Name of Unit	Integumentary System, Skeletal System and Joints
Course/Subject Name:	Human Anatomy and Physiology-I
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Learning Outcome of Module 02

LO	Learning Outcome (LO)	Course Outcome Code
LO1	To describe the structure and functions of skin.	BP101.3
LO2	To study the accessory organs of skin	BP101.3
LO3	To understand basic structure and division of skeleton system.	BP101.3
LO4	To understand various types of the bones and muscles and its physiology.	BP101.3
LO5	To understand the different types of joints involved in the movement.	BP101.3

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• Structure and functions of skin. • Accessory organs of skin • Basic structure and division of skeleton system. • Various types of the bones and muscles and its physiology. • Types of joints involved in the movement.

INTEGUMENTARY SYSTEM

INTRODUCTION

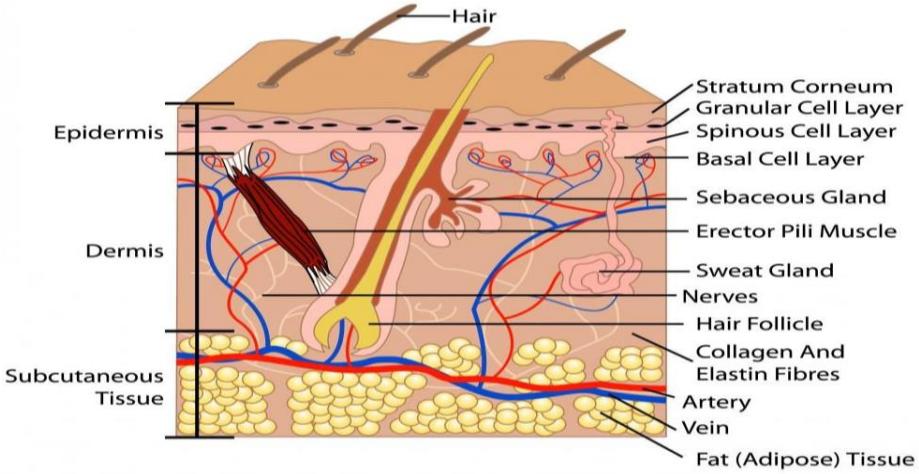
The human skin is the outer covering of the body. In humans, it is the largest organ of the integumentary system. The integumentary system helps to maintain a constant body temperature, protects the body and provides sensory information about the surrounding environment.

Dermatology:

It is the branch of medical science that deals with the diagnosis and treatment of skin disorders.

STRUCTURE OF SKIN

The skin or cutaneous membrane covers the external surface of the body and is the largest organ of the body in both surface area and weight. In adults, it covers an area of about 2 square meters and weighs about 4.5-5 kg, about 16% of total body weight. It ranges in thickness from 0.5 mm on the eyelids to 4.0 mm on the heels. It consists of two main parts.



Skin

Epidermis: The superficial, thinner portion, composed of epithelial tissue, is the epidermis.

Dermis: The deeper, thicker connective tissue portion is the dermis. Under the dermis, but not part of the skin is the subcutaneous layer called as hypodermis.

This layer consists of areolar and adipose tissues.

Epidermis: The epidermis is the outermost layer of skin. It is composed of keratinized stratified squamous epithelium. It contains four principal types of cells:

✓ Keratinocytes

✓ Melanocytes

Langerhans cells

Merkel cells

Keratinocytes:

About 90% of epidermal cells are keratinocytes arranged in four or five layers and produce the protein keratin. Keratin is a tough, fibrous protein that helps to protect the skin and underlying tissues from heat, microbes and chemicals.

Melanocytes:

About 8% of the epidermal cells are melanocytes and produce the pigment melanin.

Melanin is a yellow-red or brown-black pigment that contributes to skin colour and absorbs damaging ultraviolet (UV) light.

Langerhan's cells:

They arise from red bone marrow and migrate to the epidermis and constitute a small fraction of the epidermal cells.

They participate in immune responses mounted against microbes that invade the skin, and are easily damaged by UV light.

Merkel Cells:

These are the least numerous epidermal cells.

They are located in the deepest layer of the epidermis.

Epidermis is composed of five layers:

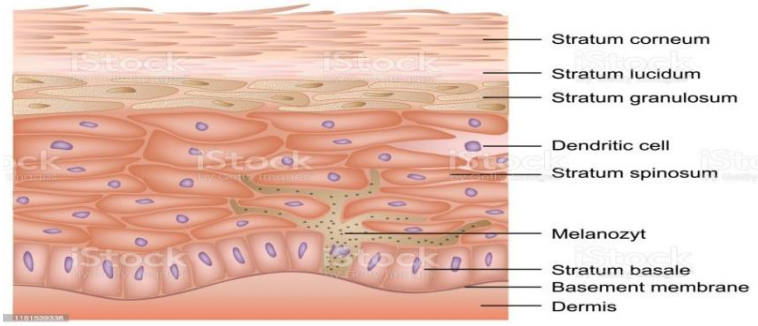
Stratum corneum (Outermost layer)

Stratum lucidum

Stratum granulosum

Stratum spinosum

Stratum basale (Innermost layer)



Epidermis

Stratum Basale:

Deepest layer of the epidermis is the stratum basale.

It is composed of single layer of cuboidal or columnar keratinocytes.

Stratum Spinosum:

Superficial to stratum basale is the stratum spinosum.

It consists of 8-10 layers of keratinocytes fits closely together.

Stratum Granulosum:

In the middle of the epidermis is the stratum granulosum.

It consists of 3-5 layers of flattened keratinocytes.

Stratum Lucidum:

It lies below the stratum corneum and consists of 3-5 layers of clear, flat, dead cells, lacking granules and nuclei.

The cells of stratum lucidum are also filled with keratin.

Stratum Corneum:

It is the outermost layer of epidermis.

It is made up of 25-30 layers of flat, dead cells, completely filled with keratin.

It is effective barrier against light, heat, bacteria, water and many chemicals.

Dermis:

The second, deeper layer of the skin is dermis.

It is composed of mainly connective tissue.

Blood vessels, nerves, glands and hair follicles are embedded in the dermal tissue.

The dermis can be divided into;

✓ Papillary region

✓Reticular region

The papillary region makes up to the 1/5th thickness of total layer. It consists of areolar connective tissue containing fine elastic fibres. Its surface area is greatly increased by small, finger-like structure called as dermal papillae. These nipple shaped structure project into the epidermis and same containing capillary loops (blood capillaries). The reticular region which is attached to the subcutaneous layer, consists of dense irregular tissue containing fibroblast, bundles of collagen and some elastic fibres A few adipose cells, hair follicles, nerves, sebaceous (oil) glands and sudoriferous (sweat) glands are present in the reticular region. The combination of collagen and elastic fibres in the reticular region provides the skin with

strength, extensibility and elasticity.

ACCESSORY STRUCTURE OF THE SKIN

It includes;

Skin glands: Regulates body temperature

Hairs: Protect the body

Nails: Protect the body

Hairs

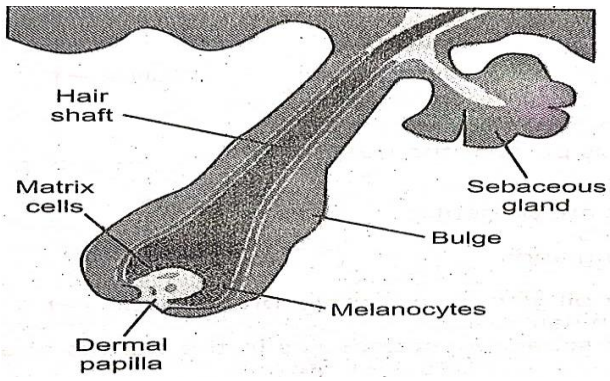
Hairs or pili are present on most skin surfaces except palms, fingers and feet surfaces. Each hair is composed of columns of dead and keratinized cells bonded together by extracellular proteins. The shaft is the superficial portion of the hair which projects above the surface of the skin. The root is the deeper portion of the hair that penetrates into the dermis and sometimes into the subcutaneous layer into the dermis and sometimes into the subcutaneous layer. The shaft and root of the hair both consists of three concentric layers of cells.

Medulla: Inner/made-up of soft keratin

Cortex: Middle/made-up of hard keratin

Cuticle of the Hair

Surrounding the root hair is the hair follicle which is made-up of external root sheath and internal root sheath. Together these are referred as epithelial root sheath. The dense dermis surrounding the hair follicle is called as dermal root sheath. The base of each hairs follicle is an anion shaped structure called as bulb. The bulb contains nipple shaped structure called as papilla of the hair contains many blood vessels that nourishes the growing hair follicle. The function of hair is to keep out dust particles from entering the eyes, ear canals and nasal chambers. Hair also acts as insulating coat of the lumen body as it keeps the body warm.



Hair

Growth Cycle:

Growth cycle consists of two stages;

Growth stage: Matrix of cells differentiates, keratinize and die. New cells are added at the base of hair root and hair grows longer.

Resting stage: In time growth of hair stops and the resting stage begins.

After the resting stage, a new growth cycle begins. Normal hair loss in adult scalp is about 70-100 hairs/day. Both the rate of growth and replacement cycle may be altered by illness, radiation therapy, chemotherapy, age, genetics, gender and emotional stress.

NAILS

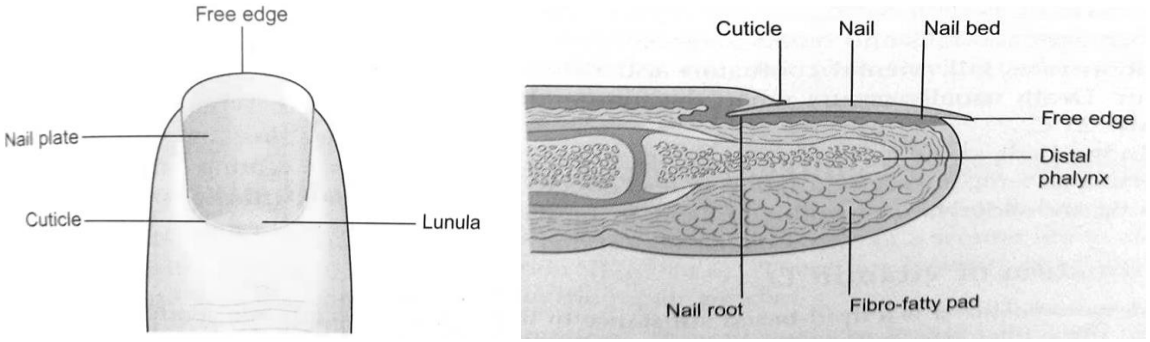
Nails are plates of tightly packed, hard, dead, keratinized epidermal cells over the dorsal surface of digits. Each nail consists of;

Nail body: It is the visible portion of the nail

Free edge: It is the free part of nail

Nail root:

It is the portion that is burried in the fold of skin. Below the nail body is the region of epithelium and deeper layer of dermis. Nail body appears pink in colour because of blood flowing through the capillaries in the dermis. The free edge is white because of no blood capillaries. The whitish, crescent shaped area of the proximal end of the nail body is called as lunula. Below, the free edge a thickened region of stratum corneum called as hyponychium, which secures the nail to the finger tip.



Nail

The eponychium or cuticle is a narrow band of epidermis that covers the nail body. The portion of epithelium present below the nail root called as nail matrix. Nails help us to grasp and manipulate small objects in various ways, provide protection against trauma to the ends of the digits and allow us to scratch various parts of the body.

Skin Glands

Two types of skin glands are present.

Sebaceous (oil) glands

Sudoriferous (sweat) glands

Sebaceous Glands:

The sebaceous glands or oil glands are simple, branched acinar glands. These are associated with hair follicles. The secreting portion of sebaceous glands lies in the dermis and usually opens into the neck of hair follicle. These glands are absent in palms and soles, sebaceous glands are small in most area of trunk and limbs, but large in the skin of the breast, face and neck. A sebaceous gland secretes an oily substance called as sebum. Sebum is a complex mixture of naturally produced fats, oils, waxes, cholesterol and other molecules.

Functions of Sebum:

- It prevents excessive evaporation of water from the skin.
- It keeps the skin soft and pliable.
- It inhibits the growth of certain bacteria.
- It coats the surface of hairs and keeps them from drying and becoming brittle.

Sweat Glands:

Also called as sudoriferous glands. These glands release sweat or perspiration into hair follicles or into the skin surface through pores. A sweat gland helps in regulating temperature of the body and also helps in removing the wastes outside the body.

Sweat glands are of two types.

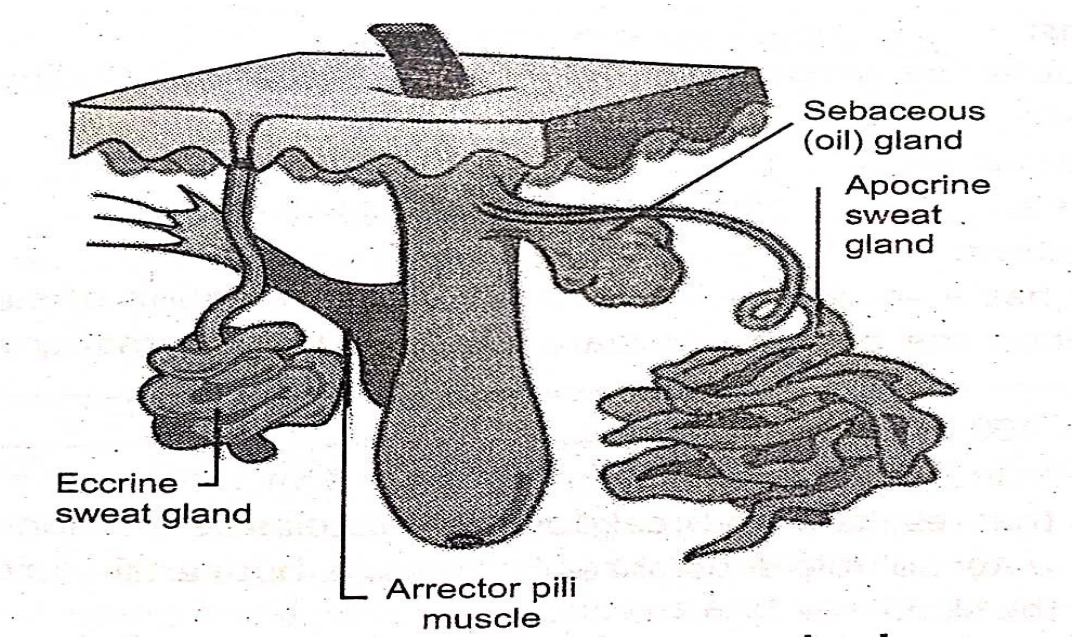
Eccrine sweat glands

Apocrine sweat glands

Eccrine Sweat Glands: These are also called as merocrine sweat glands. These are simple, coiled, tubular glands. The sweat produced by eccrine sweat glands (about 600 ml per day) consists of water, ions (sodium and chloride), urea, uric acid, ammonia, amino acid, glucose and lactic acid. The main function is regulation of body temperature through evaporation. It also removes wastes such as urea, uric acid and ammonia from the body.

Apocrine Sweat Body: These are simple, coiled and tubular glands. The secretory portion of these sweat glands is mostly located in the subcutaneous layer and excretory duct opens into hair follicles. The secretion of apocrine sweat gland is more viscous than the eccrine sweat

gland. These glands are inactive during childhood. They develop and begin function during puberty as they get stimulated by sex hormones. The components of sweat glands are same as present in eccrine sweat glands plus lipids and proteins.



Sweat and sebaceous gland

Ceruminous Glands:

The modified sweat glands in the external ear called as ceruminous glands, produces a waxy secretions. The combined secretion of ceruminous and sebaceous glands called as ceruminous earwax. Cerumen together with hairs in the external auditory canal, provides a sticky barrier that prevents the entry of foreign bodies.

FUNCTIONS OF SKIN

Thermoregulation: The skin plays an important role in thermoregulation by two ways:

- ✓ By liberating sweat at its surface.
- ✓ By adjusting the blood flow in the dermis.

In response to high environment temperature or heat produced during exercise, heat production increases producing evaporation of sweat from the skin helps to lowers the body temperature. Blood vessels in the dermis of the skin shows dilation producing more blood flows through the dermis producing increased amount of heat loss from the body. In response to low environment temperature sweat production decreases which helps in conserving heat.

Blood Reservoir: Dermis houses as extensive network of blood vessels that carry 8-10% of total blood flow in a resting adult.

Protection: The skin provides protection to the body in various ways. Keratin protects underlying tissue from microbes, abrasion, heat and chemicals. The oily sebum from sebaceous glands keeps skin and hairs from drying out and contains bactericidal chemicals that kill surface bacteria. The acidic pH of sweat retards the growth of microbes. The pigments melanin helps against the damaging effect of UV light.

Cutaneous Sensations: Cutaneous sensations are sensations that arise in the skin including touch, pressure, vibrations and tickling. It also includes thermal sensations such as warmth and coolness. Another cutaneous sensation is pain usually indicates tissue damage.

Excretion and Absorption: The skin normally has a small role in excretion (the elimination of substances from the body) and absorption the passage of materials from the external environment into the body. A person produces 400 ml of sweat daily. Sweat act as a vehicle for excretion of small amount of salts, carbon-dioxide and two organic molecules that results from breakdown of proteins i.e. ammonia and urea. The absorption of water soluble substances is possible, but certain lipid-soluble materials do not penetrates the skin. These includes fat-soluble vitamins (A, D, E and K) certain drugs, gases oxygen and F carbon-dioxide

Synthesis of Skin:

Synthesis of vitamin-D requires activation of a precursor molecule in the skin by UV rays of sunlight. Enzymes in the liver and kidneys then modify the activated molecule finally producing calcitriol, the most active form of vitamin-D. Calcitriol is a hormone that helps in absorption of calcium in foods from GIT into the blood.

OSSEOUS SYSTEM

INTRODUCTION:

Bone tissue is continuously growing, remodeling, and repairing itself. It contributes to homeostasis of the body by providing support, protection, the production of blood cells, and the storage of minerals and triglycerides.

Bone tissue, a complex and dynamic living tissue, continually engages in a process called remodeling— the construction of new bone tissue and breaking down of old bone tissue. The entire framework of bones and their cartilages, along with ligaments and tendons, constitutes the **skeletal system**.

The study of bone structure and the treatment of bone disorders are called **osteology**.

