

Unit 12: Human Skeletal and Muscular Systems

Long Questions

DESCRIPTIVE QUESTIONS

BONES AND CARTILAGE

Q1. Explain the structure of bone. / Describe the structural and chemical composition of bone.

Ans. Skeleton

Bones, cartilage and other connective tissues make an internal framework called skeleton that provides structural support, protects vital organs, and produces movement and locomotion.

Structure of Bone

Bones are made of **connective tissue** reinforced with **calcium** and specialized **bone cells**.

Following are the major components of a bone;

1. The bone's surface is covered by a tough membrane called **periosteum**.

★ The broad ends of a bone are called **epiphysis** while the middle part along the length of bone is called **diaphysis** or shaft.

2. Compact Bone / Haversian System

The thick layer under periosteum is made of hard material and is called **compact bone**. It makes up the majority of the bone tissue. The basic structural units of compact bone are called **Haversian systems**. A Haversian system is made of three parts;

(i) **Lamellae**: These are concentric **layers of mineralized** extracellular matrix that contains **collagen fibres** and small, needle-shaped **crystals of calcium phosphate**. The crystals are brittle but rigid, giving bone great strength. Collagen, is flexible but weak. As a result, bone is both strong and flexible.

(ii) **Lacunae and Osteocytes**: The lamellae are separated by small spaces called **lacunae**. **Osteocytes**, which are mature bone cells, are located in the lacunae. Osteocytes are connected to each other and to the Haversian canal by small channels called **canaliculi**.

(iii) **Haversian canal**: The concentric layers of lamellae surround a central canal called the Haversian canal. It contains blood vessels, nerves, and lymphatic vessels.

Small Channels: There are **small channels** that run perpendicular to the Haversian canals and connect them with each other and with the periosteum.

3. **Spongy Bone**: Beneath the compact bone there is **spongy bone**. It has a latticework structure consisting of bony spikes that make it light and strong.

★ **Note:** All questions and paragraphs marked with a star ★ are explanations of the Box Information provided in the textbook.

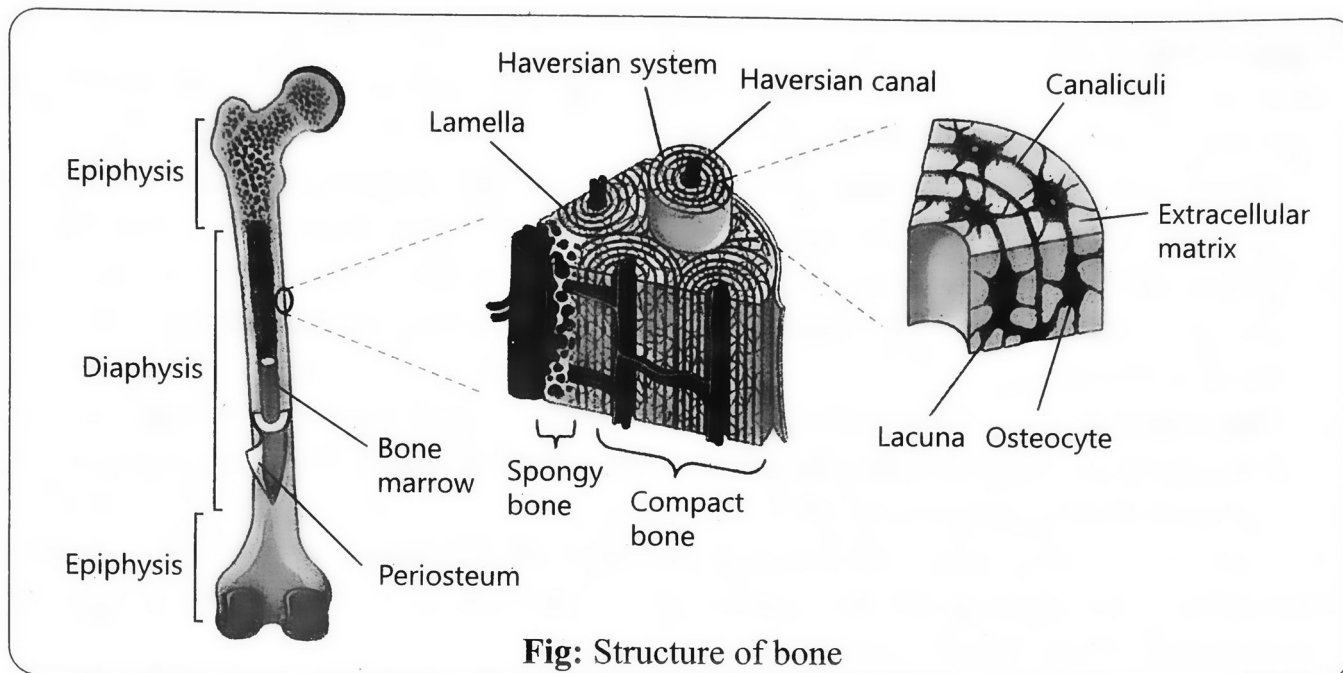


Fig: Structure of bone

4. Bone Marrow

Many bones also contain a soft tissue called bone marrow, which can be either red or yellow.

(i) **Red bone marrow** is found in spongy bone, the ends of long bones, ribs, vertebrae, the sternum, and the pelvis. It produces blood cells.

