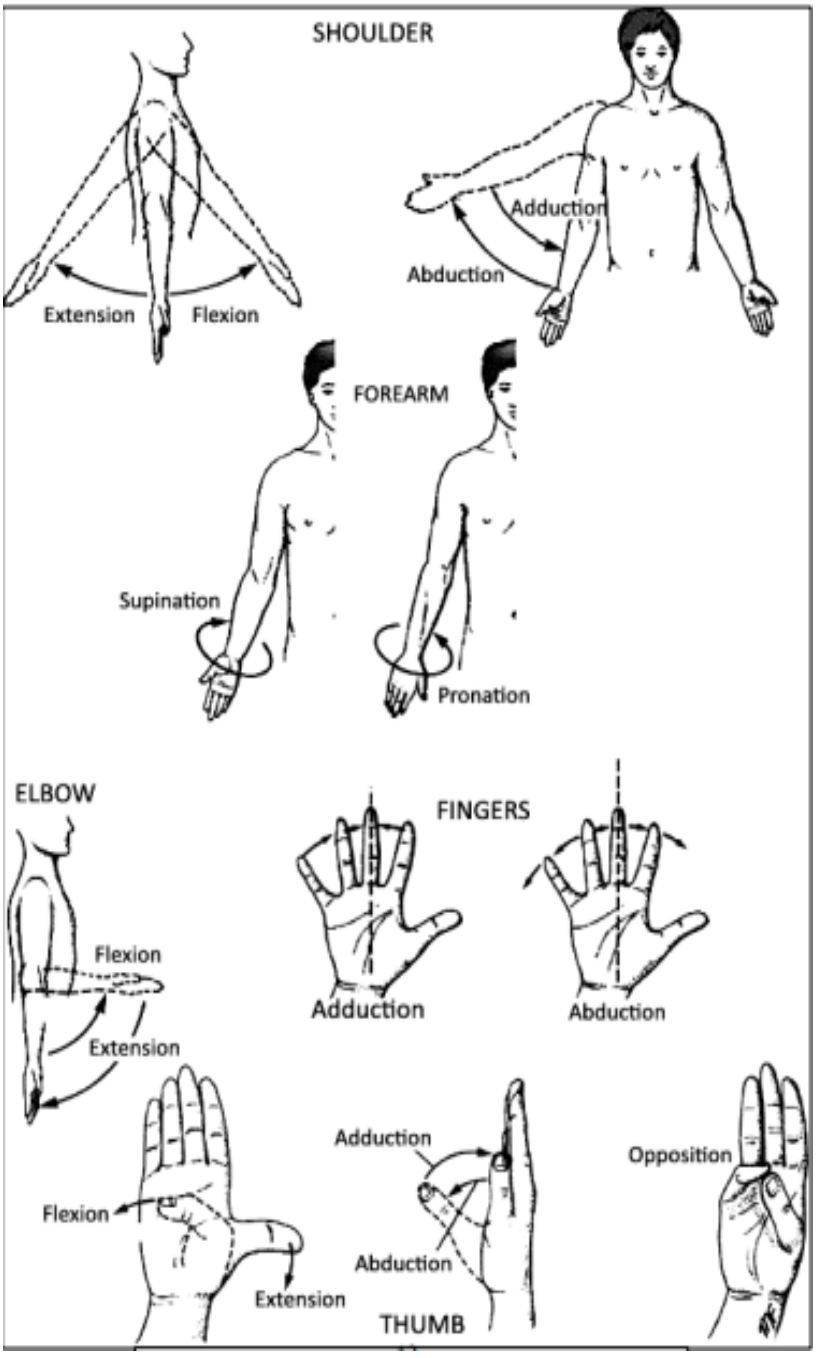
• **Flexion & Extension**: to flex a joint is to fold it (i.e. decrease the angle) and to extend a joint is to unfold it (i.e. increase the angle). In the trunk and neck lateral flexion refers to bending the neck or trunk to the right or left.