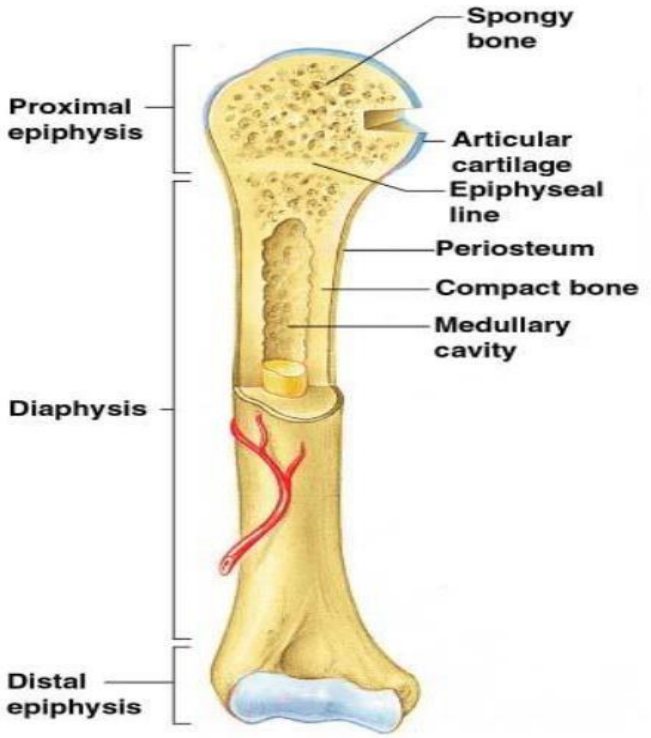
FUNCTIONS OF BONES AND SKELETAL SYSTEM:

Bone tissue makes up about 18% of the weight of the human body. The skeletal system performs several basic functions:

- **Support:** The skeleton serves as the structural framework for the body by supporting soft tissues and providing attachment points for the tendons of most skeletal muscles.
- **Protection:** The skeleton protects the most important internal organs from injury. For example, cranial bones protect the brain, vertebrae (backbones) protect the spinal cord, and the rib cage protects the heart and lungs.
- **Assistance in movement:** Most skeletal muscles attach to bones; when they contract, they pull on bones to produce movement.
- **Mineral homeostasis (storage and release):** Bone tissue stores several minerals, especially calcium and phosphorus, which contribute to the strength of bone. Bone tissue stores about 99% of the body's calcium. On demand, bone releases minerals into the blood to maintain critical mineral balances (homeostasis) and to distribute the minerals to other parts of the body.
- **Blood cell production:** Within certain bones, a connective tissue called red bone marrow produces red blood cells, white blood cells, and platelets, a process called hemopoiesis.
- **Triglyceride storage:** Yellow bone marrow consists mainly of adipose cells, which store triglycerides. The stored triglycerides are a potential chemical energy reserve. In a newborn, all bone marrow is red and is involved in hemopoiesis. With increasing age, much of the bone marrow changes from red to yellow.

STRUCTURE OF BONE:

Macroscopic bone structure may be analyzed by considering the parts of a long bone, such as the humerus (the arm bone). A long bone is one that has greater length than width.



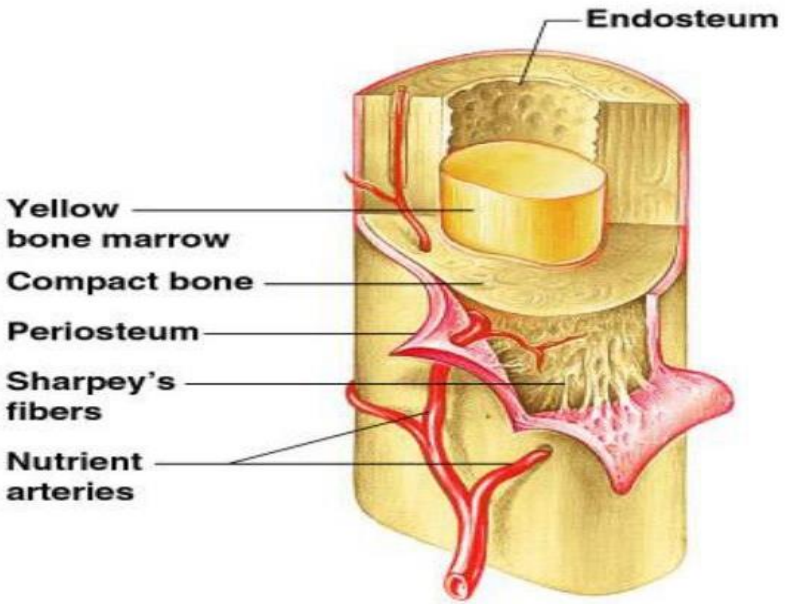
Bone Tissue

A typical long bone consists of the following parts:

1. **Diaphysis:** The bone's shaft or body—the long, cylindrical, main portion of the bone.
2. **Epiphyses:** The proximal and distal ends of the bone.
3. **Metaphyses:** The regions between the diaphysis and the epiphyses. In a growing bone, each metaphysis contains an **epiphyseal (growth) plate**, a layer of hyaline cartilage that allows the diaphysis of the bone to grow in length. When a bone ceases to grow in length at about ages 18–21, the cartilage in the epiphyseal plate is replaced by bone; the resulting bony structure is known as the **epiphyseal line.**
4. **Articular cartilage:** Thin layer of hyaline cartilage covering the part of the epiphysis where the bone forms an articulation (joint) with another bone. Articular cartilage reduces friction and absorbs shock at freely movable joints.
5. **Periosteum:** Surrounds the external bone surface wherever it is not covered by articular cartilage. It is composed of an outer fibrous layer of dense irregular connective tissue and an inner osteogenic layer that consists of cells. Some of the cells of the periosteum enable

bone to grow in thickness, but not in length. The periosteum also protects the bone, assists in fracture repair, helps nourish bone tissue, and serves as an attachment point for ligaments and tendons. It is attached to the underlying bone through **perforating (Sharpey's) fibers**, thick bundles of collagen fibers that extend from the periosteum into the extracellular bone matrix.

6. **Medullary cavity or marrow cavity:** Hollow, cylindrical space within the diaphysis that contains fatty yellow bone marrow in adults.
7. **Endosteum:** Thin membrane that lines the internal bone surface facing the medullary cavity. It contains a single layer of cells and a small amount of connective tissue.



HISTOLOGY OF BONE TISSUE:

Like other connective tissues, bone, or osseous tissue (OS-e¯-us), contains an abundant extracellular matrix that surrounds widely separated cells. The extracellular matrix is about 25% water, 25% collagen fibers, and 50% crystallized mineral salts.

Four types of cells are present in bone tissue: osteogenic cells, osteoblasts, osteocytes, and osteoclasts.

1. **Osteogenic cells:** Unspecialized stem cells derived from mesenchyme, the tissue from which almost all connective tissues are formed. They are the only bone cells to undergo cell division; the resulting cells develop into osteoblasts. Osteogenic cells are found along the inner portion of the periosteum, in the endosteum, and in the canals within bone that contain blood vessels.

2. **Osteoblasts:** These are bone-building cells. They synthesize and secrete collagen fibers and other organic components needed to build the extracellular matrix of bone tissue, and they initiate calcification.
3. **Osteocytes:** Mature bone cells, are the main cells in bone tissue and maintain its daily metabolism, such as the exchange of nutrients and wastes with the blood. Like osteoblasts, osteocytes do not undergo cell division. Four types of cells are present in bone tissue: osteogenic cells, osteoblasts, osteocytes, and osteoclasts.
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7. **Osteoclasts:** Huge cells derived from the fusion of as many as 50 monocytes (a type of white blood cell) and are concentrated in the endosteum.
8. On the side of the cell that faces the bone surface, the osteoclast's plasma membrane is deeply folded into a ruffled border. Here the cell releases powerful lysosomal enzymes and acids that digest the protein and mineral components of the underlying bone matrix. This breakdown of bone extracellular matrix, termed resorption, is part of the normal development, maintenance, and repair of bone.
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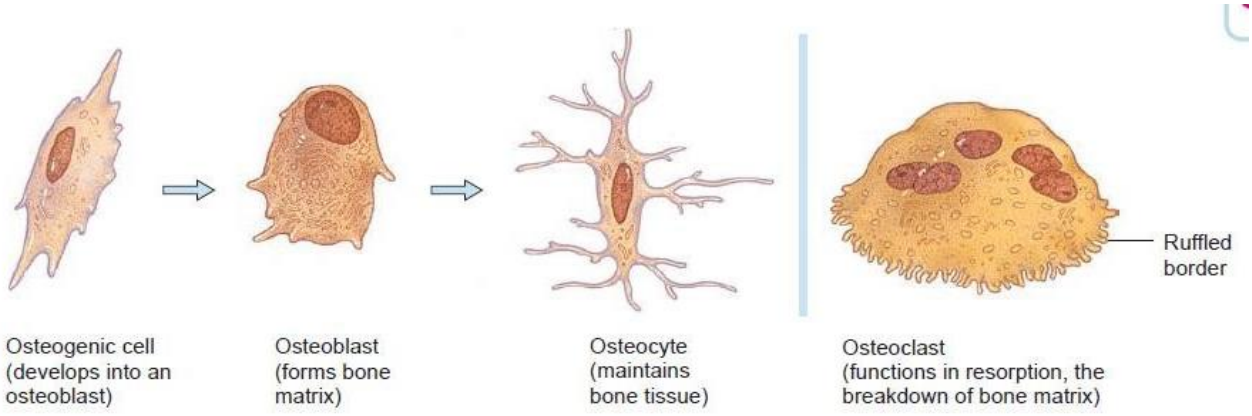
Bone is not completely solid but has many small spaces between its cells and extracellular matrix components. Depending on the size and distribution of the spaces, the regions of a bone may be categorized as compact or spongy. Overall, about 80% of the skeleton is compact bone and 20% is spongy bone.



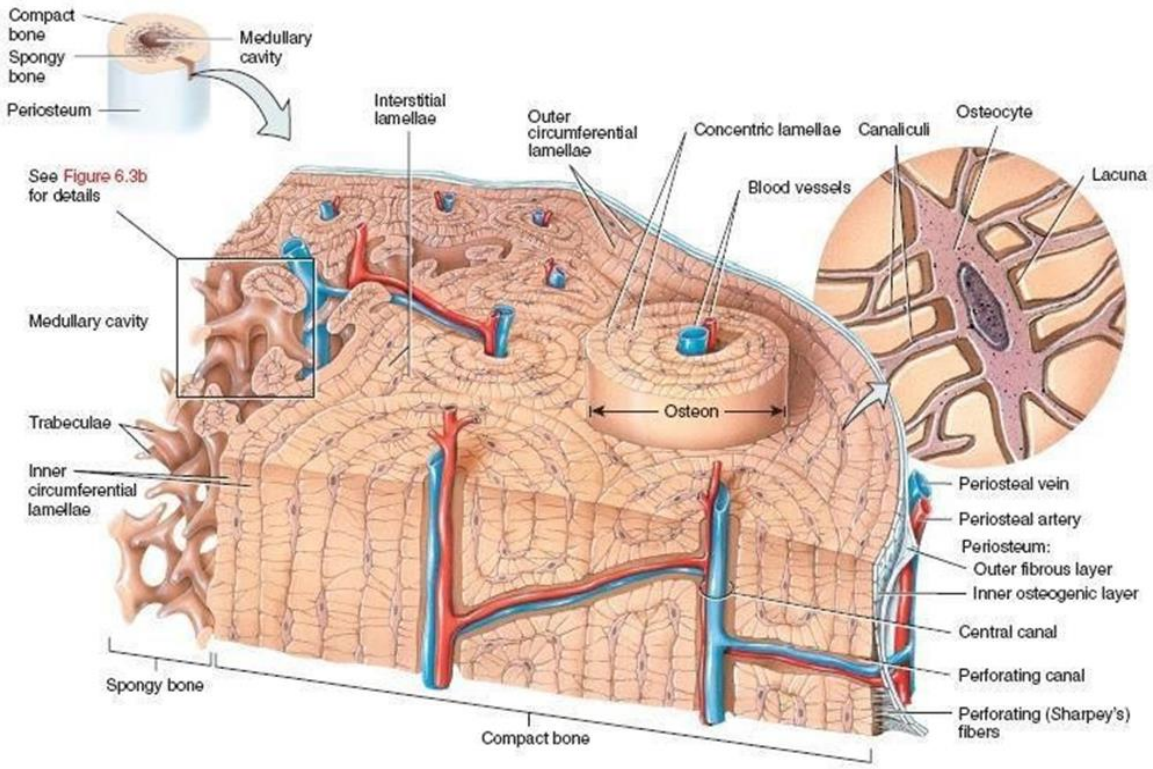
Type of Bone Cell

COMPACT (CORTICAL) BONE TISSUE:

- Compact bone tissue contains few spaces and is the strongest form of bone tissue.
- It is found beneath the periosteum of all bones and makes up the bulk of the diaphyses of long bones.
- Compact bone tissue provides protection and support and resists the stresses produced by weight and movement.
- Blood vessels, lymphatic vessels, and nerves from the periosteum penetrate compact bone through ***transverse perforating or Volkmann's canals*.**
- The vessels and nerves of the perforating canals connect with those of the medullary cavity, periosteum, and **central or haversian canals**. The central canals run longitudinally through the bone.
- Around the central canals are **concentric lamellae** —rings of calcified extracellular matrix much like the rings of a tree trunk.
- Between the lamellae are small spaces called **lacunae**, which contain osteocytes.
- Radiating in all directions from the lacunae are tiny **canaliculi** (small channels) filled with extracellular fluid. Inside the canaliculi are slender fingerlike processes of osteocytes.
- The components of compact bone tissue are arranged into repeating structural units called

osteons or haversian systems.

- Each osteon consists of a central (haversian) canal with its concentrically arranged lamellae, lacunae, osteocytes, and canaliculi.
- The areas between osteons contain **interstitial lamellae**, which also have lacunae with osteocytes and canaliculi. Interstitial lamellae are fragments of older osteons that have been partially destroyed during bone rebuilding or growth.
- Lamellae that encircle the bone just beneath the periosteum or encircle the medullary cavity are called **circumferential lamellae.**



Structure of Compact Bone

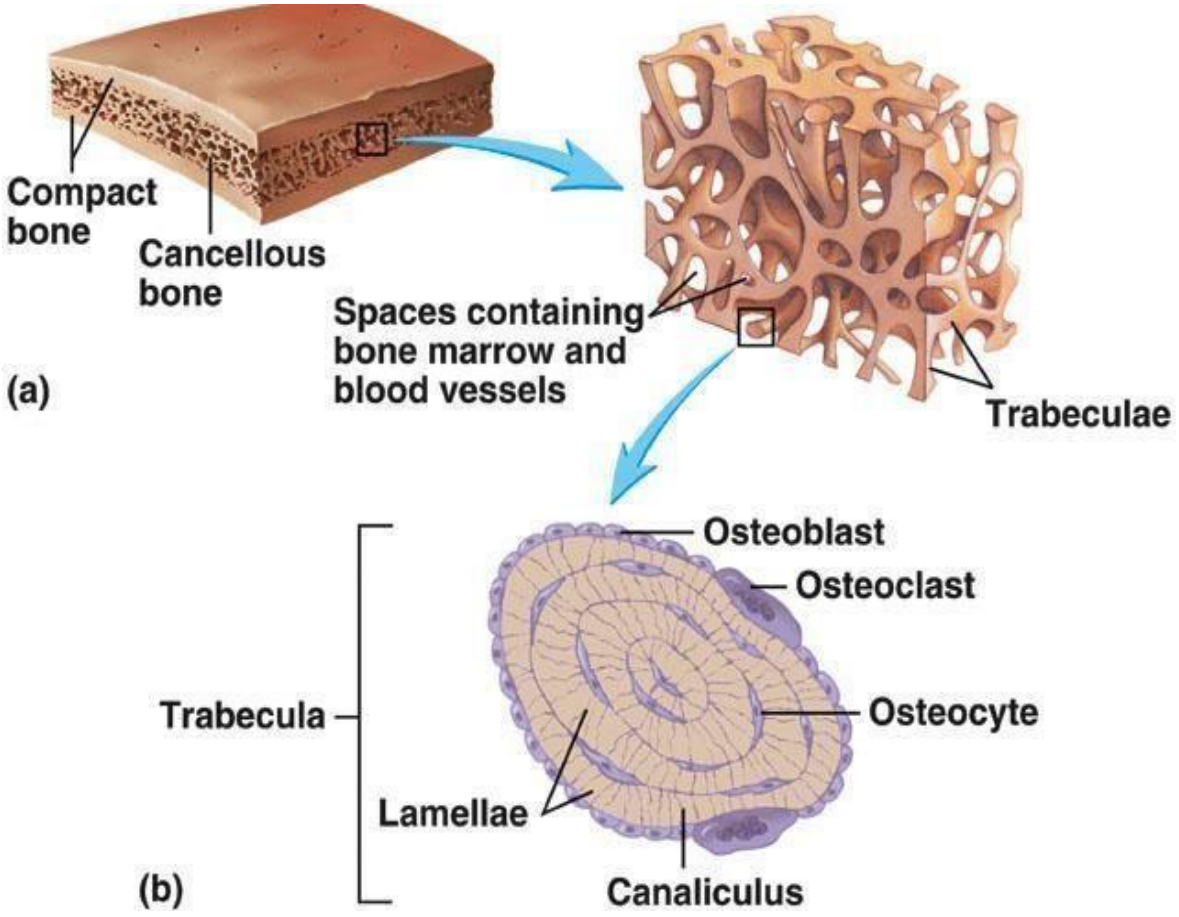
SPONGY BONE TISSUE:

- Spongy bone tissue does not contain osteons.
- Spongy bone consists of lamellae arranged in an irregular lattice of thin columns called trabeculae.
- Within each trabecula are lacunae that contain osteocytes. Canaliculi radiate outward from the lacunae. Osteocytes receive nourishment from the blood circulating through the blood vessels in the spaces between trabeculae.
- Spongy bone tissue makes up most of the interior bone tissue of short, flat, and

irregularly shaped bones, and most of the epiphyses of long bones. Spongy bone tissue also forms a narrow rim around the medullary cavity of the diaphysis of long bones, where it is covered by endosteum. Spongy bone is always covered by a layer of compact bone for protection.

- Spongy bone tissue is different from compact bone tissue in two respects.

- First, spongy bone tissue is light, which reduces the overall weight of a bone so that it moves more readily when pulled by a skeletal muscle.