(ii) **Yellow bone marrow** fills the shafts of long bones. It consists mostly of fat cells and serves as an energy reserve. It can also be converted to red bone marrow and produce blood cells when severe blood loss occurs.

★ **Living tissues:** Despite their number and size bones make up less than **20%** of the body's mass. Bones are not dry, rigid structures, as they appear. They are moist, living tissues.

5. Types of Bone Cells

There are three types of cells i.e., osteoblasts, osteocytes, and osteoclasts involved in the development, growth and remodelling of bones.

- **Osteoblasts** are **bone forming** cells that synthesize and secrete unmineralized ground substance. Once the osteoblasts are surrounded by matrix, they become the osteocytes.
- **Osteocytes** are mature bone cells which maintain healthy bone tissue by secreting enzymes and bone mineral content. They also **regulate the calcium release** from bone tissue to blood.
- **Osteoclasts** develop from macrophages and are involved in **bone resorption**, i.e., they break down bone and **release calcium and phosphate in blood**. The work of osteoclasts is important to the growth and repair of bone.

Q2. Illustrate the process of bone formation or osteogenesis. / OR

Define osteogenesis. Describe the primary pathways of osteogenesis. / Explain the process of bone development.

Ans. Bone Development

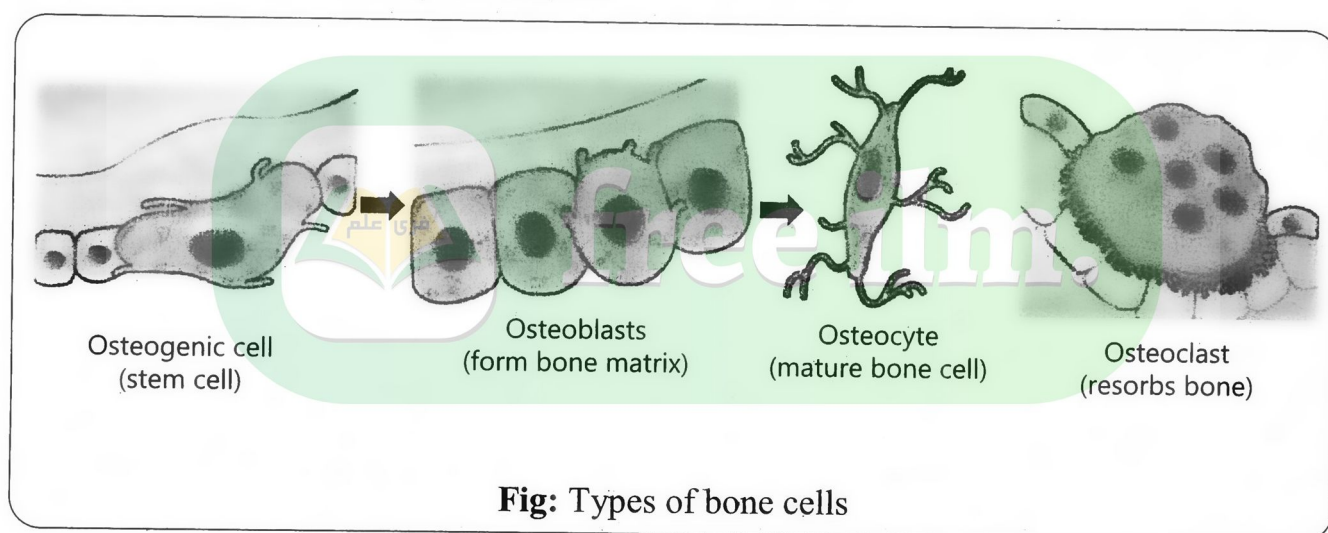
Definition: "The process of bone formation is called osteogenesis."

It begins during embryonic development and continues throughout life, playing a vital role in growth, maintenance, and repair of bones.

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- ★ Even after bones have fully formed **osteogenesis continues** in the form of bone remodelling. This ongoing process involves the breakdown of old bone by osteoclasts and the formation of new bone by osteoblasts.



Pathways: There are two **Primary pathways of osteogenesis**.

1. Endochondral Ossification/Transition of Cartilage into bone: The formation of long bones e.g., femur and humerus, involves the **transition of cartilage into bone**. In this process, the center of cartilage begins to harden (calcify), and the chondrocytes (cartilage cells) in this area die, leaving behind cavities.

Ossification: The step by which cartilage is replaced by bone by the deposition of minerals is called **ossification**. Blood vessels penetrate these cavities and introduce osteoblasts and osteoclasts. Osteoblasts (bone-forming cells) start building bone tissue, replacing the cartilage with new bone. Osteoclasts (bone-resorbing cells) break down the calcified cartilage, making room for more bone tissue to form. As the bone matures, some osteoblasts become trapped within the bone tissue and transform into osteocytes (mature bone cells), which help maintain the bone structure. This process continues until all cartilage is changed to a bone except some cartilage that remains only at the **articular (joint) surfaces** of the bones.