• **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**:

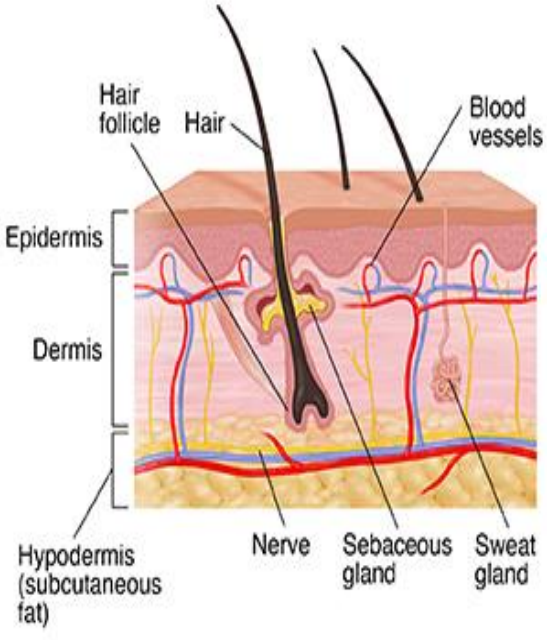
• **Elevation** (Lifting up), **depression** (Pulling down), **Protraction or Protrusion** (sliding forward) and **Retraction or Retrusion** (sliding backward) occur at the scapula and jaw, respectively.

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.



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 especially present in highly sensitive areas like the lips, eyelids & gentalia.

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

1. Nails.

2. Hairs. (not all skins have hair, e.g.: the palms, soles and lips are hairless).

3. Arrector pili 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.

Anatomical importance of the dermis:

A. The fibers of the dermis (collagen & elastic fibers) maintain their elasticity and strength.
B. The dermis contains nerve endings and receptors for skin (general) sensation. These receptors can detect five modalities of cutaneous sensation: touch, pressure, pain, temperature & vibration.

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. 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, at joints deep fascia thickens and extends from one articulating bone to another and is called ligament.

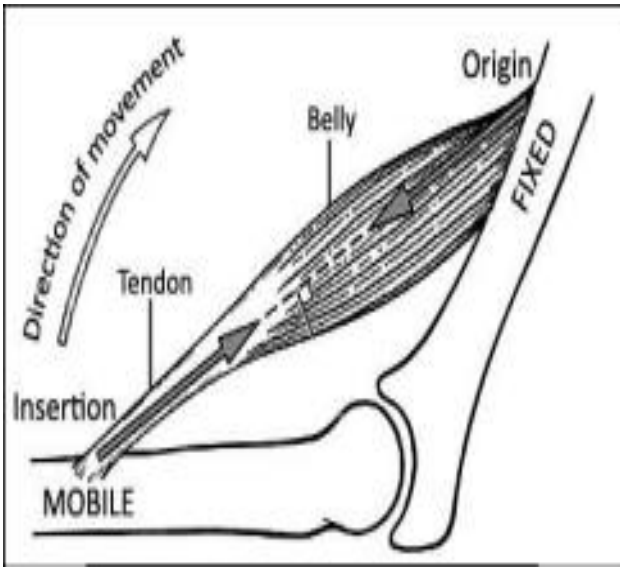
Muscles

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:



o **Origin** is the part that moves the least (almost fixed).

o **Insertion**: the part which moves the most (mobile).

o **Belly**: the fleshy part between the origin & insertion.

o **Tendon**: the fibrous band which attaches the muscle to the bone. The tendons of some muscles form a flat sheet called aponeurosis that anchor the muscle to the skeleton.

o **Neurovascular bundle**: is composed of the nerve & vessels that supply the muscle. The nerve reaches the muscle at the neuromuscular junction.

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).

- **Number of heads**: e.g. Biceps (two heads).