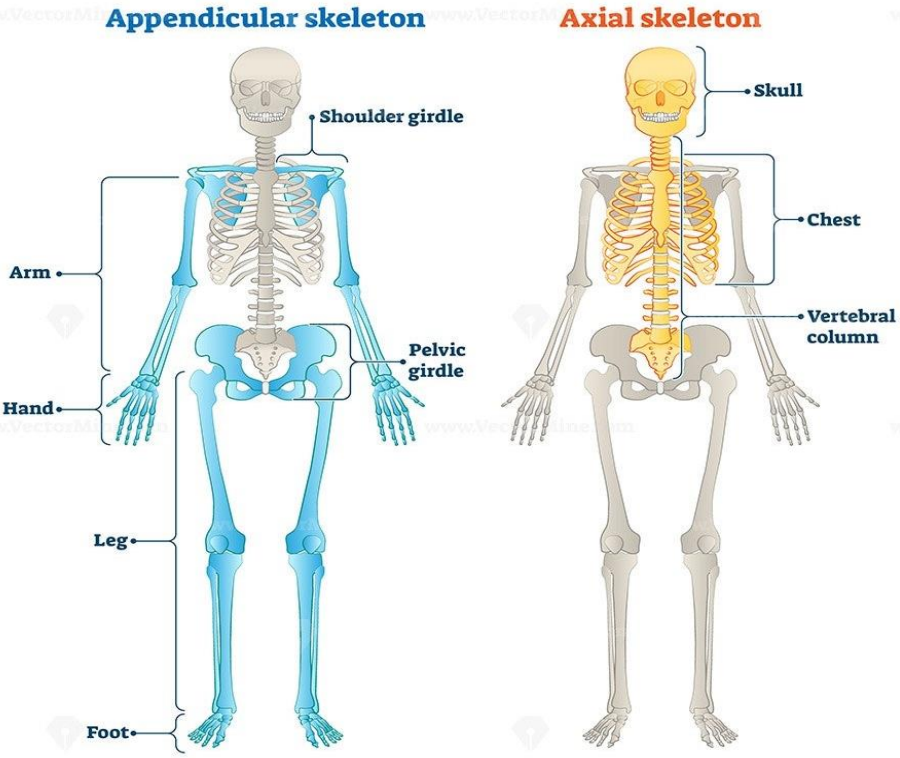
Structure of Bone Tissue

- Second, the trabeculae of spongy bone tissue support and protect the red bone marrow. The spongy bone tissue in the hip bones, ribs, sternum (breastbone), vertebrae (backbones), and the ends of long bones is where red bone marrow is stored and, thus, where hemopoiesis (blood cell production) occurs in adults.

SKELETAL SYSTEM

The skeletal system functions as the basic framework of a body and the entire body are built around the hard framework of Skeleton. It is the combination of all the bones and tissues associated with cartilages and joints. Almost all the rigid or solid parts of the body are the main components of the skeletal system.

It is composed of around 270 bones at birth – these total decreases to around 206 bones by adulthood after some bones get fused together. The bone mass in the skeleton makes up about 14% of the total body weight (ca. 10–11 kg for an average person) and reaches maximum density around age 21. The human skeleton can be divided into the axial skeleton and the appendicular skeleton.



Human Skeleton

In an adult body, it is mainly composed of 206 individual bones which are organized into two main divisions:

- **Axial skeleton**
- **Appendicular skeleton.**

Axial skeleton

The axial skeleton runs along the body's central axis; therefore, it is called the central core of the human body. The axial skeleton is composed of 80 bones and it consists of:

Skull Bone – It includes 8 cranial bones, 14 facial bones, 6 auditory ossicles, and Hyoid Bone

Thoracic Cage – It includes 25 bones of the thorax- a breastbone and 24 ribs.

Vertebral column- It includes 24 vertebrae bones, the sacrum bone, and the coccyx bone.

Appendicular skeleton

The appendicular skeleton is composed of 126 bones and it comprises of the-

1. Pelvic girdle
2. Upper Limbs
3. Lower Limbs
4. Shoulder Girdle or the Pectoral

AXIAL SKELETON SYSTEM

SKULL BONE

The skull is situated on the upper end of vertebral column and its bony structure is divided into two parts

The cranium

The face

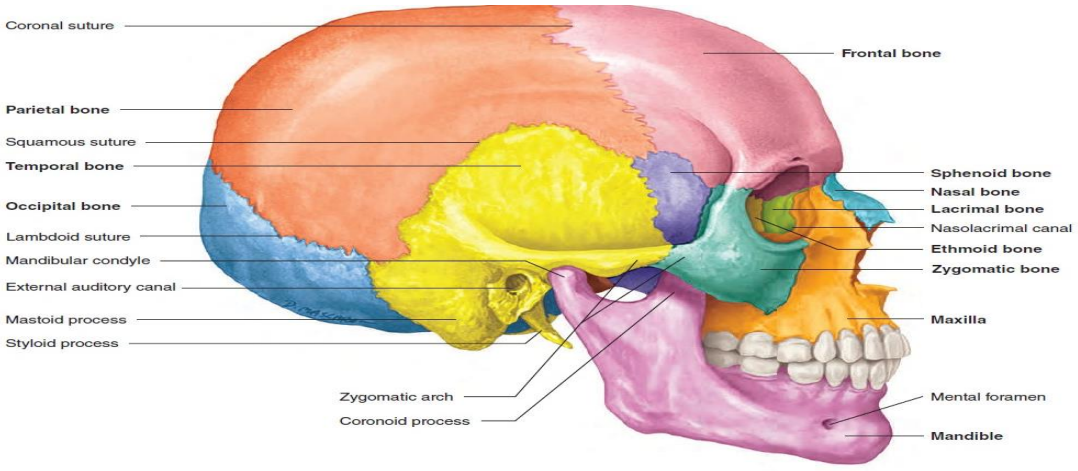
(A) Cranium:

It is formed by flat at and irregular bones that provide a bony protection to the brain.

It has a base upon which the brain rests and a vault that surrounds ana covets

In adults, the sutures between the bones are immovable

The bones have various perforations such as foramina and fissures through which nerves blood and lymph vessels passes



SKULL

The cranium consists of:

1 Frontal bone

2 Parietal bones

2 Temporal bones

1Occipital bone

1 Sphenoid bone

1 Ethmoid bone

Frontal bone:

It is the forehead bone.

It forms part of eye sockets and e prominent ridges above the eyes, the supraorbital margins.

Just above the supraorbital margins within the bone, there are two air filled cavities which have openings into the nasal cavity.

The coronal suture joins the frontal and parietal bones

Parietal bones:

These bones form the sides and roof of the skull.

They articulate with each other at the sagittal suture, with the frontal bone at the coronal suture, with the occipital bone at the lambdoidal suture and with the temporal bones at the squamous sutures.

Temporal bones:

These bones i.e one on each side of the head and form immovable joints with the parietal, occipital, sphenoid and zygomatic bones.

The squamous part articulates with the parietal bone.

The zygomatic process articulates with the zygomatic bone to form the zygomatic arch.

The mastoid part contains the mastoid process, a thickened portion behind the ear.

The temporal bone articulates with the mandible at the temporo-mandibular joint.

Occipital bone:

It forms the back of head and base of skull

It has immovable joints with the parietal, temporal and sphenoid bones.

Sphenoid bone:

It occupies the middle portion of base of skull and it articulates with the occipital temporal, parietal and frontal bones.

Ethmoid bone:

It occupies the anterior part of base of the skull and helps to form the orbital cavity, the nasal septum and the lateral walls of the nasal cavity.

It is a very delicate bone containing many air sinuses that opens into the nasal cavity.

(B) Face:

The face is formed by 13 bones in addition to the frontal bone. This includes;

2 Cheek bones

1 Maxilla

2 Nasal bones

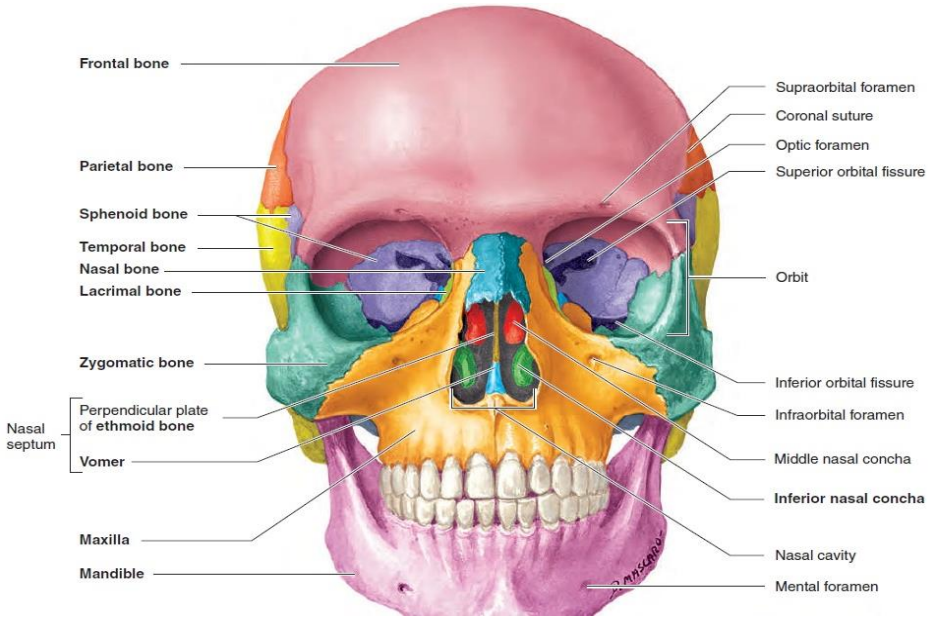
2 Lacrimal bones

1 Vomer

2 Palatine bones

2 Inferior conchae

1 Mandible



FACE

Cheek Bones It forms the prominences of the cheeks, part of the floor and lateral walls of orbital cavities.

Maxilla (Upper jaw bone):

It forms the upper jaw, the anterior part of roof of the mouth, the lateral walls of the nasal cavity and part of the floor of orbital cavities.

The alveolar process projects downwards and carries the upper teeth.

Nasal bones:

These are two small flat bones which form the part of the lateral and superior surfaces of the nose

Lacrimal bones:

These are small bones present posterior and lateral to the nasal bones and form part of the medial walls of the orbital cavities.

Vomer:

It is a thin flat bone which extends upwards from the hard palate to form the nasal septum.

Palatine bones:

These are two L-shaped bones.

The horizontal parts of bones unite to form posterior part of hard palate and to form part of the nasal cavity.

Inferior conchae:

It is a scroll-shaped bone which forms part of nasal cavity.

The superior and middle conchae are parts of the ethmoid bone

Mandible:

It It i is the only movable bone of the skull.

Each halt Consists of two main parts: a curved body with the alveolar ridge containing lower teeth and a ramus projects upwards to the posterior end of the body.

Hyoid Bone

It is a horse-shoe shaped bone lying in the neck just below the mandible.

It does not articulate with any other bone but is attached to the styloid process of the temporal bone.

It gives attachment to the base of the tongue.

Anterior view

Lateral view
(from the left side)

Sinuses:

Sinuses containing air are present in the sphenoid, ethmoid, maxillary and frontal bones. They all communicate with the nasal cavity and are lined with ciliated mucous membrane. Its functions are to tone the voice and to lighten the bones of the face and cranium.

Vertebral Column (Spinal Column)

It is composed of a series of bones called as vertebrae. The vertebral column, the sternum, and the ribs form the skeleton of the trunk of the body. The vertebral column consists of spinal cord. It supports the head, and serves as a point of attachment for the ribs, pelvic girdle, and muscles of the back and upper limbs. The adult vertebral column consists present of 26 vertebrae;

7 cervical vertebrae: These are in the neck region.

12 thoracic vertebrae: These are posterior to the thoracic cavity.

5 lumbar vertebrae: It supports the lower back.

1 sacrum: It consists of five bones fused with sacral vertebrae.

1 coccyx: It consists of four fused coccygeal vertebrae.

The cervical, thoracic, and lumbar vertebrae are movable, but the sacrum and coccyx are not movable.

Functions of Vertebral Column:

It provides a strong bony protection for the spinal cord.

The pedicles of adjacent vertebrae form intervertebral foramina providing access to the spinal cord for spinal nerves, blood vessels and lymph vessels.

It supports the skull.

The intervertebral discs act as shock absorbers, protecting the brain.

It forms the axis of the trunk, giving attachment to the ribs, shoulder girdle and upper limbs, and the pelvic girdle and lower limbs.

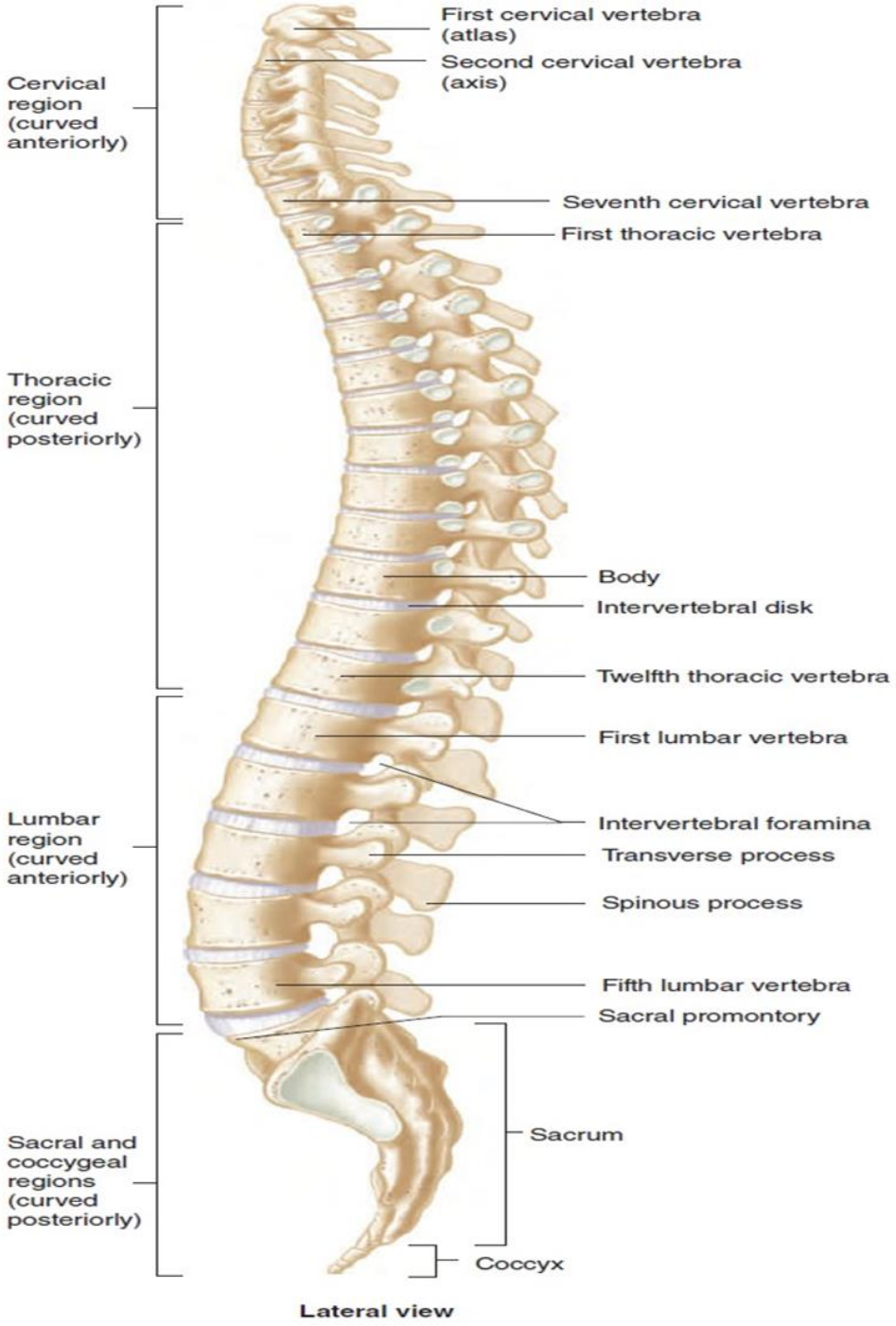
Parts of a Typical Vertebra:

A typical vertebra consists of a body, a vertebral arch and several processes.

Body: The body is a thick, disc-shaped structure. It is positioned anteriorly and is the weight bearing part of a vertebra. Its superior and inferior surfaces are roughened for the attachment of intervertebral discs. The anterior and lateral surfaces contain foramina, openings through which blood vessels deliver nutrients, oxygen and remove carbon dioxide and wastes from the bone tissue.

Vertebral Arch:

Two short, thick processes, the pedicles, project posteriorly from the vertebral body to form the vertebral arch. The vertebral arch extends posteriorly from the body of the vertebra, Together the body of vertebra and the vertebral arch surround the spinal cord by forming the vertebral foramen.



Vertebral column

Vertebral Foramen:

The vertebral foramen contains the spinal cord, adipose areolar connective and blood vessels.

Pedicles:

The pedicles exhibit superior and inferior indentations called vertebral notches. When the vertebral notches are stacked on top of one another, they form an opening between adjoining vertebrae on both sides of the column.

Processes:

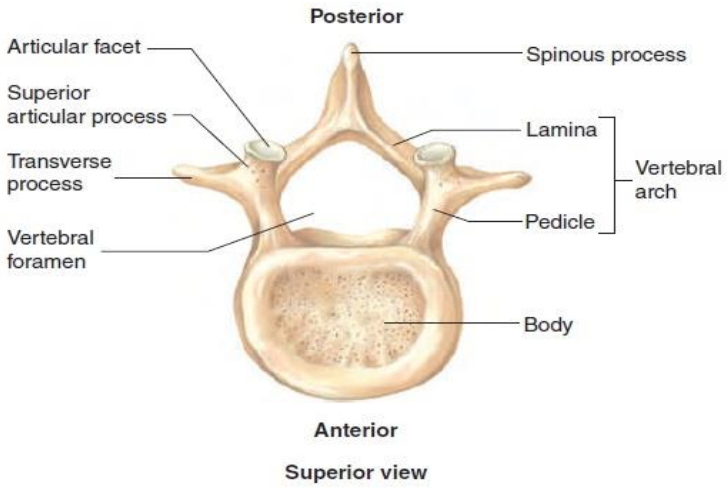
Seven processes arise from the vertebral arch are as follows:

Transverse process: At the point where a lamina and pedicle join, a transverse process extends laterally on each side.

Spinous process: A Single spinous process projects posteriorly from the junction of the laminae. These three processes serve as points of attachment for muscles.

Superior articular processes: The two superior articular processes of a vertebra articulate with the two inferior articular processes of the vertebra immediately above them.

Inferior articular processes: The two inferior articular processes of vertebra articulate with the two superior articular processes of the vertebra immediately below them. The articulating surfaces of the articular processes are called as facets.

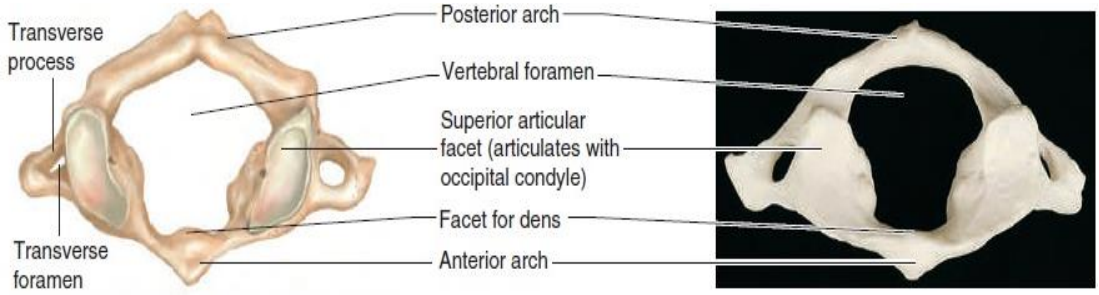


Typical thoracic vertebrae

ATLAS VERTEBRAE

It is the first cervical vertebrae. It is a ring of bone with anterior and posterior arches and large lateral masses.lacks a body and a spinous process. The superior surfaces of the lateral masses called as superior articular facets. They articulate with the occipital condyles of the Occipital

bone to form the paired atlanto-occipital joints The inferior surfaces of the lateral masses called as the inferior articular facets. The transverse processes and transverse foramina of the atlas vertebrae are relativelylarge.