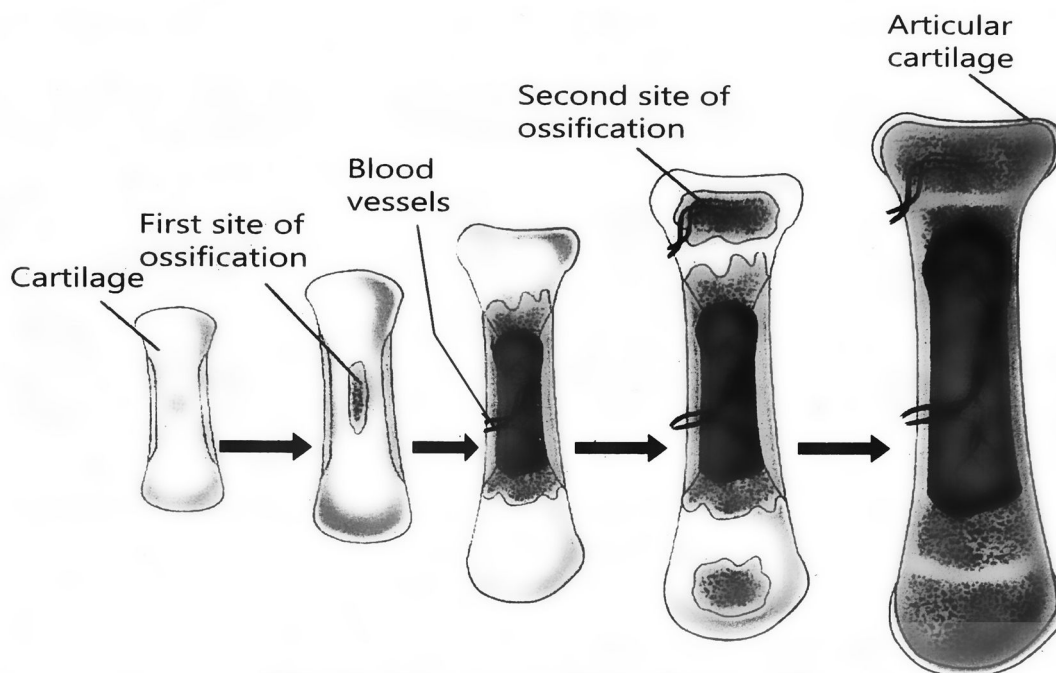


Fig: Development of bone from cartilage

2. Intramembranous ossification: The short bones develop directly into hard bone without forming cartilage first e.g., some bones of the skull.

- In these cases, the osteocytes are initially scattered randomly throughout the embryonic connective tissue but soon fuse into layers and become flat plates of bone.

Q3. Describe the structure of cartilage and its types.

Ans. Definition: Cartilage is a type of connective tissue, which is made up of **perichondrium**, **cartilage matrix** and **chondrocytes**.

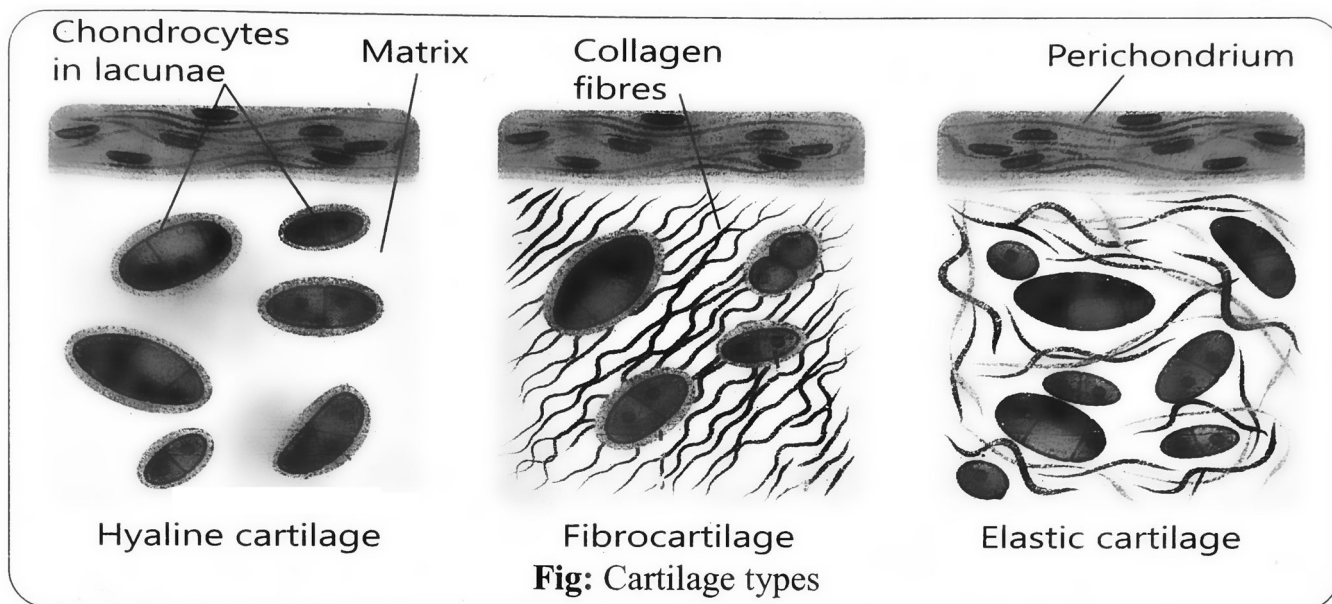
Structure of Cartilage

1. Perichondrium: A layer of connective tissue called **perichondrium** surrounds the cartilage. It contains blood vessels, lymphatic vessels, and nerves that supply the cartilage tissue.