- **Number of bellies**: e.g. Digastric (two bellies).

- **Points of attachment**: 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:

o **Circular and longitudinal fibers** produce 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.

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

• The cardiac muscle

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

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

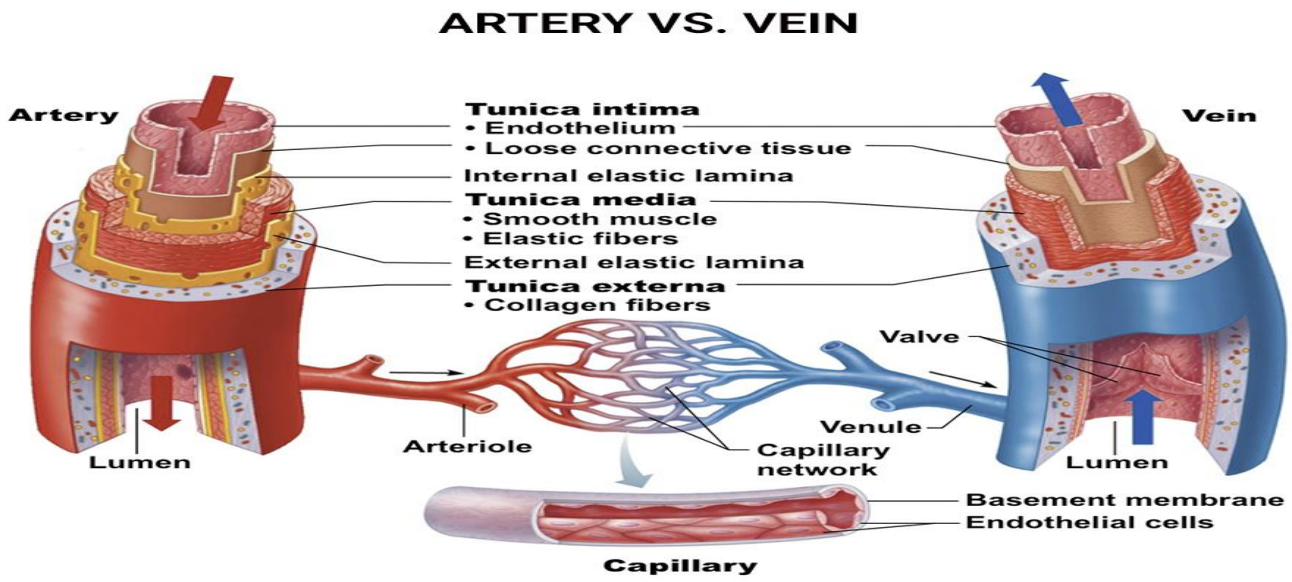
re-branch as the run in the body. Eventually, arterioles break up into a capillary network.

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 sufficient collateral circulation; are called functional end arteries. In anatomical illustrations, arteries are always colored 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 networks. They're the site of exchange of nutrients, gases and waste products between blood and tissues. After blood has delivered O2 & nutrients to the tissues and taken up CO2 & other waste products, it is drained from the capillaries by post-capillary venules.