Atlas vertebrae

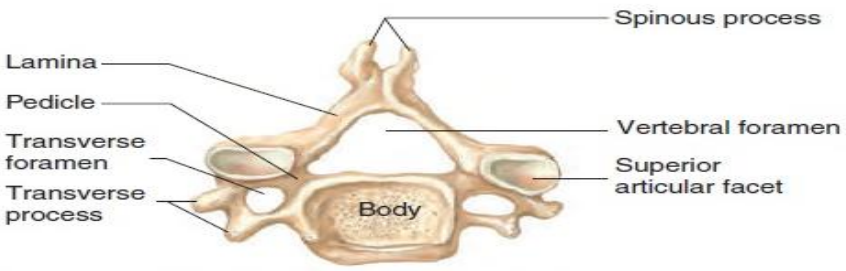
AXIS VERTEBRAE

It is the second cervical vertebra. It consists of body and odontoid process (dens) that projects superiorly. The articulation formed between the anterior arch of the atlas and dens of the axis, and between their articular facets is called as atlanto-axial joint.

Axis vertebrae

CERVICAL VERTEBRAE

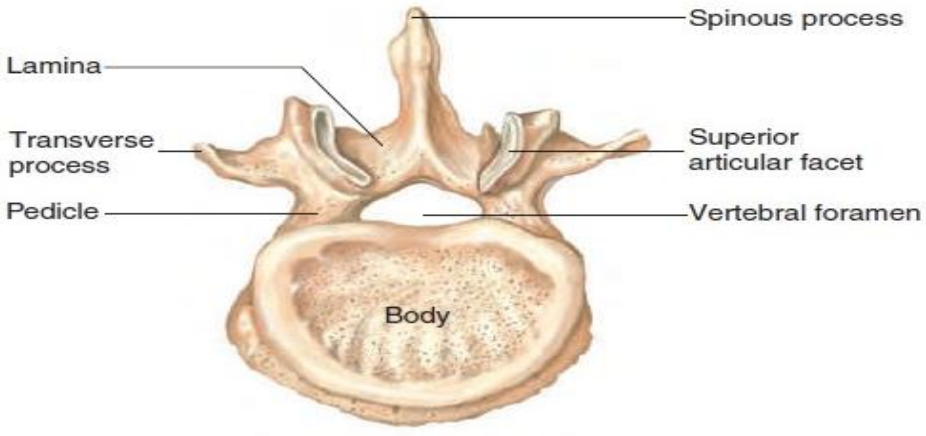
The body of the cervical vertebrae is smaller and the vertebral arches are larger. The cervical vertebrae have three foramina: one vertebral foramen and two transverse foramina. The vertebral foramen is the largest in the spinal column .Each cervical transverse process contains a transverse foramen through which the vertebral artery, vertebral vein and nerve fibers pass. The spinous processes are split into two parts.



Cervical vertebrae

LUMBAR VERTEBRAE

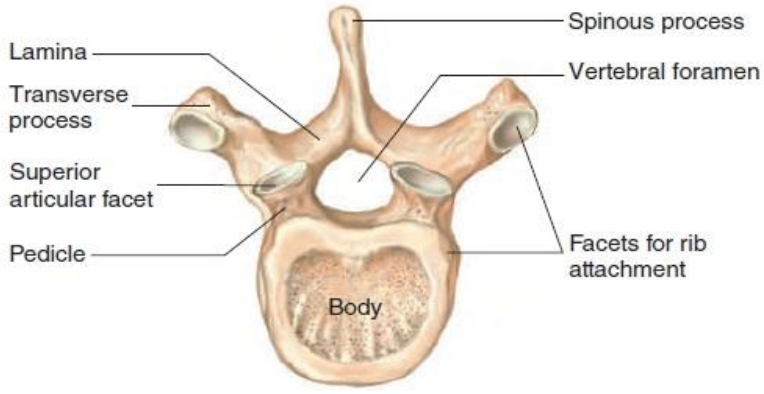
The lumbar vertebra is the largest and strongest vertebrae of the vertebral column. The projections are short and thick. The superior articular processes are directed medially instead of superiorly and the inferior articular processes are directed laterally instead of inferiorly. The spinous processes are quadrilateral in shape, thick, broad and project straight.



Lumbar vertebrae

THORACIC VERTEBRAE

These are larger and stronger than cervical vertebrae. The spinous processes are long and flattened. Thoracic vertebrae have longer and larger transverse processes. The bodies of thoracic vertebrae have facets for articulation with the heads of the ribs.



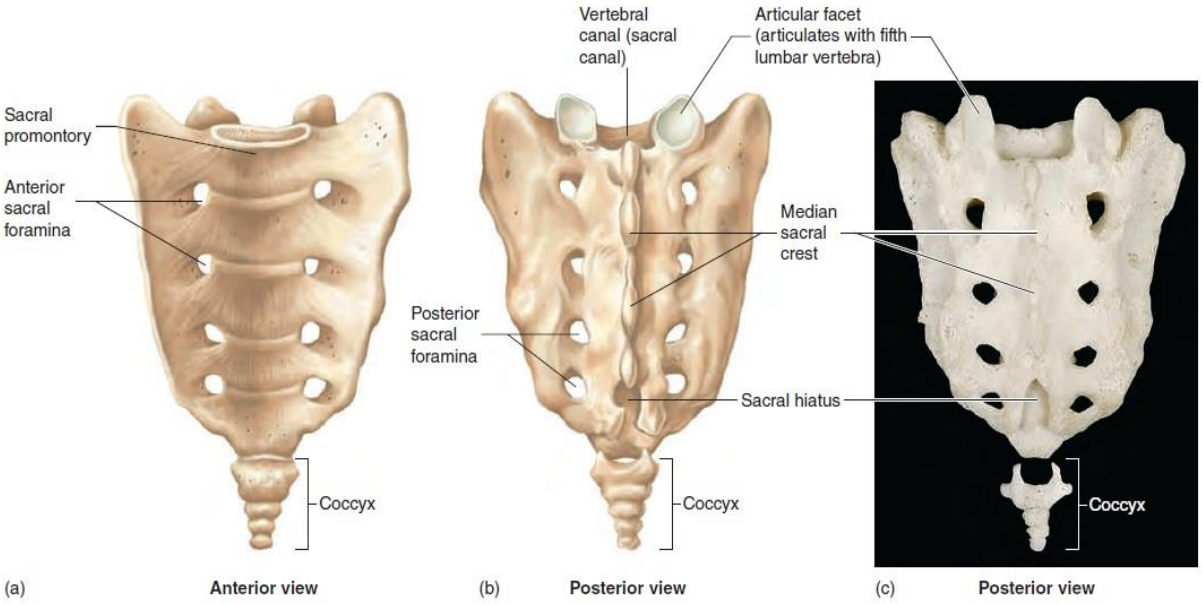
Thoracic vertebrae

SACRUM

It consists of five vertebrae fused to form a triangular bone. The upper part of sacrum articulates with the 5th lumbar vertebra. On each side it articulates with the ilium to form a sacroiliac joint, and at its inferior tip it articulates with the coccyx.

COCCYX

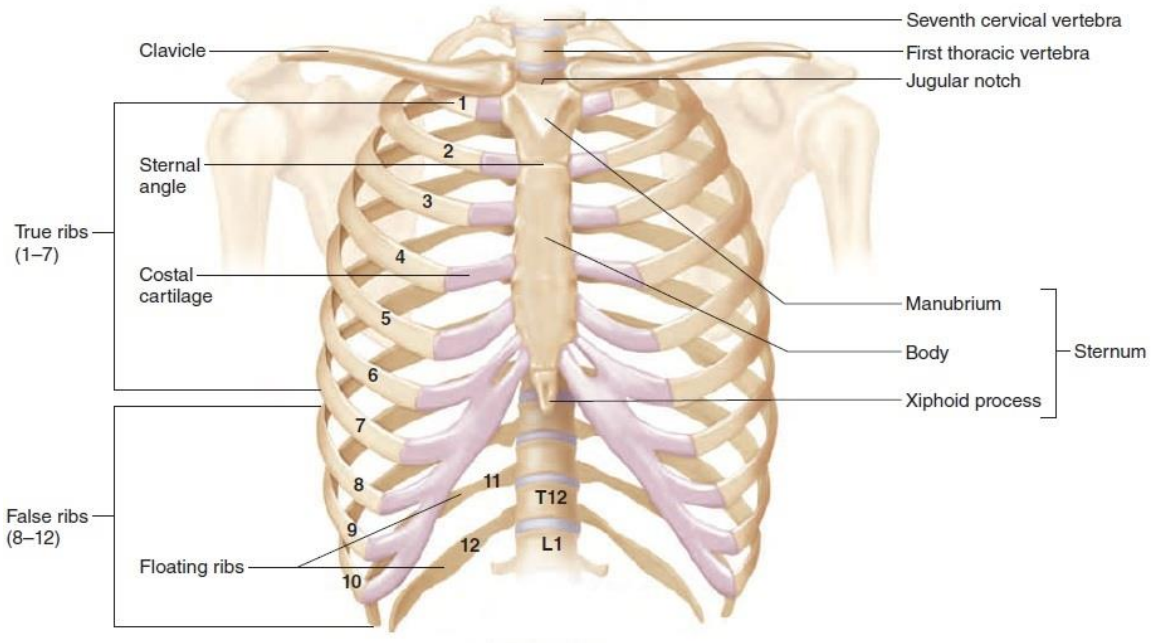
It consists of four terminal vertebrae fused to form a small triangular bone, the broad base of which articulates with the tip of the sacrum.



Sacrum and Coccyx

THORACIC CAGE

The bones of thoracic cage are divided into: 1 Sternum, 12 Pairs of ribs and12 Thoracic vertebrae



Thoracic cage

Sternum (Breast Bone):

It is a flat bone present under the skin in the middle of the front of the chest. It consists of three parts.

Manubrium: It is the uppermost section and articulates with the clavicles and with the first two pairs of ribs.

Body: It is the middle portion which gives attachment to the ribs

Xiphoid process: It is the tip of the bone. It gives attachment to the diaphragm and muscles of the anterior abdominal wall.

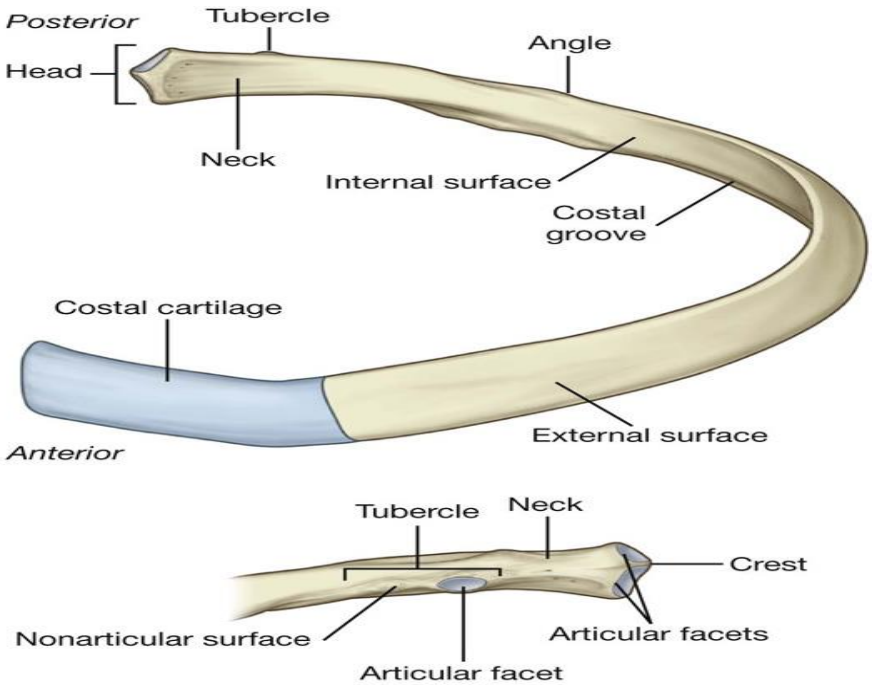
Rilbs

There are 12 pairs of ribs which form the lateral walls of thoracic cage and which articulate with the thoracic vertebrae. Each rib articulates posteriorly with its respective thoracic vertebra.

***True ribs*:** The seven pairs of ribs having costal cartilages and which attached directly to the sternum is called true ribs. The articulations formed between the true ribs and the sternum is called sternocostal joints.

False ribs: The remaining five pairs of ribs are called as false ribs because their costal cartilages either attach indirectly to the sternum or do not attach to the sternum at all.

The eleventh and twelfth pairs of ribs are false ribs also called as floating ribs because the costal cartilage at their anterior ends does not attach to the sternum at all.



RIBS

APPENDICULAR SKELETON SYSTEM

The appendicular skeleton consists of the pectoral girdle with the upper limbs and the pelvic girdle with the lower limbs.

Pectoral (Shoulder Girdle)

The human body has two pectoral girdles that attach the bones of the upper limbs to the axial skeleton.

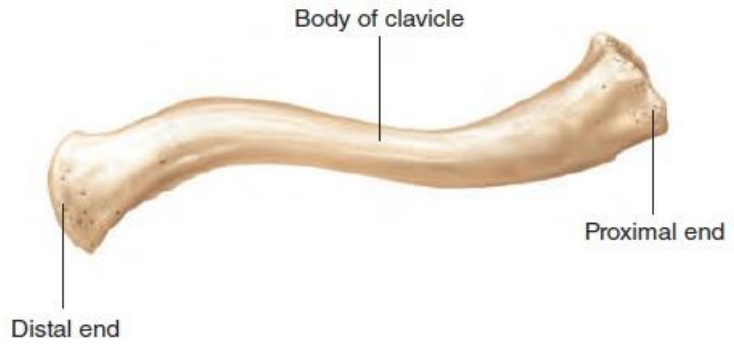
The pectoral girdles consist of

1 Clavicle

1 Scapula

Clavicle (Collar Bone):

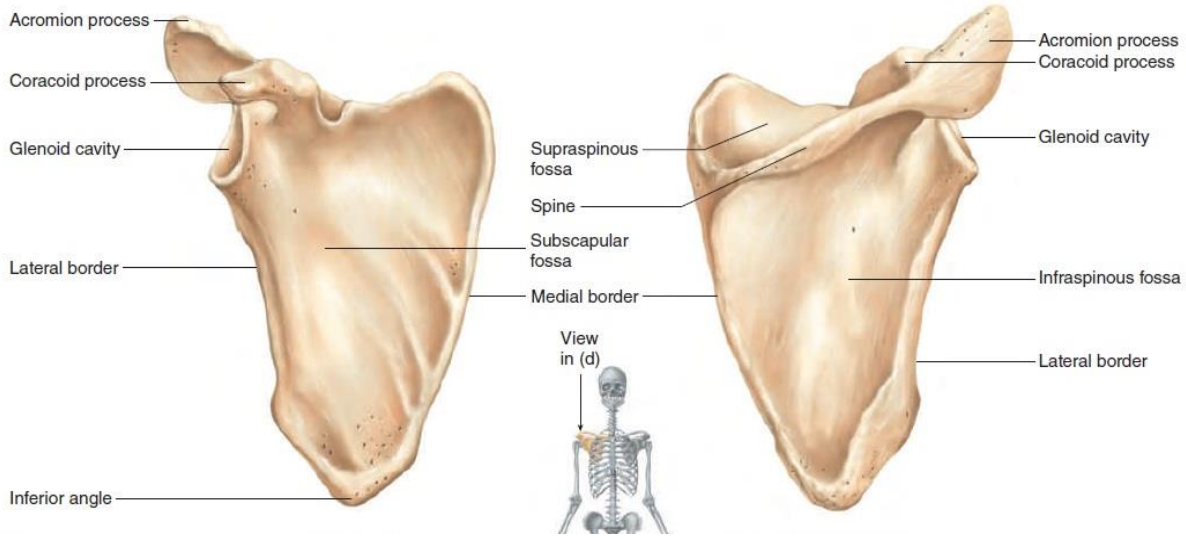
It is 'S' shaped long bone which has a double curvevIt articulates with the manubrium of the sternum at the sternoclavicular joint and forms the acromioclavicular joint with the acromion process of the scapula. The medial end (sternal end) is rounded and articulates with the manubrium of the sternum to form the sternoclavicular joint. The broad, flat, lateral end the acromial end, articulates with the acromion of the scapula to form the acromioclavicular joint. The clavicle provides the bony link between the upper limb and the axial skeleton.



Clavicle Bone

Scapula:

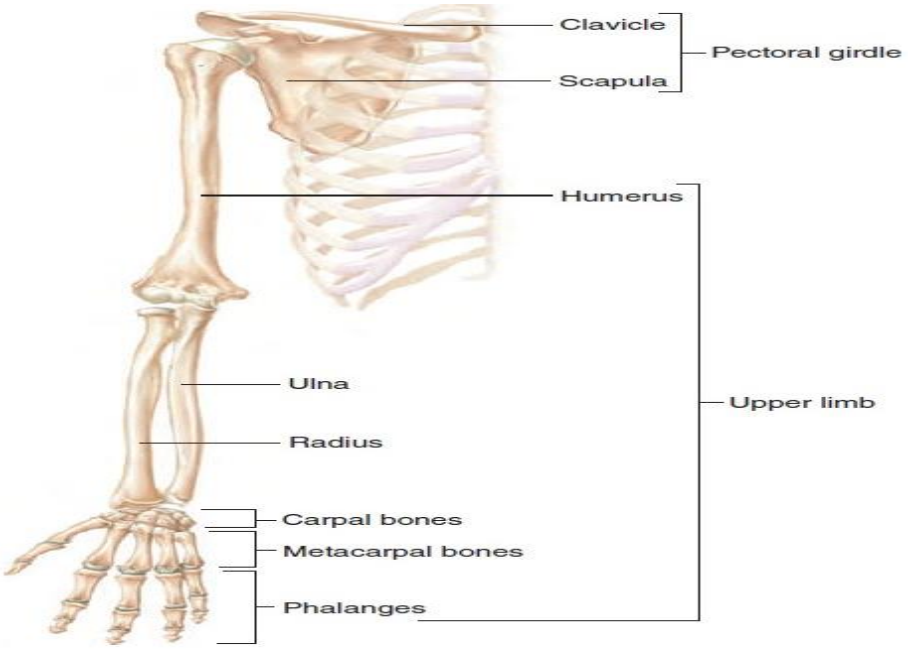
It is a large, flat, triangular shaped bone, lying on the posterior chest wall superficial to the ribs. At the lateral angle there is a shallow articular surface called as glenoid cavity in which the head of the humerus fits and forms the shoulder joint. On the posterior surface there is a spinous process called as acromion process. Acromion process articulates with the clavicle at the acromioclavicular joint. The coracoid process, a projection from the upper border of the bone, gives attachment to muscles that move the shoulder joint.