2. Cartilage matrix: Inside perichondrium is the **cartilage matrix** which is composed of **collagen**, **elastin**, **proteoglycans**, and other **fibres**. It gives the tissue its strength, flexibility, and resistance to compression. Unlike other connective tissues, there are no blood vessels inside cartilage matrix. The cells of cartilage are supplied by diffusion. Because of this, it heals very slowly.

3. Chondrocytes: The cartilage cells, called **chondrocytes**, are present within small spaces called **lacunae**, which are embedded in cartilage matrix. Chondrocytes are responsible for synthesizing and maintaining the matrix of cartilage.

Most of the cartilage of **foetus** is replaced by **bone**. However, some cartilage remains throughout life and provides **flexibility**. For example, at the areas between bones, at the end of nose, in the outer ear, and along the inside of the trachea.



4. Types of Cartilage

- Cartilage can be classified into three types.
- **Hyaline** cartilage is the **most common** type and is found in the nose, trachea, and the articulating surfaces of bones in joints.
- **Fibrocartilage** is found in areas of the body that experience **high stress and tension**, such as the intervertebral discs and the pubic symphysis.
- **Elastic cartilage** is found in the external ear and epiglottis.

Q4. Describe the arrangement of bones of human axial skeleton.

Ans. Axial Skeleton

The axial skeleton forms the axis of the body. It is composed of **80 bones**. Its bones support and protect the organs of the head, neck, and chest. It consists of **skull, ribs, spine, and sternum**.

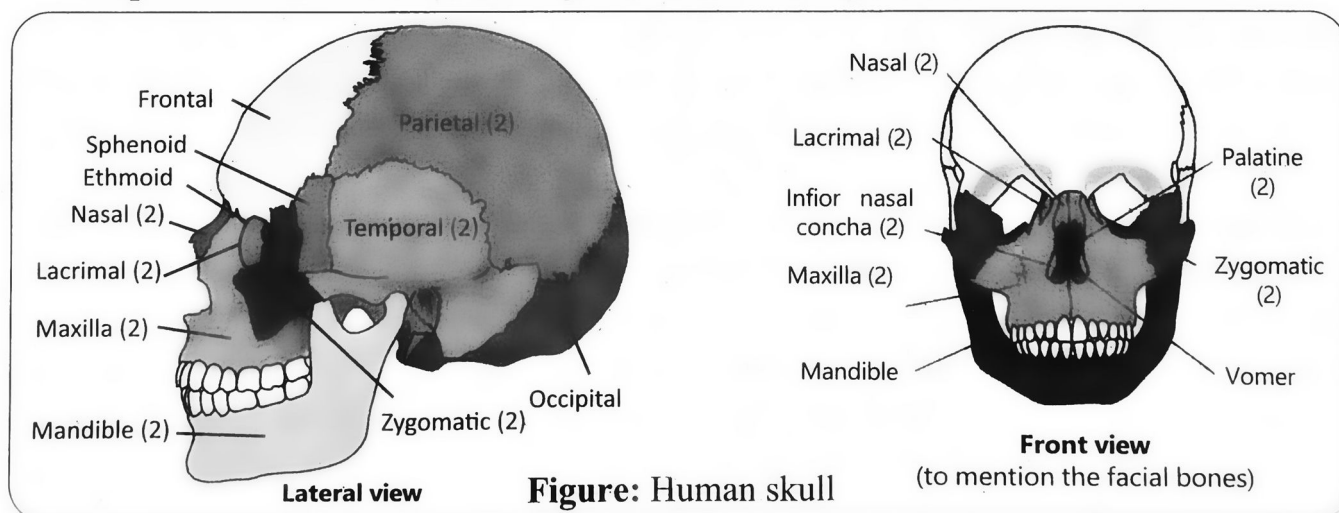
Description

a. Skull

The skull bones are divided into cranial bones (8) and facial bones (14). It consists of total 22 bones and 6 middle ear ossicles.

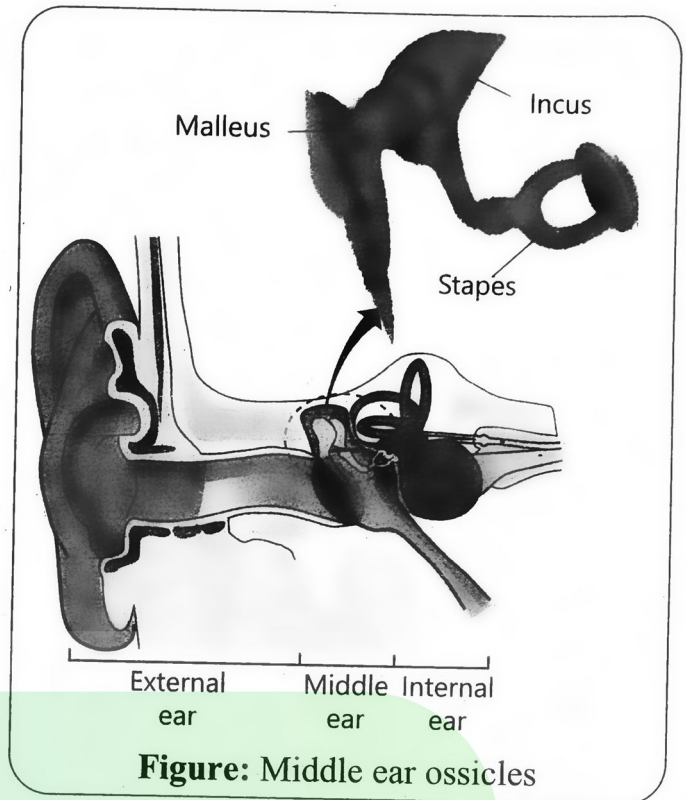
Cranial Bones: Eight **cranial bones** form cranium (brain box).