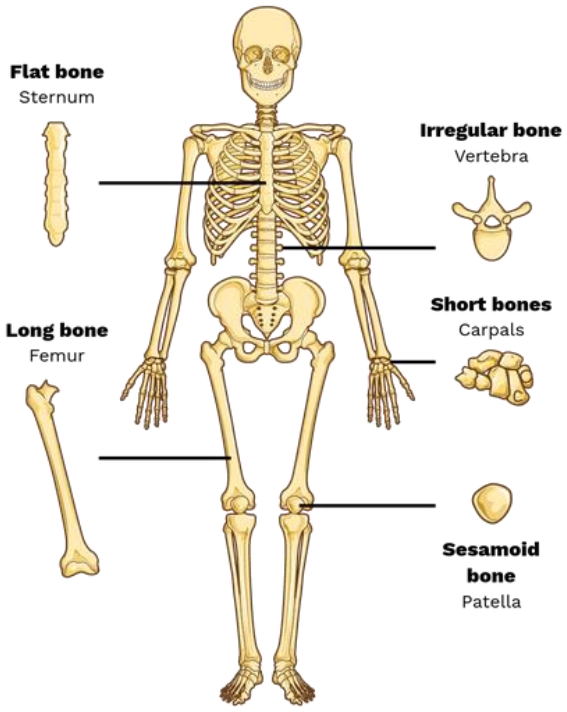
3. Veins: A vein is a blood vessel that drains blood from the tissues towards or back to the heart. The venous side of the circulation starts at the post-capillary venules (<0.1 mm) which join other venules and receive tributaries along the way to form small, medium-sized and finally large veins. Therefore, 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 blue.



Bone

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.

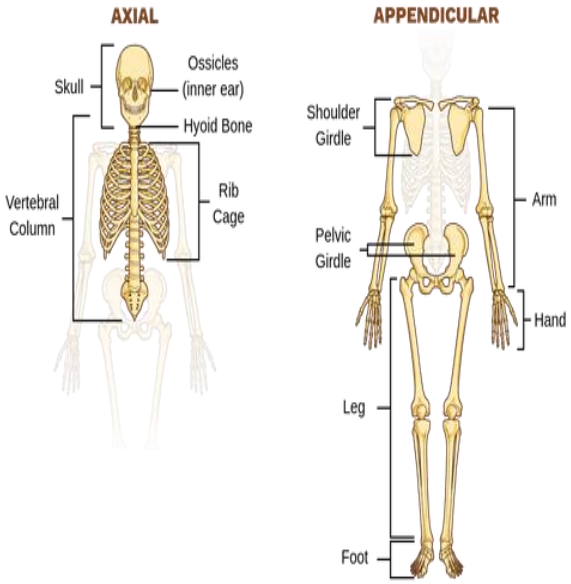
3. **Short bones** (e.g., Carpal bones= wrist bones): are almost as long as they are in width.

4. **Irregular bones** (e.g., vertebrae= spine bones): do not follow any regular shape as the other bones.

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 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.

Joints

A joint is the area where two or more bones meet 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:

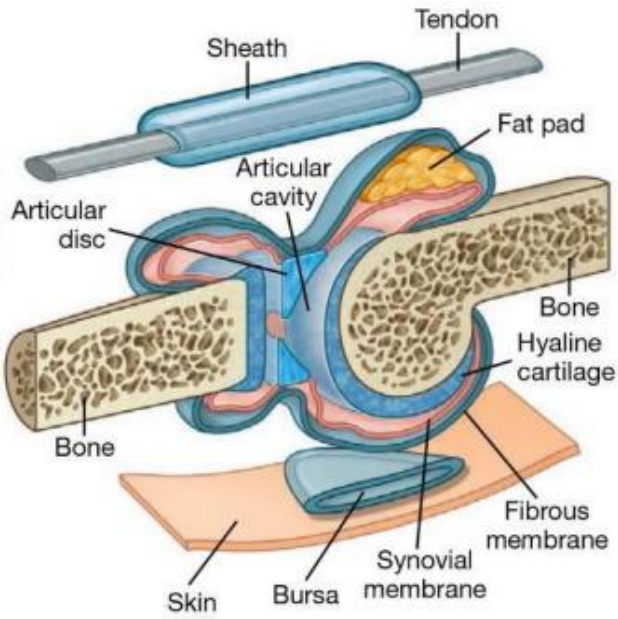
A. Fibrous joints: In these joints, a fibrous connective tissue fills the space between the articulating bones allowing little or no movement at all e.g., sutures of the skull & gomphoses of the teeth.

B. 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.

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

Accessory structures associated with synovial joints

There are several accessory structures associated with synovial joints:



o **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.

o **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.