Scapula

Upper Limbs (Upper Extremity)

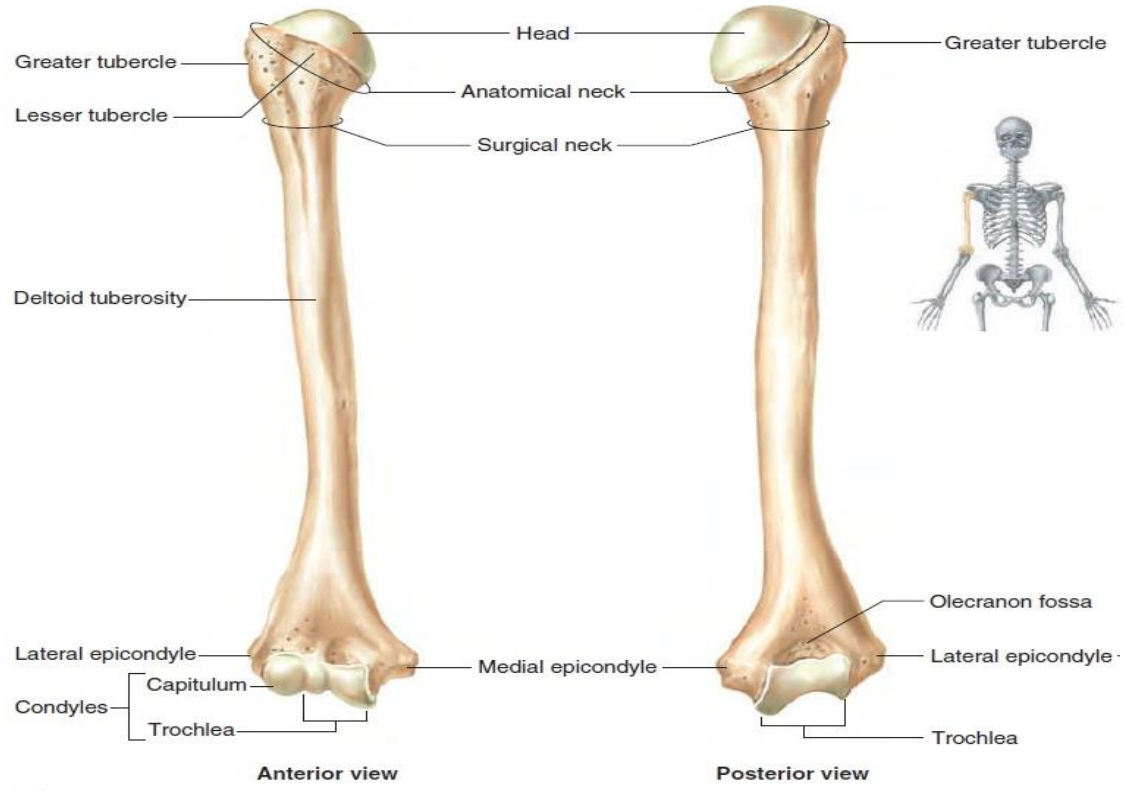
Each upper limb has 30 bones in three locations. It consists of: 1 Humerus in the arm,1 Ulna and 1 Radius in the forearm, 8 Carpals in the carpus (wrist), 5 Metacarpals in the metacarpus (palm) and 14 Phalanges (bones of the digits) in the hand.



Humerus:

It is the longest and largest bone of the upper limb. It articulates proximally with the scapula and distally to the elbow with two bones the ulna and the radius. The proximal end of the humerus has rounded head that articulates with the glenoid cavity of the scapula. Neck is present distal to

the head of humerus. The greater tubercle is a lateral projection present distal to the neck. The lesser tubercle projects anteriorly. Between the two tubercles there is a groove called as intertubercular sulcus. The shaft of the humerus is roughly cylindrical at its proximal end, but it becomes flattened and broad at its distal end. At the middle of the shaft, there is a me roughened V-shaped area called as deltoid tuberosity. The capitulum is a rounded knob that articulates with the head of the radius. The trochlea located medial to the capitulum articulates with the ulna. The coronoid fossa is an anterior depression that receives the coronoid process of the ulna. The olecranon fossa is a large posterior depression that receives the olecranon of the ulna. The medial epicondyle and lateral epicondyle are rough projections present on either side of distal end of the humerus.



Humerus

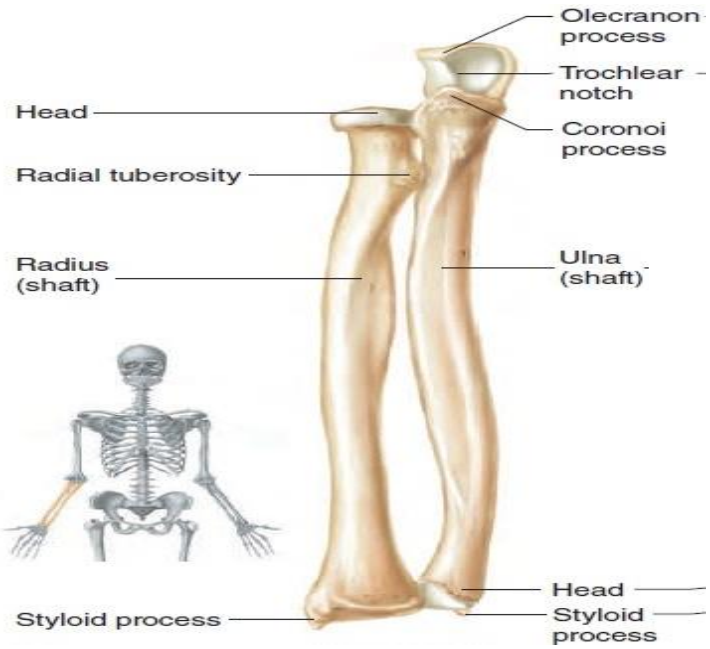
Ulna:

Ulna and radius are the two bones of the forearm. The ulna is relatively longer than the radius. At the proximal end of the ulna olecranon process is present. Along with the olecranon process, an anterior projection called as the coronoid process is present that articulates with the trochlea of the humerus. The trochlear notch is a large curved area between the olecranon and coronoid process. The radial notch is a depression that articulates with the head of the radius. Inferior to

the coronoid process, there is the ulnar tuberosity to which the biceps muscle attached. The distal end of the ulna consists of a head. At the distal end of ulna styloid process is present.

Radius:

The radius is the smaller bone of the forearm and is located on the lateral side of the forearm. The radius is narrow at its proximal end and widens at its distal end. The proximal end of the radius has a disc-shaped head that articulates with the capitulum of the humerus and the radial notch of the ulna. Inferior to the head, the neck is present. A rough area of the neck is called as radial tuberosity. The shaft of the radius widens to the distal end to form a styloid process. The ulna and radius articulate with the humerus at the elbow joint. The ulna and radius connect with one another at three sites. A broad and fibrous connective tissue called as interosseous membrane joins the shafts of radius and ulna. This membrane provides a site of attachment for tendons of skeletal muscles of the forearm. The ulna and radius articulate directly at their proximal and distal ends. Proximally the head of the radius articulates with the ulna radial notch called as proximal radioulnar joint. Distally, the head of the ulna articulates with the ulnar notch of the radius and is called as distal radioulnar joint The distal end of the radius articulates with three bones of the wrist (the lunate, the scaphoid, and the triquetrum) to form the radiocarpal joint.



Ulna and radius

The Carpels (Wrist):

It is the proximal region of the hand. It consists of eight small bones arranged in two transverse rows consisting of four bones each. It consists of

Proximal row: Scaphoid, lunate, triquetrum, pisiform.

Distal row: Trapezium, trapezoid, capitate, hamate.

The bones of the proximal row are associated with the wrist joint

The bones of the distal row form joints with the metacarpal bones.

The Metacarpus (Palm):

It is the intermediate region of the hand. It consists of five bones called metacarpals.

It consists of

Proximal base

Intermediate shaft

Distal head

The metacarpal bones are numbered as 1-5, starting with the thumb. The bases articulate with the distal row of carpal bones to form the carpometacarpal joints. The heads articulate with the proximal phalanges to form the metacarpophalangeal joints.

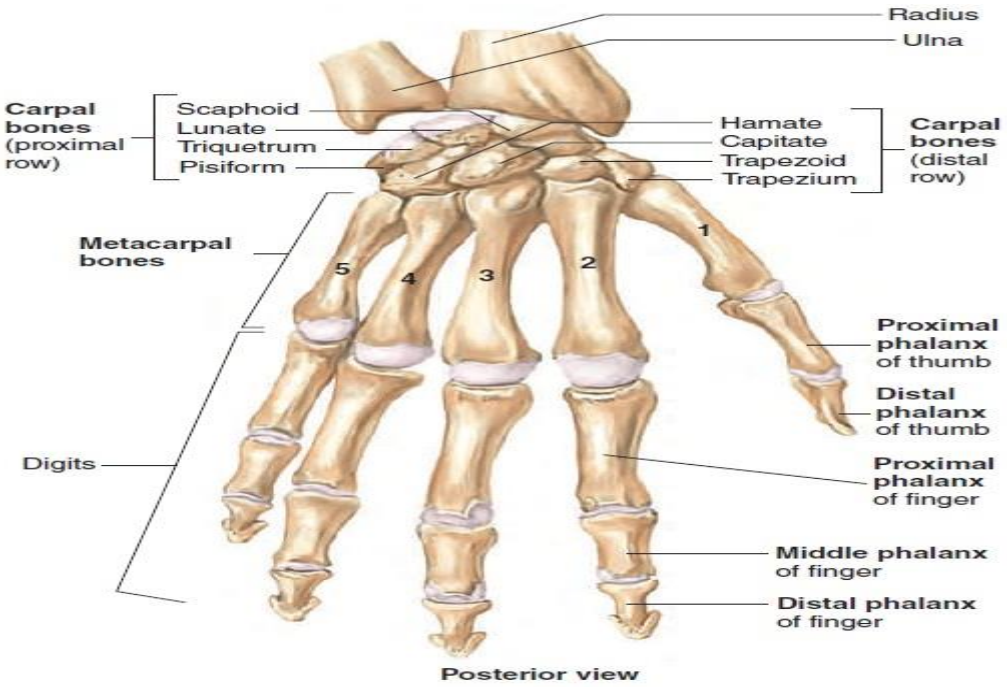
Phalanges (Finger Bones):

It makes up the distal part of the hand. There are 14 phalanges in the five digits of each hand.

A single bone of a digit is called as a phalanx.

Each phalanx consists of:

Proximal base, Intermediate shaft and Distal head



Bones of wrist hand and fingers

The thumb has two phalanges and other four digits have three phalanges In order from the thumb other four digits are called as index finger, middle finger, RING finger, and little finger. The first row of phalanges (proximal row) articulates with the metacarpal bone and second row of phalanges. The second row of phalanges (middle row) articulates with the proximal row and the third row called as distal row. Joints between phalanges are called interphalangeal joints.

Pelvic (Hip) Girdle

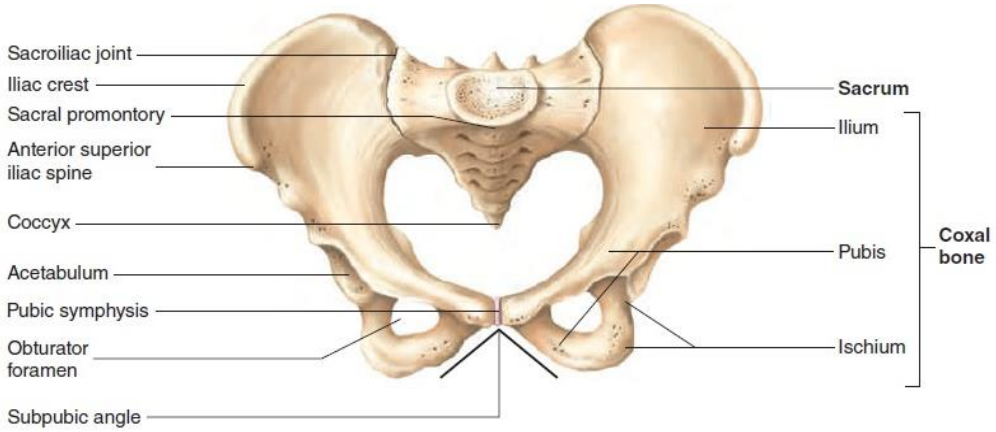
It consists of two hip bones called as pelvic bones. The hip bones unite together to form the pubic symphysis The hip bones unite together posteriorly with the sacrum at the sacroiliac joints. The complete ring composed of the hip bones, pubic symphysis and sacrum forms deep, basin like structure called as the bony pelvis. The bony pelvis provides a strong support for the vertebral column pelvic and lower abdominal organs.

A hip bone consists of three bones:

Ilium

Pubis

Ischium



Pelvic girdle

Ilium:

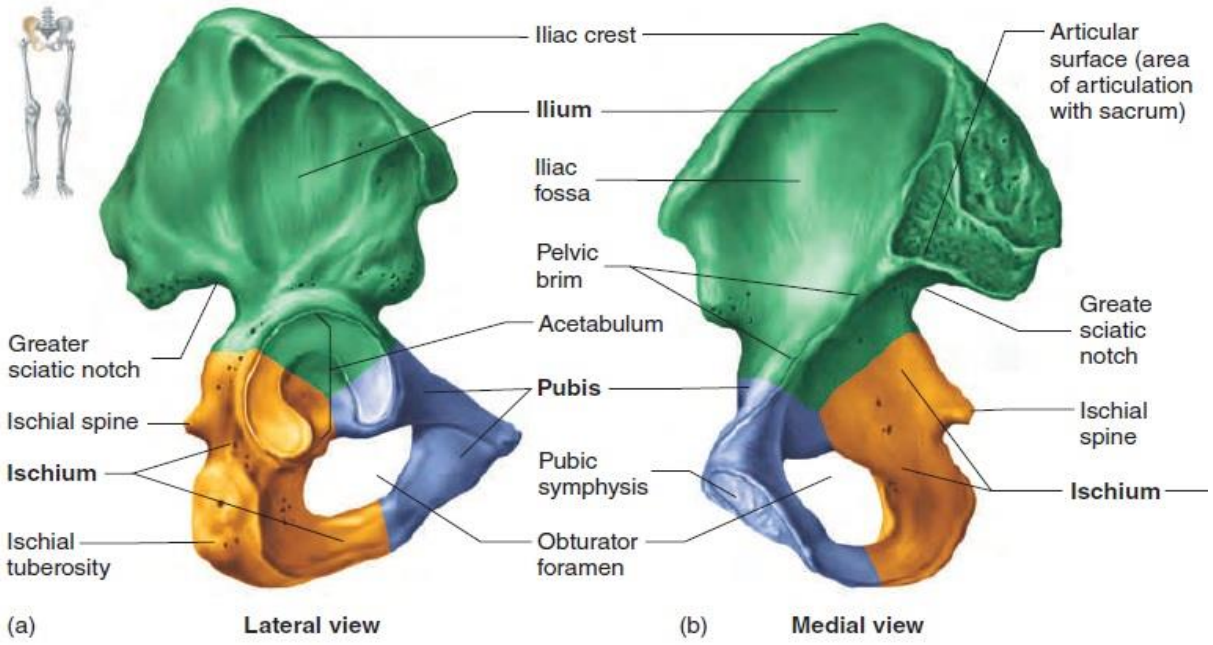
It is the largest hip bone. It is composed of a superior wing and an inferior body. The body helps to form the acetabulum, the socket for the head of femur. The superior border of ilium is called as the iliac crest. Below anterior superior iliac spine there is the anterior inferior iliac spine. The iliac crest ends in a posterior superior iliac spine and below this spine posterior inferior iliac spine is present. The spines serve as points of attachment for the muscles of the trunk, hip, and thighs.

Ischium:

It is the posterior portion of the hip bone. It is composed of a superior body and an inferior ramus. The ramus is the portion of ischium that fuses with the pubis. It includes the ischial spine and a rough and thickened ischial tuberosity. Together the ramus and the pubis surround the obturator foramen, the largest foramen in the skeleton

Pubis:

It is the interior part of hip bone. The anterior border of body is called as pubic crest, and at its lateral end is called as pubic tubercle. The acetabulum is a deep fossa formed by the ilium, ischium and pubis. It functions as the socket that accepts the rounded head of the femur.



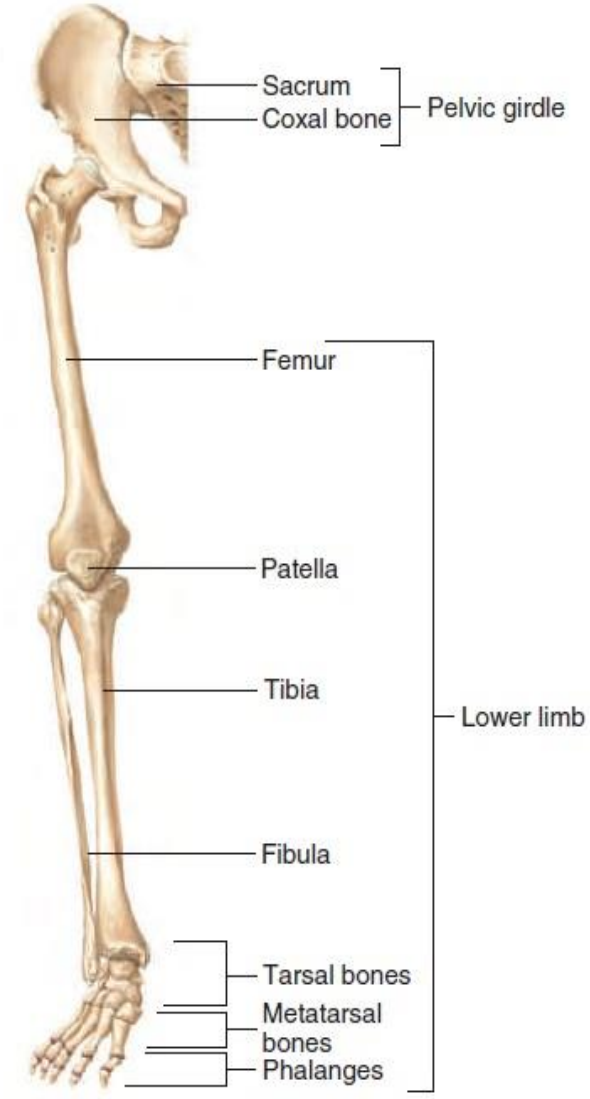
Innominate bone

LOWER LIMB (LOWER EXTREMITY)

Each lower limb consists of 30 bones in four locations.