- **2 paired bones** are parietal and temporal.
- **4 unpaired bones** are frontal, occipital, ethmoid and sphenoid.

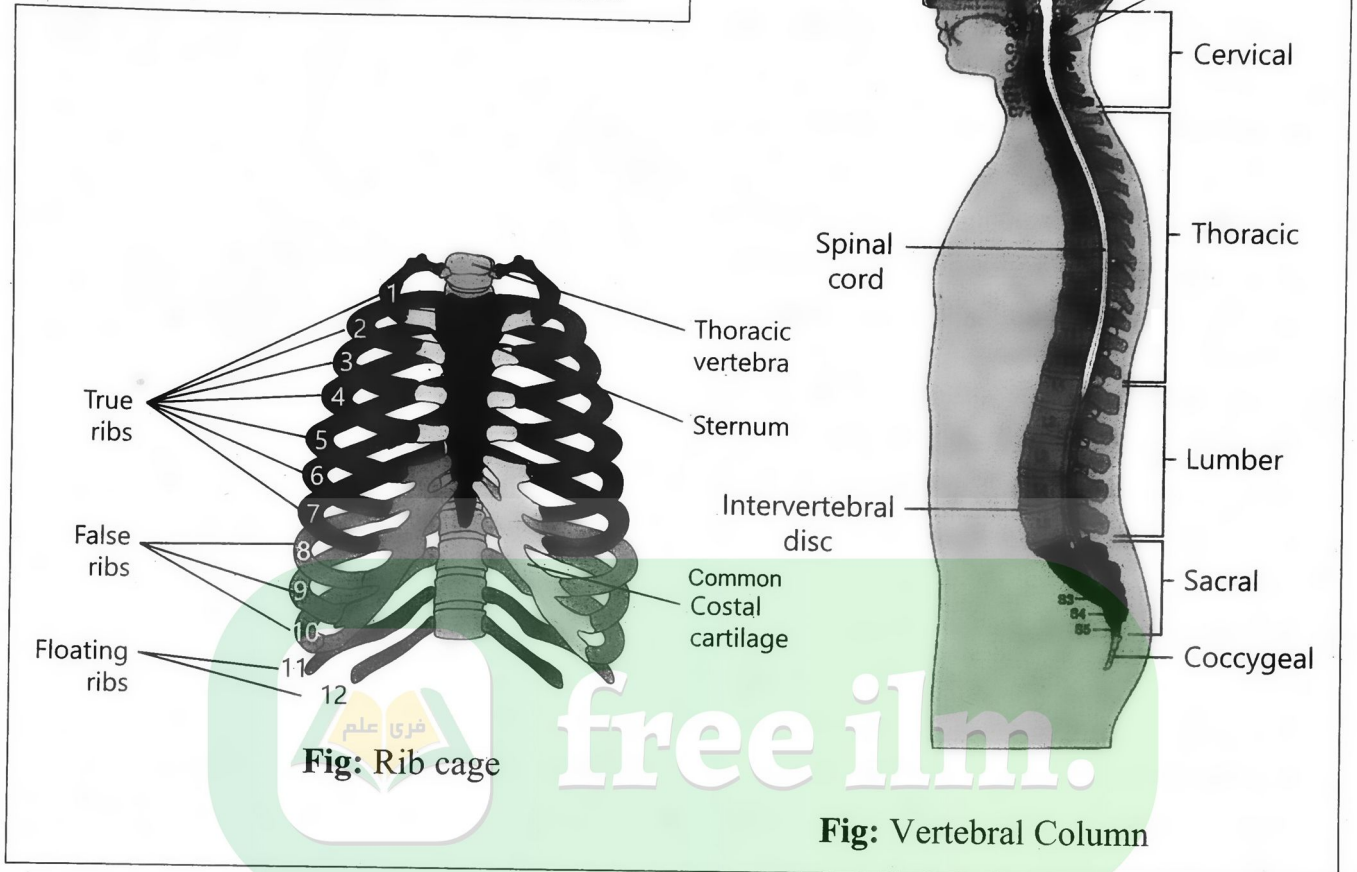


Facial Bones: Fourteen **facial bones** are attached to the cranium.