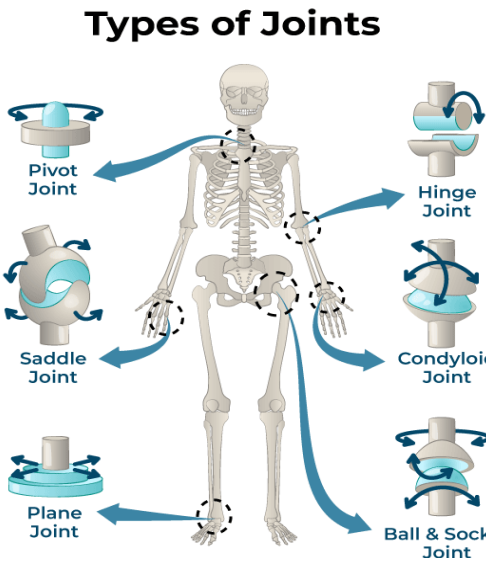
o **Ligaments** are cords of connective tissue holding the articulating bones together & giving support & stability to the joint. Most ligaments are thickenings of the fibrous capsule; some are thickenings of deep fascia around the joint.

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).

o **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.

o **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.



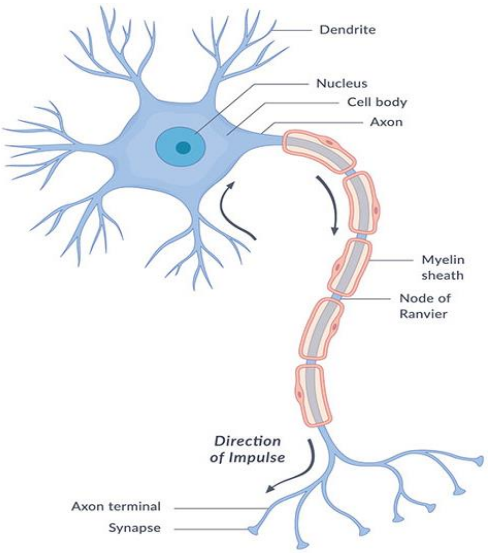
Types of synovial joints

- 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).

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 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 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.



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:

o **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.

o **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.

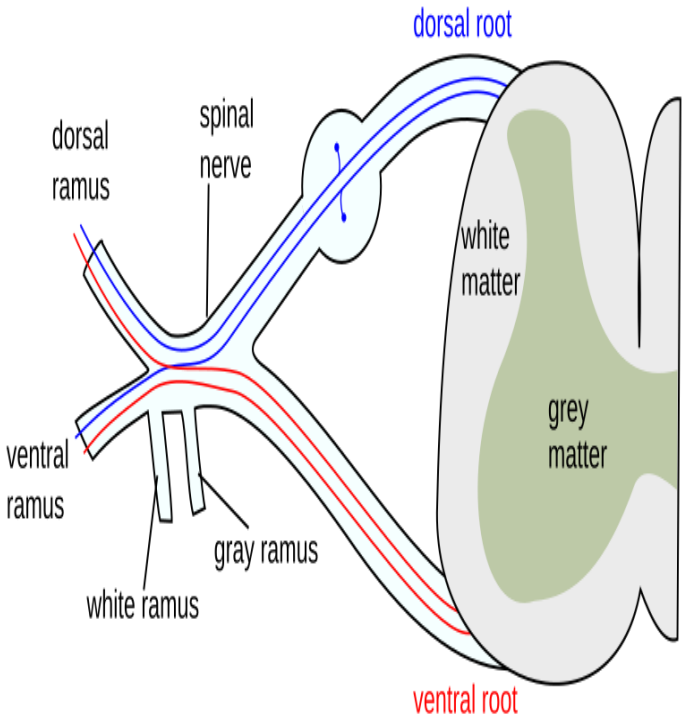
The Spinal Nerves

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 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.