They consist of:

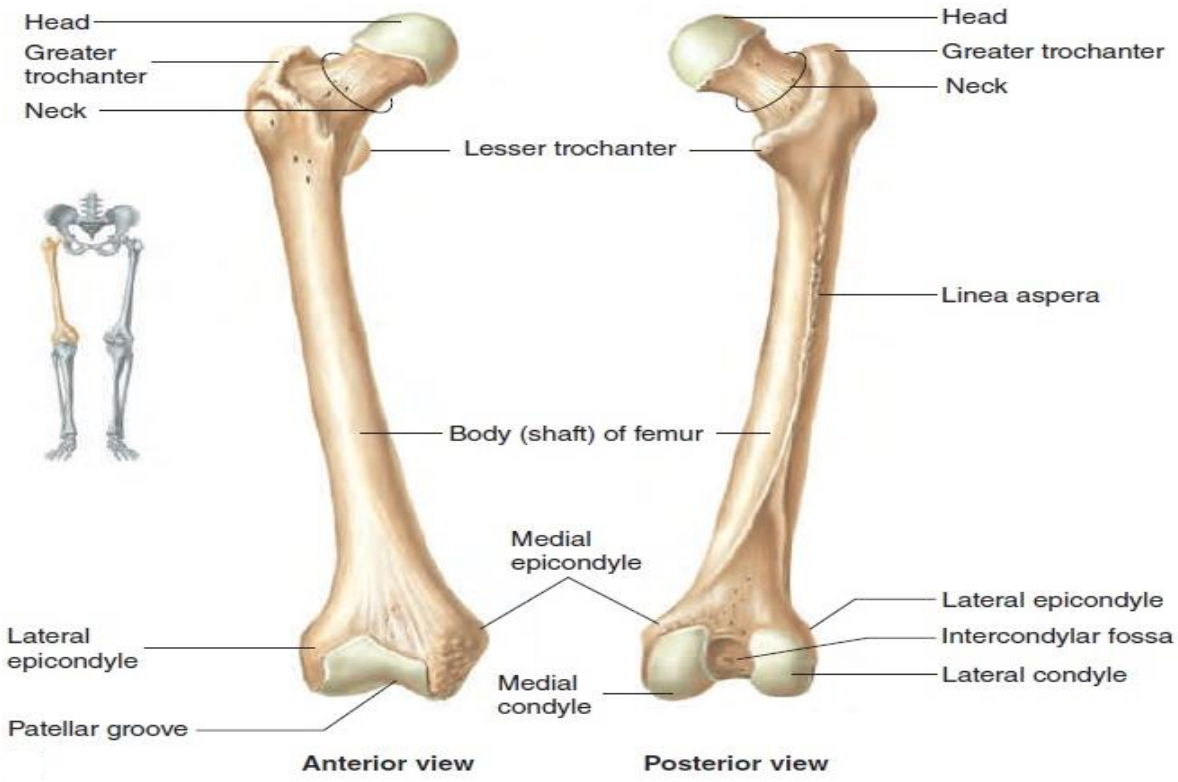
- Femur in the thigh
- Patella (knee cap)
- Tibia and fibula in the leg
- 7 tarsals in the tarsus (ankle)
- 5 metatarsals in the metatarsus
- 14 phalanges (bones of the digits) in the foot



Pelvic griddle and lower limb

Femur (Thigh Bone):

It is the longest, heaviest and strongest bone of the body. Its proximal end articulates with the acetabulum of the hip bone. Its distal end articulates with the tibia and patella. The proximal end consists of a rounded head that articulates with the acetabulum of the hip bone to form the hip joint. The neck is a constricted portion present distal to the head. The greater and lesser trochanters are projections from the junction of the neck and shaft. The distal end of the femur consists of medial condyle and lateral condyle. These articulate with the medial and lateral condyles of the tibia. A depressed area between the condyles on the posterior surface is called the intercondylar fossa.



Femur

Patella (Knee Cap):

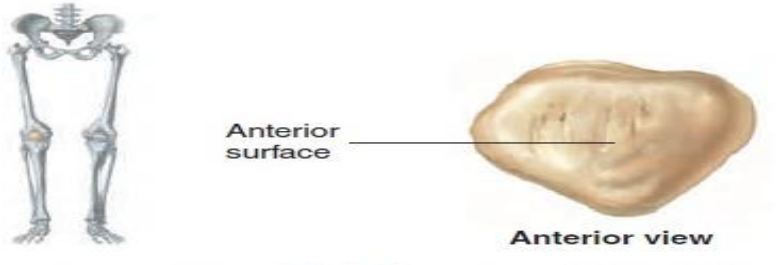
It is a small, triangular bone located anterior to the knee joint.

It consists of two parts:

Base: It is broad proximal end of patella.

Apex: It is pointed distal end.

The posterior surface contains two articular facets, one for medial condyle of the femur and another for lateral condyle of the femur.



Patella

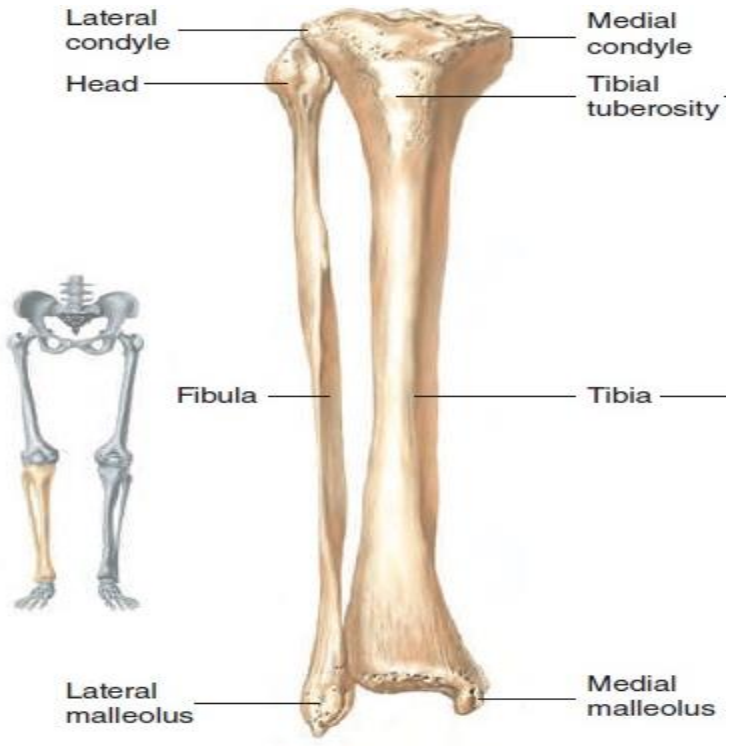
Tibia (Shin Bone):

Tibia or shin bone is the larger and weight bearing bone of the leg. It articulates at its proximal end with the femur and fibula, and at its distal end with the fibula and the talus bone of the ankle.

The proximal end of tibia is expanded into lateral condyle and medial condyle. These articulate with the condyles of the femur. The interior surface of the lateral condyle articulates with the head of the fibula. The tibia at its anterior surface consists of tibial tuberosity. The distal end of tibia forms the medial malleolus. Medial malleolus articulates with the talus of the ankle. The fibular notch articulates with the distal end of the fibula to form the distal tibiofibular Joint.

Fibula:

The fibula is parallel and lateral to the tibia, but it is smaller. The proximal head of the fibula articulates with the lateral condyle of the tibia to form the proximal tibiofibular joint. The distal end is arrowhead shaped and consists of a projection called as lateral malleolus that articulates with the talus of the ankle. The tibia and fibula are connected by an interosseous membrane. The fibula articulates with the tibia at the fibular notch to form the distal tibiofibular joint.



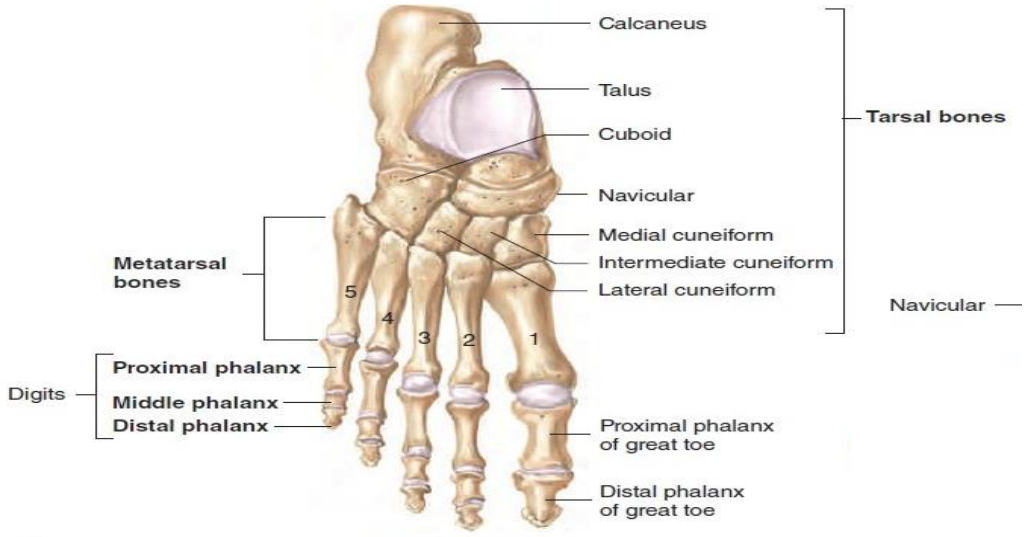
Tibia and fibula

Tarsals, Metatarsals and Phalanges

Tarsals (Ankle):

It is the proximal region of the foot. It consists of seven tarsal bones. They consist of talus and calcaneus located in the posterior part of the foot. The calcaneus is the largest and strongest tarsal bone. The anterior tarsal bones are the navicular three cuneiform bones called the third

(lateral), Second (intermediate), and first (medial) cuneiforms, and the cuboid. Joints between tarsal bones are called as intertarsal joints. The talus is the most superior tarsal bone.



Bones of foot

Metatarsus:

The intermediate region of the foot, consists of five metatarsal bones numbered 1-5 from the medial to lateral position. Each metatarsal consists of:

Proximal base

Intermediate shaft

Distal head

The metatarsals articulate proximally with the first, second, and third cuneiform bones and with the cuboid to form the tarsometatarsal joints. Distally they articulate the proximal row of phalanges to form the metatarsophalangeal joints.

Phalanges:

It is the distal component of the foot.

The phalanges are numbered from 1-5 beginning with the great toe, from medial to lateral.

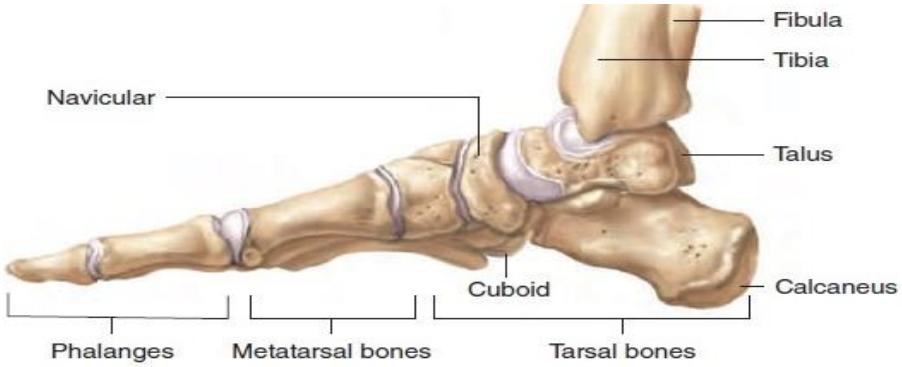
Each phalanx consists of:

Proximal base

Intermediate shaft

Distal head

The toe (hallux) has two large phalanges called proximal and distal phalanges. The other four toes consist of three phalanges proximal, middle and distal Joints between phalanges of the foot are called interphalangeal joints.

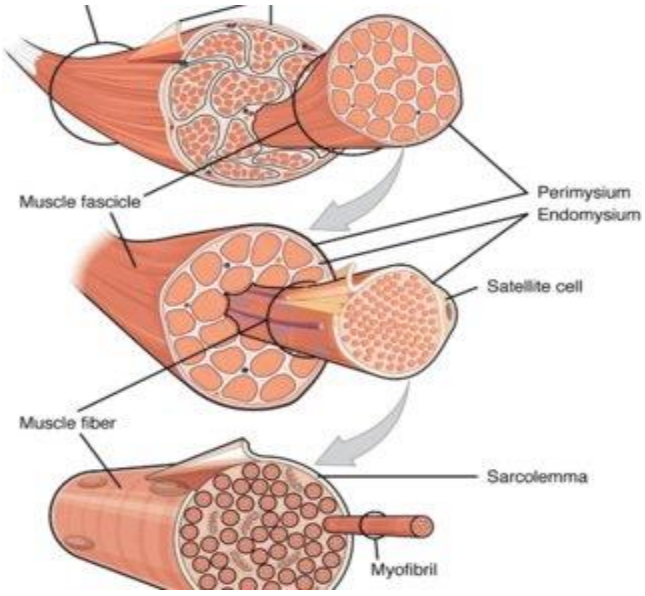


Bones of foot

ORGANIZATION OF SKELETAL MUSCLE

Skeletal Muscle Tissue

Skeletal muscles are made up of hundreds to thousands of cells which are called as muscle fibres. The muscle fibres are of elongated shapes. The outermost layer encircling the entire muscle called as epimysium. Perimysium surrounds a group of 10 to 100 or more muscle fibres separating them into bundles called as fascicles.



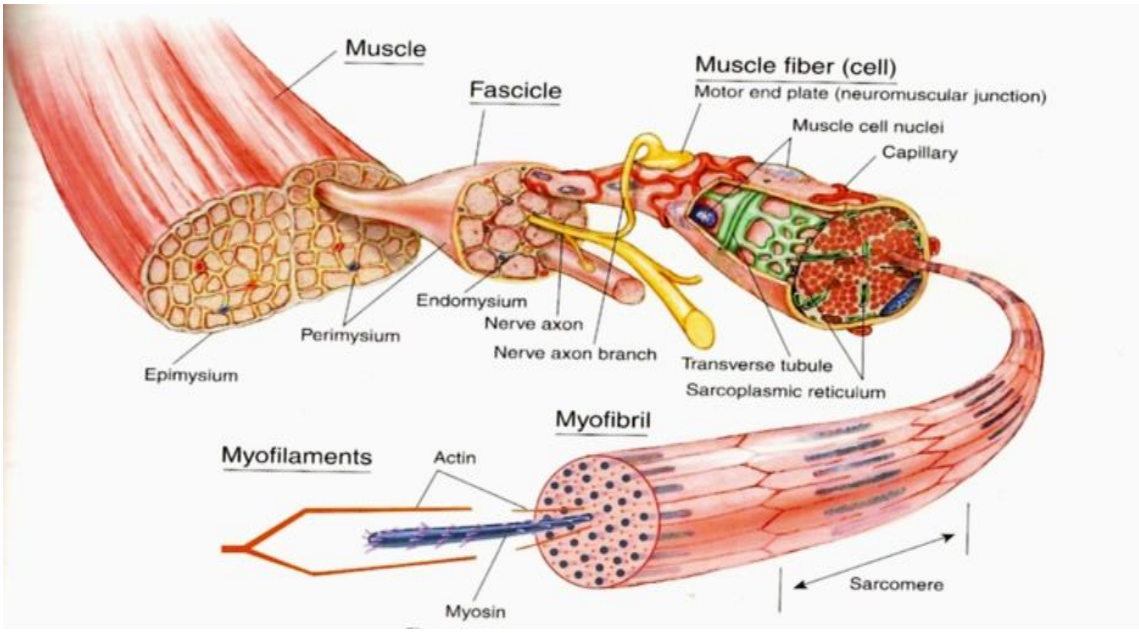
Components of skeletal muscle

Endomysium is a sheath of areolar connective tissue that penetrates the interior of each fascicle and separates individual muscle fibres from one another. The epimysium, perimysium and Endomysium binds the fibres into highly organized structure and blends together at the end of muscles to form tendons which are rope shaped but sometimes it takes sheet like structure called as aponeurosis. The tendon attaches the muscle to bones.

Skeletal Muscle Fiber:

It is roughly cylindrical in shape. They lie parallel to one another with alternate dark and light strips. Individual fibre may be very long, upto 25 cm in the longest muscle. Each cell has several nuclei which are situated just under the cell membrane called as sarcolemma. The cytoplasm of muscle cells is called as sarcoplasm. Skeletal muscle fibres contain many mitochondria which are used for production of ATP from glucose and oxygen. Sarcoplasm also contains red coloured, oxygen binding protein called as myoglobin which stores oxygen within the molecule

Myofibrils and Sarcoplasmic Reticulum: At higher magnification, the sarcoplasm appears stuffed with little threads. These small structures are called as myofibrils. Myofibrils are about 2 um in diameter. A fluid-filled system of membranous sacs called as sarcoplasmic reticulum or SR encircles each myofibrils. In relaxed muscle fibre, the SR stores calcium ions. Release of calcium from the terminal cisterns of the SR triggers muscle contraction.



Components of skeletal muscle fibre

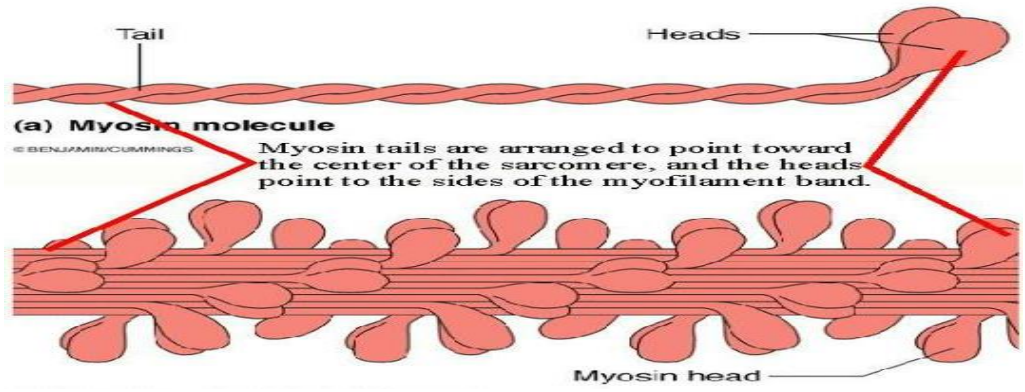
Filaments and Sarcomere:

Within myofibrils are smaller structure called as filaments. Two types of filaments are present:

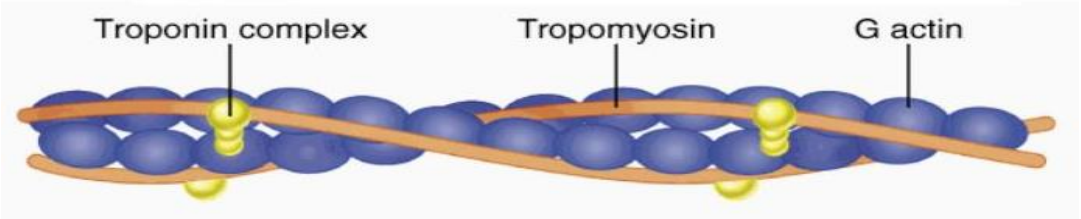
✓ Thin filament

✓ Thick filament

Thin filaments are 8 mm in diameter and 1-2 um long. Thick filaments are 16 mm in diameter and 1-2 μm long. Both these thin and thick filaments are involved in contraction. The filaments in the myofibrils do not extend the entire length of a muscle fibre. Instead they are arranged in compartments called as sarcomere, the basic functional unite of myofibrils. Z-discs separate one sarcomere from the next.