- **6 paired bones** are lacrimal, zygomatic, nasal, inferior nasal concha, maxilla and palatine.
 - **2 unpaired bones** are mandible (jaw bone) and vomer.
- b. **Middle ear:** There are 6 bones (3 pairs) in middle ears. These are called ossicles and include **malleus, incus** and **stapes** (Smallest human bone).
- c. **Neck bone:** Hyoid bone is a small **U-shaped** single bone which lies at the base of skull below the tongue. It does not articulate with any other bone of head.
- d. **Vertebral column:** It consists of 33 bones called vertebrae. The vertebrae make five groups. However, in adults there are only 26 vertebrae after fusion.
- (i) **Cervical vertebrae (C1-C7):** These are the **seven** vertebrae of the **neck**. The first one is called **atlas** and the second one is called **axis** (it facilitates rotational movement).
- (ii) **Thoracic vertebrae (T1-T12):** These are the **twelve** rib-carrying vertebrae and are found in **chest** region.
- (iii) **Lumbar vertebrae (L1-L5):** These are the **five** vertebrae present in **abdominal** region.
- (iv) **Sacral vertebrae (S1-S5):** These are the **five fused** vertebrae in the **pelvic region** forming the sacrum. The sacrum articulates with the iliac bones of the hip to form the back of the pelvis.
- (v) **Coccygeal vertebrae (Co1-Co4):** These are the **four fused** vertebrae in the **pelvic region** in adults also known as **coccyx** or (tail bone). Sacral and coccygeal vertebrae are together called pelvic vertebrae.
- e. **Rib Cage & Chest bone:** The rib cage consists of 24 bones (12 pairs) called ribs and a sternum. The sternum (chest bone) is a long flat bone located in the central part of the chest. The ribs articulate posteriorly with the thoracic vertebrae.
- **True Ribs:** On anterior side, 7 pairs of ribs attach directly with the sternum by means of separate costal cartilages. These are called true ribs.
 - **False Ribs:** The 8th, 9th and 10th pairs attach to the sternum by means of a **common costal cartilage** and are called false ribs.



- **Floating Ribs:** The last 2 pairs of ribs (11th and 12th) are known as floating ribs, because they do not attach to the sternum.



Bones	Number
Skull	22
Middle ear ossicles	06
Hyoid	01
Sternum	01
Ribs	24
Vertebral Column	26 (in adults)
Total	80

Q5. Describe the arrangement of bones of human Appendicular skeleton.

Ans. Appendicular skeleton includes the bones present in appendages (arms and legs). It is composed of 126 bones. These are **pectoral girdle**, **pelvic girdle**, **forelimbs** and **hindlimbs**.

- Pectoral girdle:** It consists of 2 pairs i.e., a pair of clavicles (collar bones) and a pair of scapulae (shoulder bones). **One end** of clavicle articulates with the **sternum** and other end articulates with the **scapula**.
- Forelimbs:** Each forelimb (arm, wrist, hand, fingers) consists of the following **30 bones**.

- i. **One humerus:** It is a long bone, the end of which has a spherical head, which fits into the glenoid cavity of scapula forming shoulder joint or glenohumeral joint.
- ii. **One ulna and one radius:** These are long bones. Ulna is on the inner side (little finger side) of arm while radius is on outer side (thumb side). Ulna is slightly bigger than radius. The lower end of humerus (trochlea) articulates with olecranon process of ulna, forming elbow joint.
- iii. **Eight carpels:** There are short bones present in two rows and form the **wrist**. The upper row articulates with the radius and forms the wrist joint also called radiocarpal joint.
- iv. **Five metacarpals:** These bones make up the **palm** of the hand.
- v. **Fourteen phalanges:** Each **finger** has 3 phalanges while the thumb has 2 phalanges.

Bones	Numbers
Pectoral Girdle	04
Humerus	02
Radius	02
Ulna	02
Carpals	16
Metacarpals	10
Phalanges	28 (hands)
Pelvic Girdle	02
Femur	02
Tibia	02
Fibula	02
Patella	02
Tarsals	14
Metatarsals	10
Phalanges	28 (feet)
Total	126