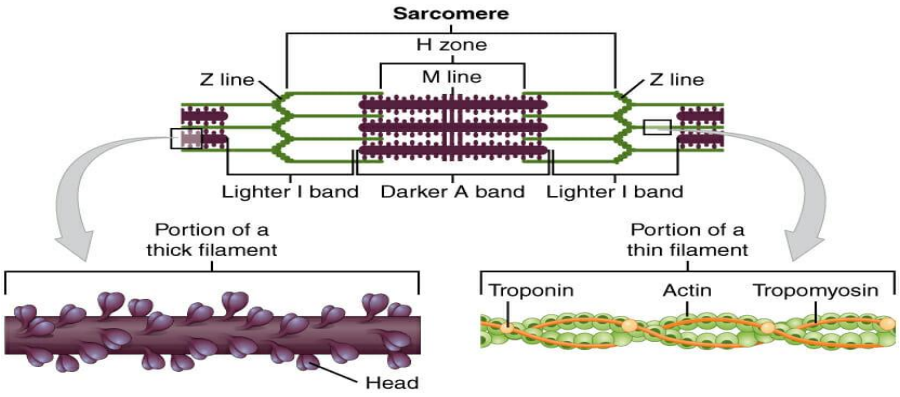
Thick filaments of myosin molecule



Thick and thin filament

Sarcomere is the repeating contractile units of myofibril. It is a segment consisting of a highly organised assembly of filaments delimited by two Z lines. Two important proteins namely actin and myosin form thin and thick filaments respectively. The filaments partly overlap and slide past each other during contraction. Perpendicular protein plates called Z discs form the lateral boundaries of a sarcomere. During contraction, the thick filaments pull the thin filaments

towards the centre of the sarcomeres. This movement causes the sarcomere, myofibrils and the muscle fibres to shorten.



Sarcomere

Muscle protein: Myofibrils are made up of three types of proteins.

Contractile protein: It helps in contraction process.

Regulatory protein: It regulates the contraction process by switching on or shutting the process

Structural protein: It keeps thick and thin filaments in proper alignment and is responsible for myofibril elasticity and extensibility.

Thick filaments are made up of protein called as myosin. Thin filaments are made up of protein called as actin. Smaller amount of two regulatory proteins, tropomyosin and troponin are also part of thin filament.

PHYSIOLOGY OF MUSCLE CONTRATION

Sliding Filament Mechanism of Muscle Contraction: The length of skeletal muscle shortens during contraction because the thick and thin filaments slide over one another. The process is known as the sliding filament mechanism. The thick filaments contain 300 myosin molecules.

It consists of two parts:

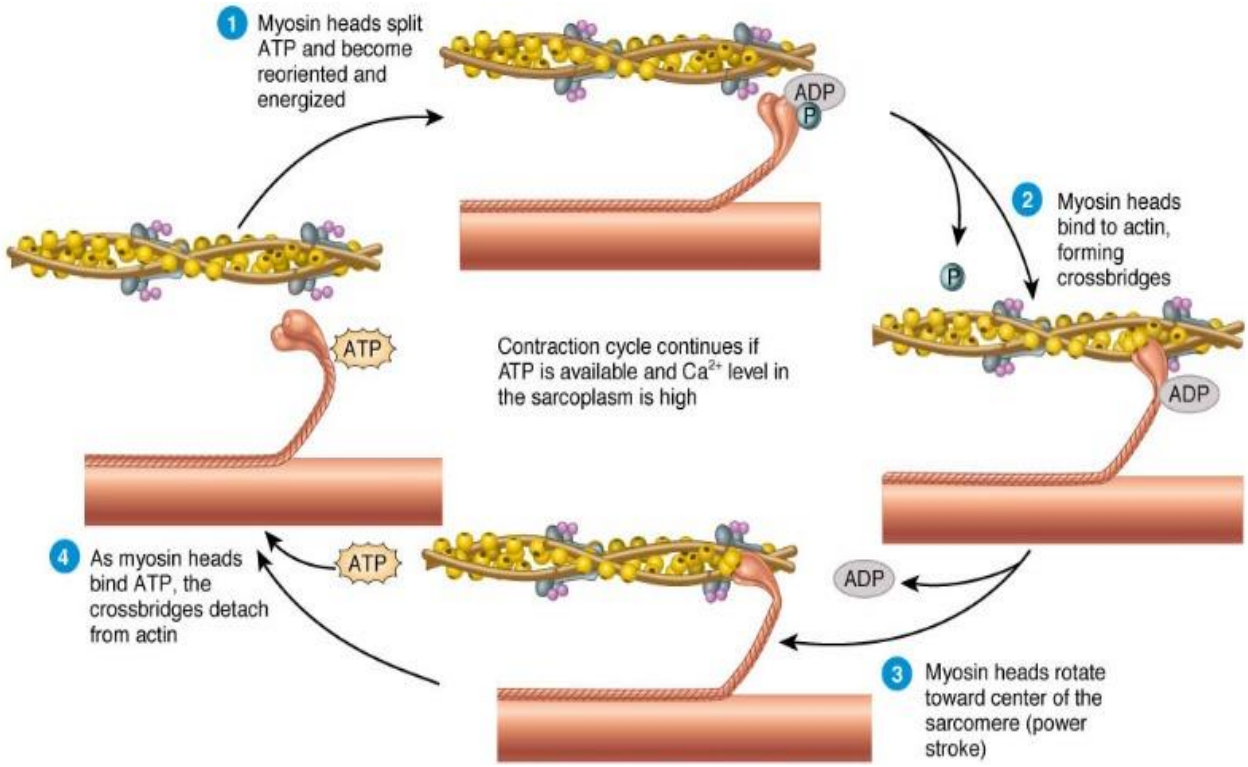
✓ Myosin tail

✓ Myosin heads

Myosin tail forms the shaft of the thick filament and heads project towards the thin filament. Thin filaments contain actin, troponin and tropomyosin, At the onset of contraction, the

sarcoplasmic reticulum releases calcium ions (Ca^{2}-) into the cytosol. There, they bind to troponin and cause the troponin-tropomyosin complexes to move away from myosin binding site on actin. Once the binding sites are free, the repeating sequence of events of the contraction cycle occurs that causes the filaments to slide on each other. The contraction cycle consists of four steps:

ATP Hydrolysis: The myosin head includes an ATP-binding site and an ATPase, an enzyme that hydrolyses ATP into ADP (adenosine diphosphate) and a phosphate group. This hydrolysis gives energy to myosin head. ADP and a phosphate group remain attached to the myosin head.



Sliding filament mechanism of muscle contraction

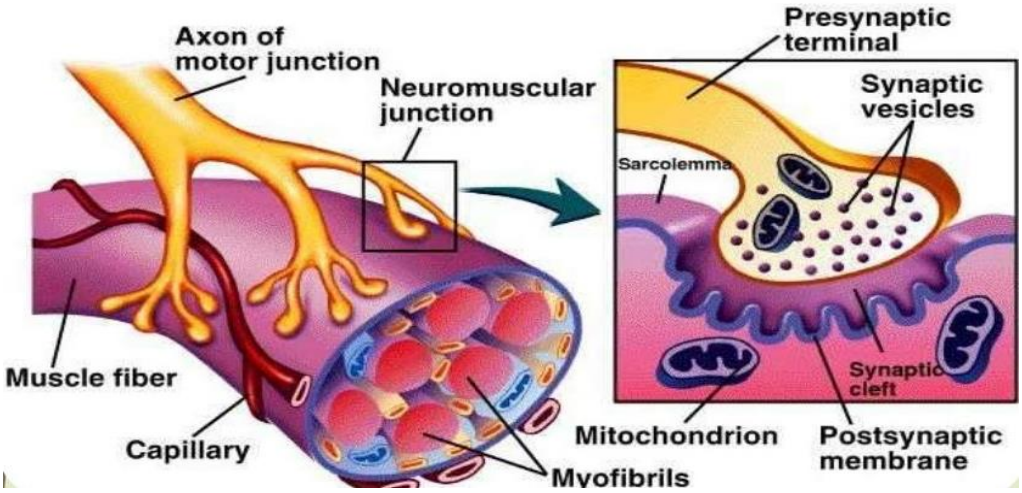
Attachment of myosin to actin to form cross-bridges: The energized myosin head attaches to the myosin binding site on actin and releases the previously hydrolysed phosphate group. When the myosin heads attach to actin during contraction, they are referred to as cross- bridges.

Power stroke: Once the cross-bridges are formed, the power stroke occurs. The cross-bridge rotates towards the centre of the sarcomere and releases the ADP molecule. The cross-bridge generates a force which slides the thin filament over the thick filament.

Detachment of myosin from actin: At the end of the power stroke, the cross-bridge remains firmly attached to actin until it binds another molecule of ATP. As ATP binds to the ATP binding site on the myosin head, the myosin head detaches from actin.

NEUROMUSCULAR JUNCTION (NMJ)

The neurons that stimulate the skeletal muscle fibres to contract are called somatic motor neurons. Neuromuscular junction is the synapse between a somatic motor neuron and a skeletal muscle fibre. A synapse is a region between two neurons, or between a neuron and a target cells(between somatic motor neuron and muscle fibre). Synapse contains a small gap, called as synaptic cleft which separates the two cells. The first cell communicates with the second cell by releasing a chemical called as neurotransmitter. At the NMJ, the end of the motor neuron called as axon terminal, divides into a cluster of synaptic end bulbs. Suspended in the cytosol within each synaptic end bulb contains hundreds of membrane- enclosed sacs called synaptic vesicles. Inside each synaptic vesicle are thousands of molecules of acetylcholine (Ach), the neurotransmitter released at the NMJ. The region of the sarcolemma opposite the synaptic end bulbs, called the motor end plate is the muscle fibre part of the NMJ. Within each motor end plate are 30 to 40 million acetylcholine receptors are present. These receptors are abundant in the motor end plate that provides a large surface area for ACh. A neuromuscular junction includes all the synaptic end bulbs on one side of the synaptic cleft, plus the motor end plate of the muscle fibre on the other side.Human Anatomy and Physiology - I



Neuromuscular junction (NMJ)

JOINTS

A joint is a point of contact between two bones, between bone and cartilage or between bone and teeth. It is also called an articulation or arthrosis. Joints have mainly two important functions: to hold the bones securely and to provide mobility to rigid skeleton.

CLASSIFICATION OF JOINTS:

Joints are classified structurally (based on their anatomical characteristics) and functionally (based on the type of movement they produce).

Structurally joints are of 3 types:

Synovial joints: The bones forming the joint have a synovial cavity and are united by the dense irregular connective tissue of an articular capsule and accessory ligaments.

Fibrous joints: There is no synovial cavity and the bones are held together by dense irregular connective tissue.

Cartilaginous joints: There is no synovial cavity and the bones are held together by cartilage.

Functionally joints are classified as one of the following types:

Synarthrosis (syn = together): These are immovable joints.

Amphiarthrosis (amphi = on both sides): These are slightly movable joints.

Diarthrosis: These are freely movable joints. All diarthroses are synovial joints. They have a variety of shapes and permit several different types of movements.

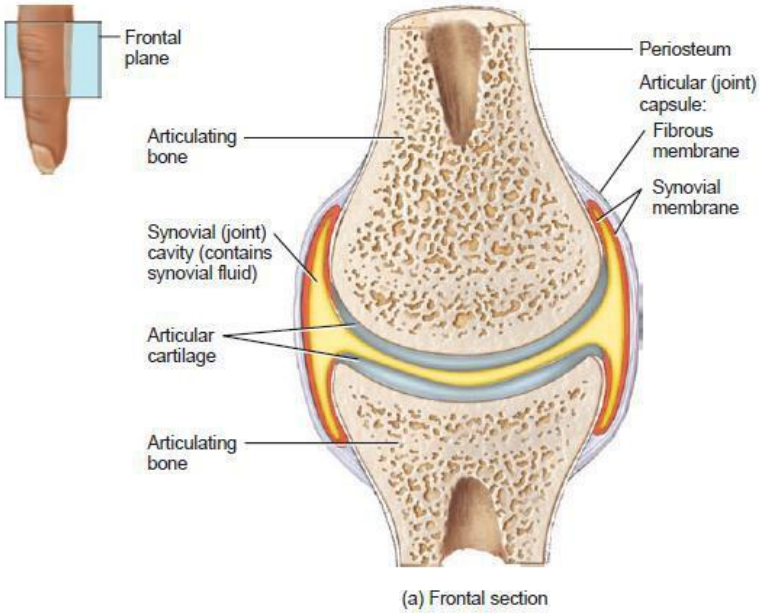
SYNOVIAL JOINTS:

These are freely movable joints. Synovial joints have a space called a synovial (joint) cavity between the articulating bones. Because the synovial cavity allows a joint to be freely movable, all synovial joints are classified functionally as diarthroses. Synovial joints have 4 special featuress:

Articular cartilage: The bones at a synovial joint are covered by a layer of hyaline cartilage called articular cartilage. The cartilage covers the articulating surface of the bones with a smooth, slippery surface but does not bind them together. Articular cartilage reduces friction between bones in the joint during movement and helps to absorb shock.

Articular cartilage: An articular (joint) capsule surrounds a synovial joint, encloses the synovial cavity and unites the articulating bones. The articular capsule is composed of two layers, an outer

fibrous membrane and an inner synovial membrane. The fibrous membrane consists of dense irregular connective tissue. The flexibility of the fibrous membrane permits considerable movement at a joint, while its great tensile strength (resistance to stretching) helps prevent the bones from dislocating. The fibers of some fibrous membranes hold bones close together in a synovial joint.



(a) Frontal section

The inner layer of the articular capsule is called the synovial membrane. It is composed of areolar connective tissue with elastic fibers.

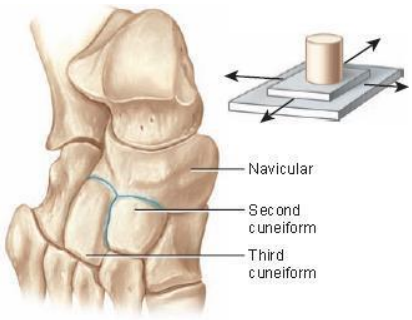
Synovial fluid: The synovial membrane secretes a viscous, clear or pale yellow fluid named synovial fluid. It forms a thin film over the surfaces within the articular capsule. Its functions include reducing friction by lubricating the joint, absorbing shocks and supplying oxygen and nutrients to and removing carbon dioxide and metabolic wastes and remove microbes and the debris that results from normal wear and tear in the joint.

Accessory Ligaments and Articular Discs: Many synovial joints also contain accessory ligaments called extracapsular ligaments and intracapsular ligaments. By modifying the shape of the joint surfaces of the articulating bones, articular discs allow two bones of different shapes to fit together. Articular discs also help to maintain the stability of the joint and direct the flow of synovial fluid to the areas of greatest friction.

TYPES OF SYNOVIAL JOINTS

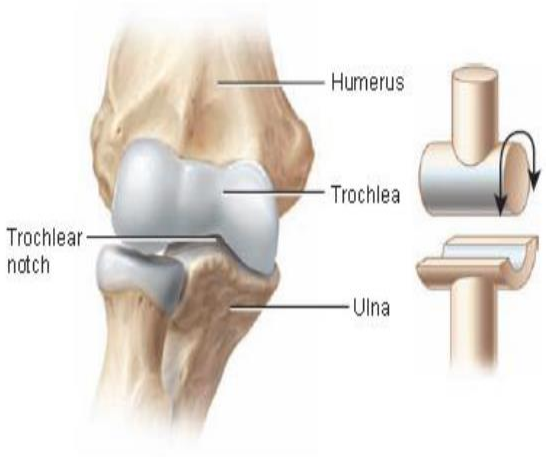
Synovial joints are divided into six categories based on type of movement: planar, hinge, pivot, condyloid, saddle and ball-and-socket.

Planar joint: The articulating surfaces of bones in a planar joint are flat or slightly curved. Planar joints primarily permit back-and-forth and side-to-side movements between the flat surfaces of bones. Many planar joints are biaxial because they permit movement around two axes. Examples of planar joints are the intercarpal joints (between carpal bones at the wrist), intertarsal joints (between tarsal bones at the ankle), sternoclavicular joints (between the manubrium of the sternum and the clavicle), vertebrocostal joints (between the heads and tubercles of ribs and transverse processes of thoracic vertebrae).

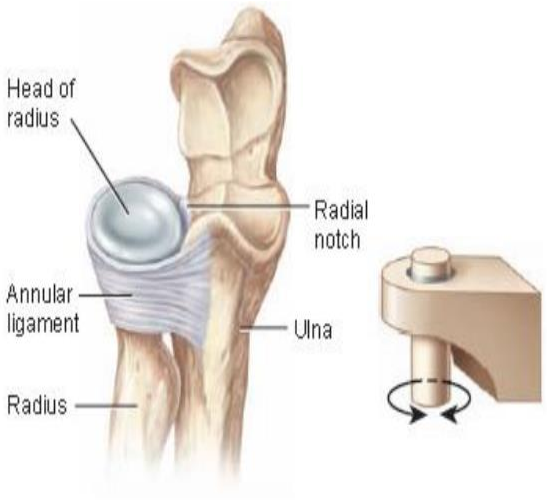


(a) Planar joint between navicular and second and third cuneiforms of tarsus in foot

Hinge joint: The convex surface of one bone fits into concave surface of other bone in a hinge joint. One bone remain fixed while other move around an axis. Hinge joints are monaxial (uniaxial) because they typically allow motion around a single axis. Hinge joints permit only flexion and extension. Examples of hinge joints are the knee (actually a modified hinge joint), elbow, ankle, and interphalangeal joints.



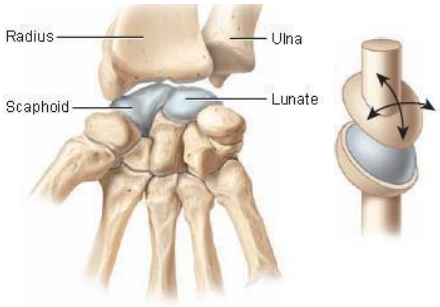
(b) Hinge joint between trochlea of humerus and trochlear notch of ulna at the elbow



(c) Pivot joint between head of radius and radial notch of ulna

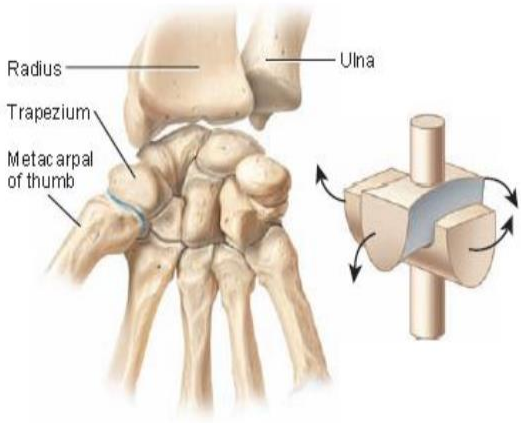
Pivot joint: In a pivot joint, rounded or pointed end of one bone articulates with the ring formed by another bone and ligament. These are Uniaxial or monoaxial joint as movement is only around longitudinal axis. Eg Radioulnar joints which enable to turn palm anteriorly and posteriorly.

Condyloid joint: In a condyloid joint the convex oval-shaped projection of one bone fits into the oval-shaped depression of another bone. A condyloid joint is biaxial because the movement it permits is around two axes (flexion–extension and abduction–adduction). Examples of condyloid joints are the wrist and metacarpophalangeal joints for the second through fifth digits.

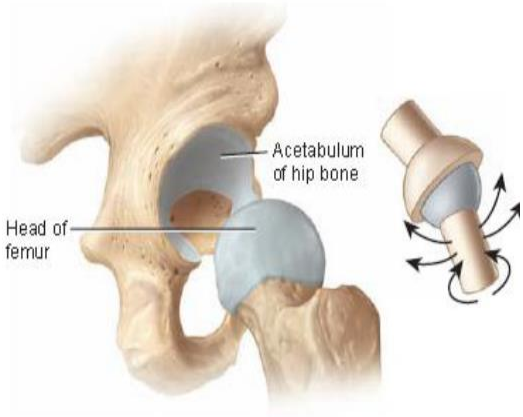


(d) Condyloid joint between radius and scaphoid and lunate bones of carpus (wrist)

Saddle joint: In a saddle joint, the articular surface of one bone is saddle shaped and the articular surface of the other bone fits into the ―saddle‖ as a sitting rider would sit. A saddle joint is a modified condyloid joint in which the movement is somewhat freer. Saddle joints are triaxial, permitting movements around three axes (flexion–extension, abduction–adduction and rotation). An example of a saddle joint is the carpometacarpal joint between the trapezium of the carpus and metacarpal of the thumb.



(e) Saddle joint between trapezium of carpus (wrist) and metacarpal of thumb



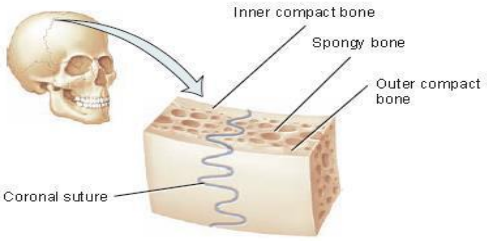
(f) Ball-and-socket joint between head of femur and acetabulum of hip bone

Ball and socket joint: A ball-and-socket joint consists of the ball-like surface of one bone fitting into a cuplike depression of another bone. Such joints are triaxial, permitting movements around three axes (flexion–extension, abduction–adduction and rotation). Examples of ball-and-socket joints are the shoulder and hip joints. At the shoulder joint, the head of the humerus fits into the glenoid cavity of the scapula. At the hip joint, the head of the femur fits into the acetabulum of the hip bone.

FIBROUS JOINTS:

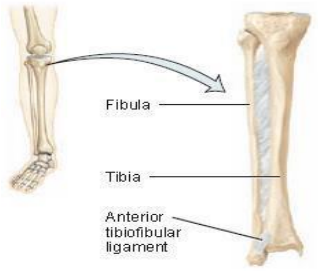
Fibrous joints lack a synovial cavity and the articulating bones are held very closely together by dense irregular connective tissue. Fibrous joints permit little or no movement. There are three types of fibrous joints are sutures, syndesmoses and interosseous membranes.

Sutures: These are fibrous joint composed of thin layer of dense irregular connective tissue. These occur only between skull e.g. frontal sutures, sagittal sutures. These joints are immovable or synarthrosis.

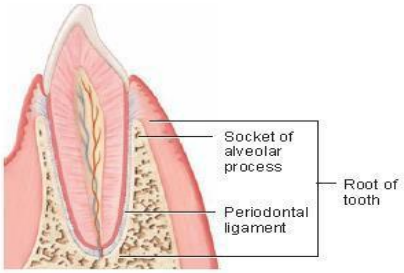


(a) Suture between skull bones

Syndesmoses: It is a fibrous joint in which there is more distance in articulating surfaces and denser irregular connective tissue than suture. Dense irregular connective tissue is arranged in bundles to permit little movement. E.g. At distal tibiofibular joint, tibiofibular ligament connects tibia and fibula or dentoalveolar joint where tooth fits into socket.



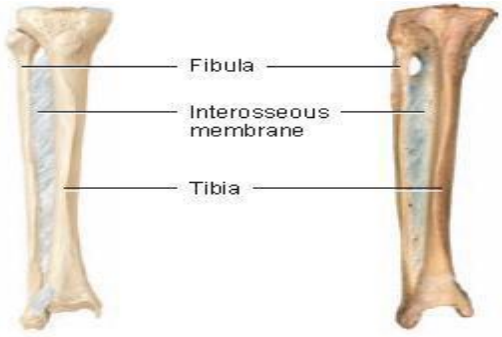
Syndesmosis between tibia and fibula



Syndesmosis between tooth and socket of alveolar process (gomphosis)

(b) Syndesmosis

Interosseous membrane: In tThe interosseous membrane, a substantial sheet of dense irregular connective tissue binds neighboring long bones and permits slight movement (amphiarthrosis). There are two principal interosseous membrane joints in the human body. One occurs between the radius and ulna in the forearm and the other occurs between the tibia and fibula in the leg.



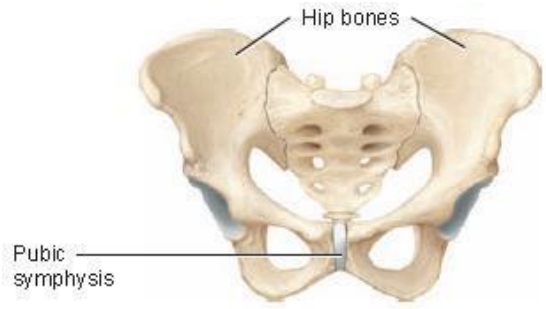
(c) Interosseous membrane between tibia and fibula

CARTILAGENOUS JOINTS:

Cartilagenous joints lack synovial cavity and allows little or no movement. Articulating bones are tightly connected by hylaine or fibrocartilage. It is of 2 types: Synchondroses and Symphysis.

Synchondroses: A cartilagenous joint in which connecting material is hyaline cartilage is called synchondroses. It is also immovable joint (synarthrosis). E.g. joint between first rib and manubium.

Symphesis: It is a cartilagenous joint in which fibrocartilage connects the bones. It is amphiarthrosis joint (slightly movable). E.g. pubic symphysis and intervertebral discs.

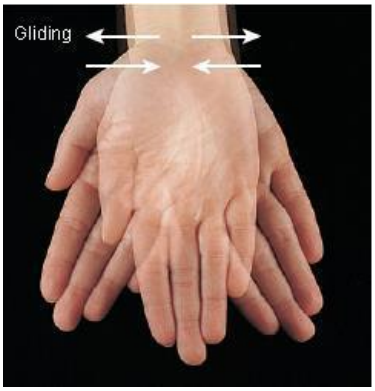


(b) Symphysis

MOVEMENTS OF SYNOVIAL JOINTS: Movements at synovial joint are of 4 types:

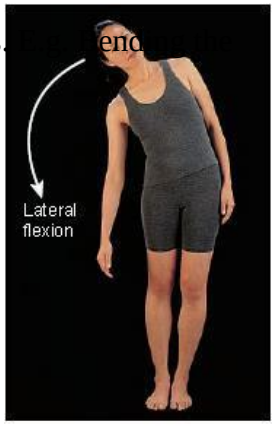
- **Gliding**
- **Angular movements**
  - Flexion, extension, lateral flexion and hyperextension
  - Abduction, adduction and circumduction
- **Rotation**
- **Special movements**

- **Gliding:** Gliding is a simple movement in which relatively flat bone surfaces move back-and-forth and from side-to-side with respect to one another. There is no significant alteration of the angle between the bones. Gliding movements are limited in range due to the structure of the articular capsule and associated ligaments and bones. The intercarpal and intertarsal joints are examples of articulations where gliding movements occur.



- **Angular movements:** In angular movements, there is an increase or a decrease in the angle between articulating bones. The major angular movements are flexion, extension, lateral flexion, hyperextension, abduction, adduction, and circumduction. These movements are discussed with respect to the body in the anatomical position.

FLEXION: In flexion there is decrease in angle between articulating bones. It is end of the trunk forward at the intervertebral joints

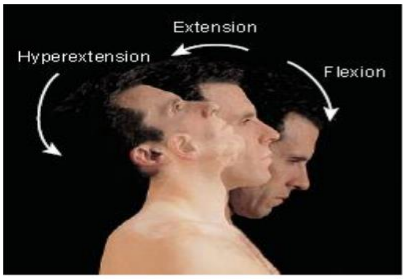


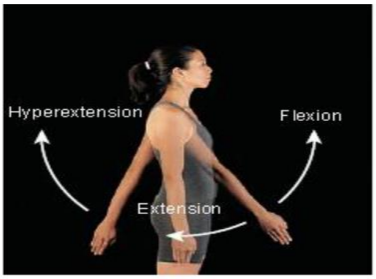
(g) Intervertebral joints

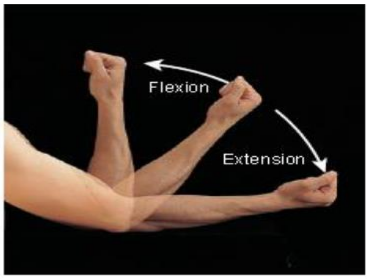
EXTENSION: It is opposite to flexion. In this there is increase in angle between articulating bones, often to restore the bones to their anatomical position after flexion. Flexion and extension generally occur in sagittal plane

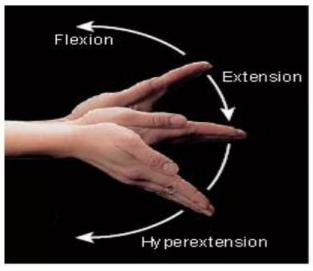
LATERAL FLEXION: This movement occurs in frontal plane and involves vertebral column. E.g movement of trunk to sidewise at waist.

HYPEREXTENSION: It is continuation of extension beyond anatomical position. E.g. Bending the trunk backward at the intervertebral joints. Hyperextension of hinge joints such as elbow, knee etc is prevented.

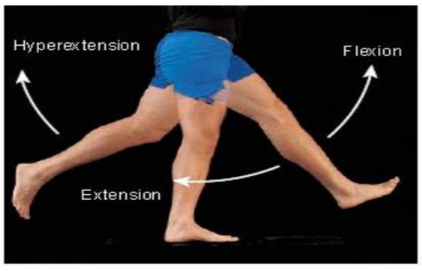




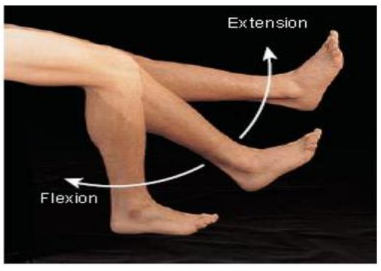




(d) Wrist joint



(e) Hip joint

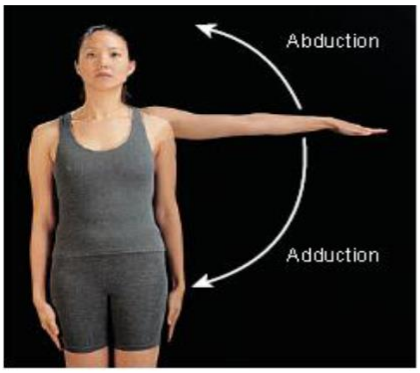


(f) Knee joint

ABDUCTION: It is movement of bone away from midline.

ADDUCTION: It is movement of bone toward midline. Both abduction and adduction movement occur generally in frontal plane. Examples of abduction include moving the humerus laterally at the shoulder joint, moving the palm laterally at the wrist joint, and moving the femur

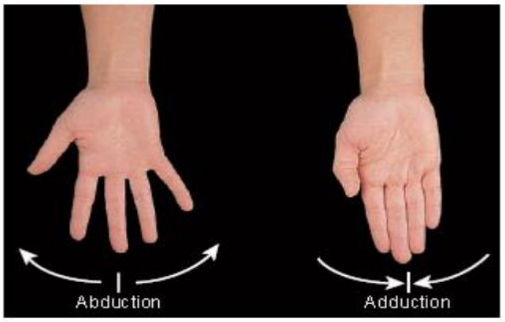
laterally at the hip joint. The movement that returns each of these body parts to the anatomical position is adduction.



(a) Shoulder joint

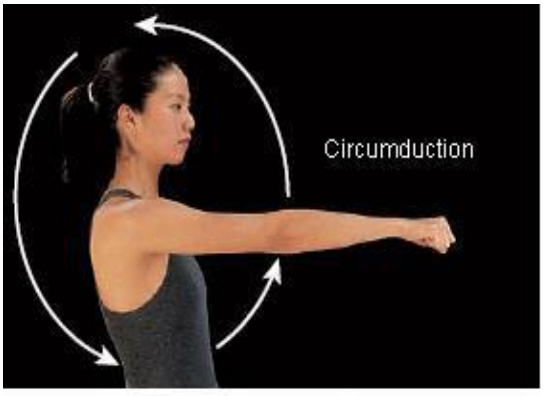
(b) Wrist joint

(c) Hip joint



(d) Metacarpophalangeal joints of the fingers (not the thumb)

CIRCUMDUCTION: It is movement of distal end of body part in circle. It is not an isolated movement but continuous sequence of flexion, abduction, extension, adduction and rotation of joints. E.g movement of humerus in circle at shouler joint, wrist movement, movement of thumb, fingers etc.



(a) Shoulder joint

(b) Hip joint

DISORDERS OF JOINTS

Rheumatism and Arthritis: Rheumatism is any painful disorder of the supporting structures of the body (bones, ligaments, tendons or muscles) that is not caused by infection or injury. Arthritis is a form of rheumatism in which the joints are swollen, stiff, and painful.

Osteoarthritis (OA): It is a degenerative joint disease in which joint cartilage is gradually lost. It results from a combination of aging, obesity, irritation of the joints, muscle weakness, and wear and abrasion. Osteoarthritis is a progressive disorder of synovial joints, particularly weight-bearing joints.

Articular cartilage deteriorates and new bone forms at the margins of the joint. These bones decrease the space of the joint cavity and restrict joint movement.

Osteoarthritis affects mainly the articular cartilage, although the synovial membrane often becomes inflamed late in the disease. Osteoarthritis first afflicts the larger joints (knees, hips) and is due to wear and tear, whereas rheumatoid arthritis first strikes smaller joints and is an active attack of the cartilage.

Rheumatoid arthritis (RA): It is an autoimmune disease in which the immune system of the body attacks its own tissues, cartilage and joint linings. RA is characterized by inflammation of the joint, which causes swelling, pain, and loss of function. Usually, this form of arthritis occurs bilaterally.

The primary symptom of RA is inflammation of the synovial membrane. If untreated, the membrane thickens and synovial fluid accumulates. The resulting pressure causes pain and tenderness. When the cartilage is destroyed, fibrous tissue joins the exposed bone ends. The fibrous tissue ossifies and fuses the joint so that it becomes immovable.

Gouty arthritis: It occurs due to excessive production of uric acid or decreased excretion than normal. The result is a build-up of uric acid in the blood. This excess acid then reacts with sodium to form a salt called sodium ureate. Crystals of this salt accumulate in soft tissues of the joints.

Gout most often affects the joints of the feet, especially at the base of the big toe. The crystals irritate and erode the cartilage, causing inflammation, swelling, and acute pain. Eventually, the

crystals destroy all joint tissues. If the disorder is untreated, the ends of the articulating bones fuse, and the joint becomes immovable.

Ankylosing spondylitis: It is an inflammatory disease of unknown origin that affects joints between vertebrae (intervertebral) and between the sacrum and hip bone (sacroiliac joint).

The disease sets in between ages 20 and 40. It is characterized by pain and stiffness in the hips and lower back that progress upward along the backbone. Inflammation can lead to ankylosis (severe or complete loss of movement at a joint) and kyphosis (hunchback). Treatment consists of anti-inflammatory drugs, heat, massage, and supervised exercise.

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. Define the muscular skeleton system?
2. Write about the various types of the muscle tissues?
3. What is the skeleton muscles tissue?
4. Define cardiac muscles tissue?
5. Define smooth muscles tissue?
6. Define the term joint?
7. Mention name of shortest and longest bone of human body?
8. Define the term Bone?
9. Define the tern ligaments?
10. What is tendon?
11. One most common disorder associated with of synovial joint?
12. How many bones are present in vertebra?
13. ..... Number of bones present in adult human?

SHORT ANSWER TYPE QUESTIONS (5 Marks)

1. Write a note on the types of joint on the bases of movement?
2. Draw a well labelled structure of knee joint and explain its parts?
3. Write the about the compact and spongy bone?
4. Classify the Muscles of the body?

5. Mention the names of axial and appendicular part of the human skeleton?
6. Write a short note on the face and neck muscle of the body?
7. Write a short note on the abdominal muscle of the body?
8. Discus about pelvic floor muscle of the body?
9. Write a short note on the muscle of back?
10. Mention the functions of muscles?
11. Write about the functions of the bone?
12. Write note on functions of skin.
13. Describe the term thermoregulation.
14. Draw well labelled diagram of skin.
15. Explain structure and function of skin.
16. Enlist the functions of skeleton system.
17. Give the classification of bones.
18. Explain physiology of skeletal muscle contraction.
19. Explain the bones of thoracic cage.
20. Write a note on thoracic vertebra.
21. Write a note on humerus.
22. Describe the structure of rib.
23. Describe the different bones of cranium.
24. Describe the structure of femur.
25. Write a note on atlas and cervical vertebra.
26. Describe the structure and function of pelvic girdle.
27. Explain the functions of muscular tissue.
28. Describe the skeletal muscle tissue.
29. Write a note on neuromuscular junction.
30. Discuss physiology of muscle contraction.

LONG ANSWER TYPE QUESTIONS (10 MARKS)

1. Discuss in detail various type of muscles in the human body?
2. Draw a diagram of skull and mention the bones present in skull?
3. Mention the name of the various types of joints and write in detail about any 3joints

with diagram?

4. Write detailed description about the bones and sections of vertebra column?
5. Classify joint and describe different types of joints.
6. Define and classify joints.
7. Write a note on ball and socket joint.
8. Describe structure of typical synovial joints.
9. Describe structure and function of pivot and gliding joint.
10. Write a note on fibrous joint.
11. Describe the anatomy and physiology of bones of vertebral column.
12. Describe the anatomy and physiology of bones of upper limb.
13. Describe the anatomy and physiology of bones of lower limb.
14. Explain the sliding filament mechanism.
15. Write a note on neuromuscular junction.
16. Discuss anatomy of skeletal muscle and explain in detail mechanism of muscle contraction.