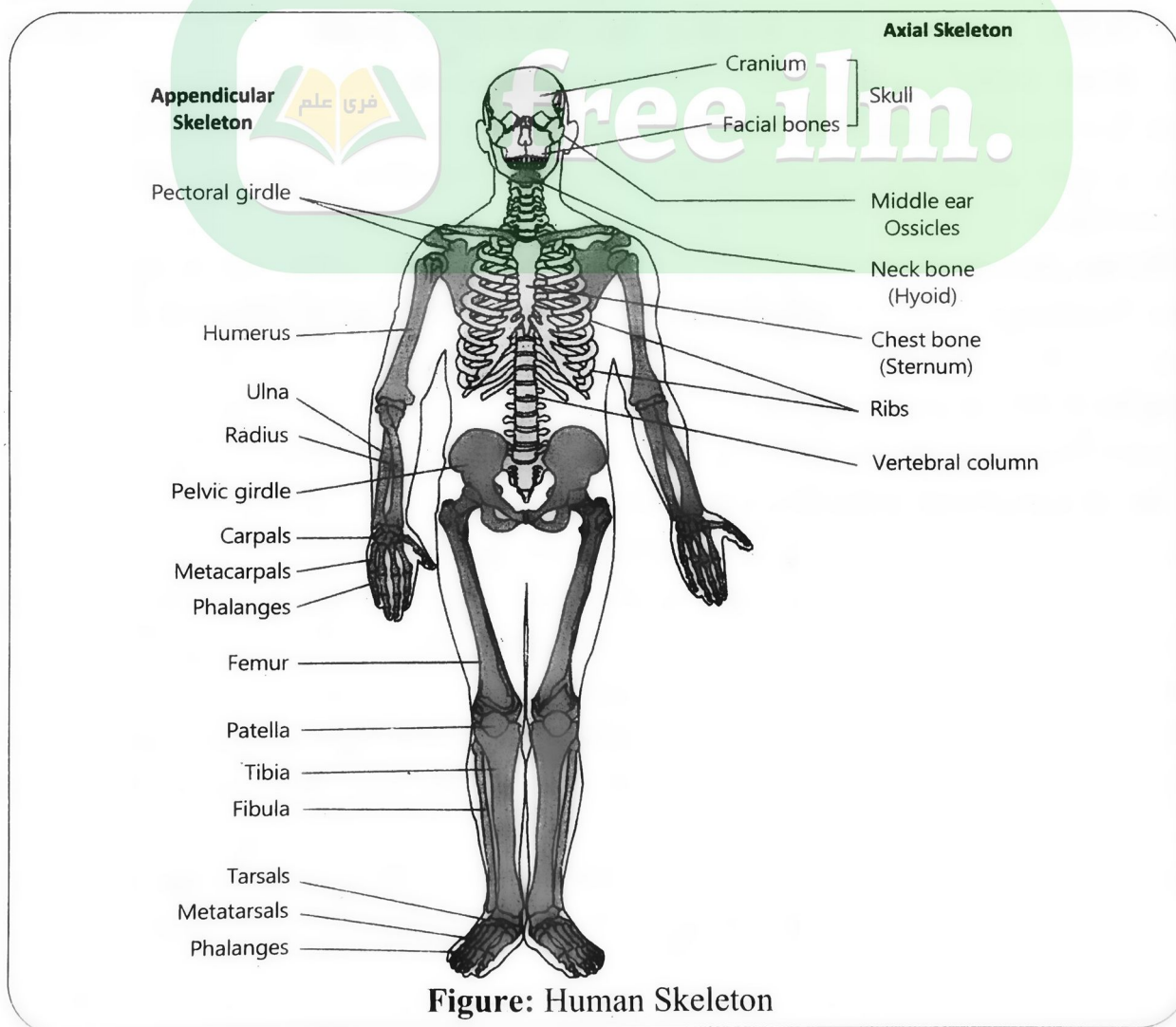


Figure: Human Skeleton

- c. **Pelvic girdle:** It is made up of a pair of hip bones. Each hip bone (coxal bone) contains 3 fused bones i.e., **ilium**, **ischium** and **pubis**. In each hip bone, there is a bony socket, called **acetabulum** that is formed by the fusion of three bones. The two hip bones are joined at the front by the pubic symphysis (a cartilaginous joint that connects the pubic bones at the midline of the body).
- d. **Hind limbs:** Each hind limb (leg, ankle, foot, toes) consists of **30 bones**.
- i. **One femur:** It is a long thigh bone. Its head fits into the acetabulum of pelvic girdle. It is the largest human bone.
- ii. **One patella or knee cap:** It is a small triangular sesamoid bone (i.e. it is embedded in quadriceps tendon).
- iii. **One tibia and one fibula:** Tibia or **shin bone** is the large bone in the leg. Fibula or outer bone is a thin bone that joins the tibia just below the knee joint and just above the ankle.
- iv. **Seven tarsals:** These are short bones which are tightly attached to form the ankle.
- v. **Five metatarsals:** These bones articulate with the tarsal and phalanges to form the sole of the foot.
- vi. **Fourteen phalanges:** Each toe has 3 phalanges while the big toe comprises 2 phalanges.

Q6. Define joints. Write a detailed classification of joints.

Ans. Joint: A joint is a place where two bones or bone and cartilage come together.

Types: Three major kinds of joints are found in human body on the basis of structure i.e., fibrous (immovable) joints, cartilaginous (slightly moveable) joints and synovial (freely moveable) joints.

1. Fibrous Joints: In fibrous joints, the bones are directly connected to each other by fibrous connective tissue consisting mainly of collagen. These joints permit no movement of bones.

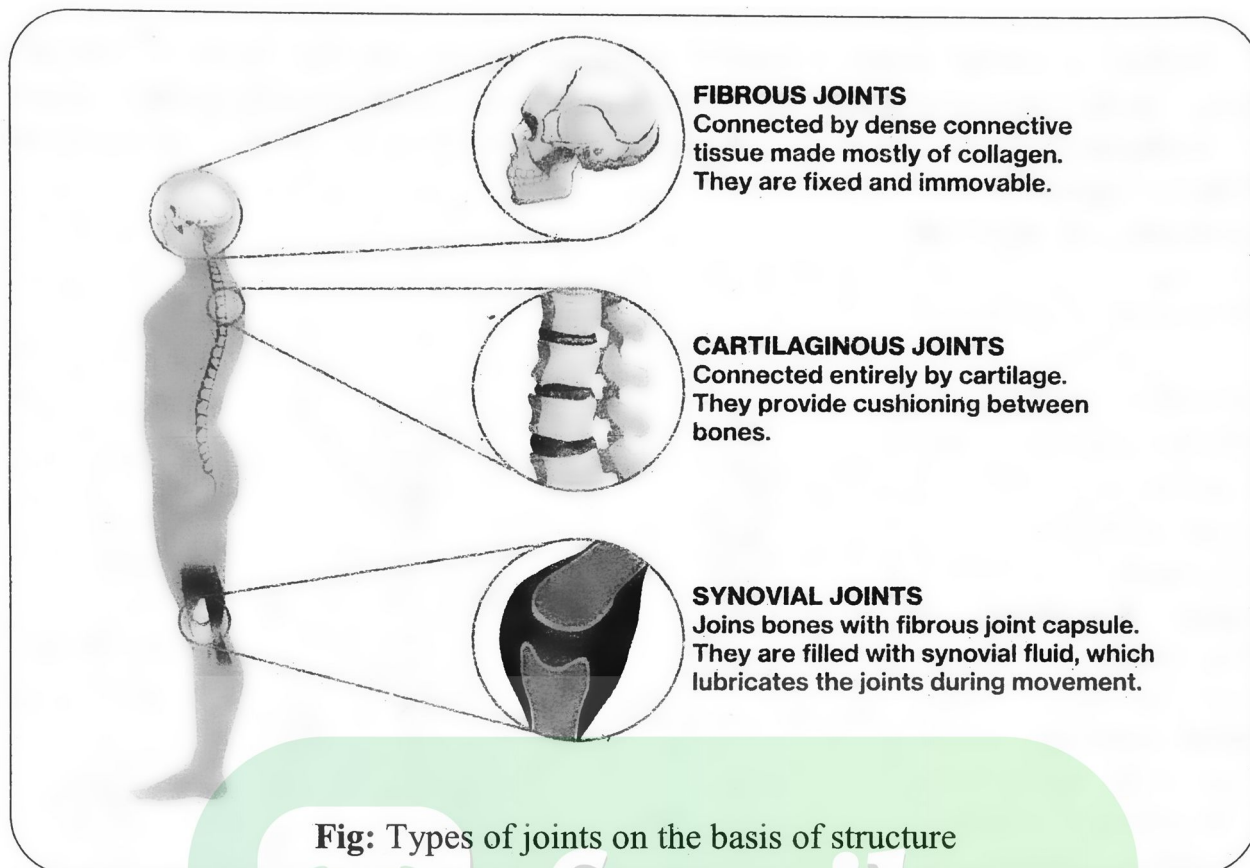
Examples of fibrous joints include:

- **Sutures** that occur only between the immovable bones of the skull.
- Joints between the tibia and fibula bones in the lower leg.
- Joints between teeth and their sockets in the jawbone.

2. Cartilaginous Joints: In these joints, the bones are connected by a layer of cartilage. Cartilaginous joints allow little movement of the bones.

Types: There are two main types of cartilaginous joints:

- i. **Primary cartilaginous joints (synchondrosis):** In some cartilaginous joints, the bones are connected by **hyaline cartilage**. For example, the joint between the first rib and sternum (**sternocostal joint**).
- ii. **Secondary cartilaginous joints (symphysis):** In some cartilaginous joints, the bones are connected by **fibrocartilage**. For example, pubic symphysis in the pelvic girdle and intervertebral discs.



3. Synovial joints

A type of joint which is characterized by a fluid filled cavity surrounded by a **fibrous capsule**. Synovial joints are the most common type of joint in the human body, and they allow a wide range of movement.

Components of synovial joint

Synovial joint is composed of:

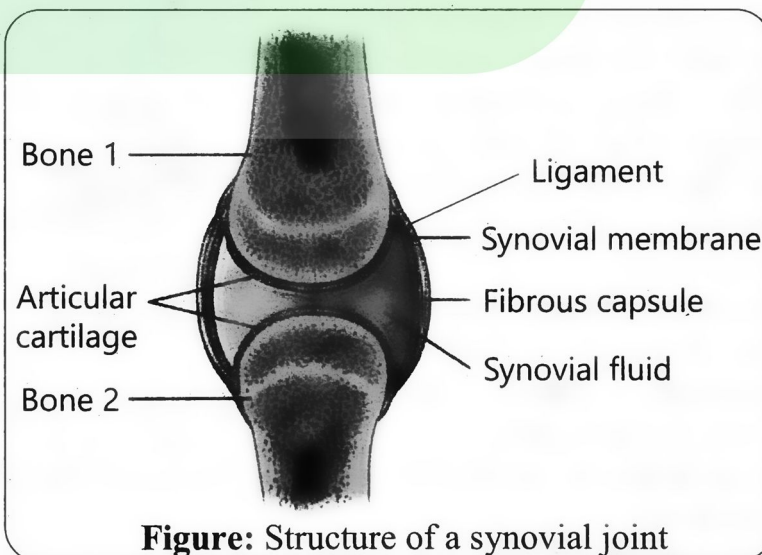
- Articular cartilage
- Fibrous capsule (joint capsule)
- Synovial fluid
- Ligaments

Articular Cartilage: A smooth, tough, and elastic hyaline cartilage, called **articular cartilage**, covers the ends of the bones in the joint. It provides a smooth and frictionless surface for movement.

Fibrous Capsule: A **fibrous capsule** surrounds the synovial joint and helps to hold the bones together. The fibrous capsule is composed of an outer layer of ligaments and an inner lining of synovial membrane.

Synovial Fluid: Synovial membrane secretes **synovial fluid**, which lubricates the joint.

Ligaments: Strong bands of connective tissue that connect the bones in the joint are called **ligaments**.



Q7. Define synovial joint. Classify synovial joints on the basis of range of motion. / Define synovial joint. Write its components and classification.

Ans. Definition: A type of joint which is characterized by a fluid filled cavity surrounded by a fibrous capsule.

Components of synovial joint

Synovial joint is composed of:

- Articular cartilage
- Fibrous capsule (joint capsule)
- Synovial fluid
- Ligaments

Articular Cartilage: A smooth, tough, and elastic hyaline cartilage, called **articular cartilage**, covers the ends of the bones in the joint. It provides a smooth and frictionless surface for movement.

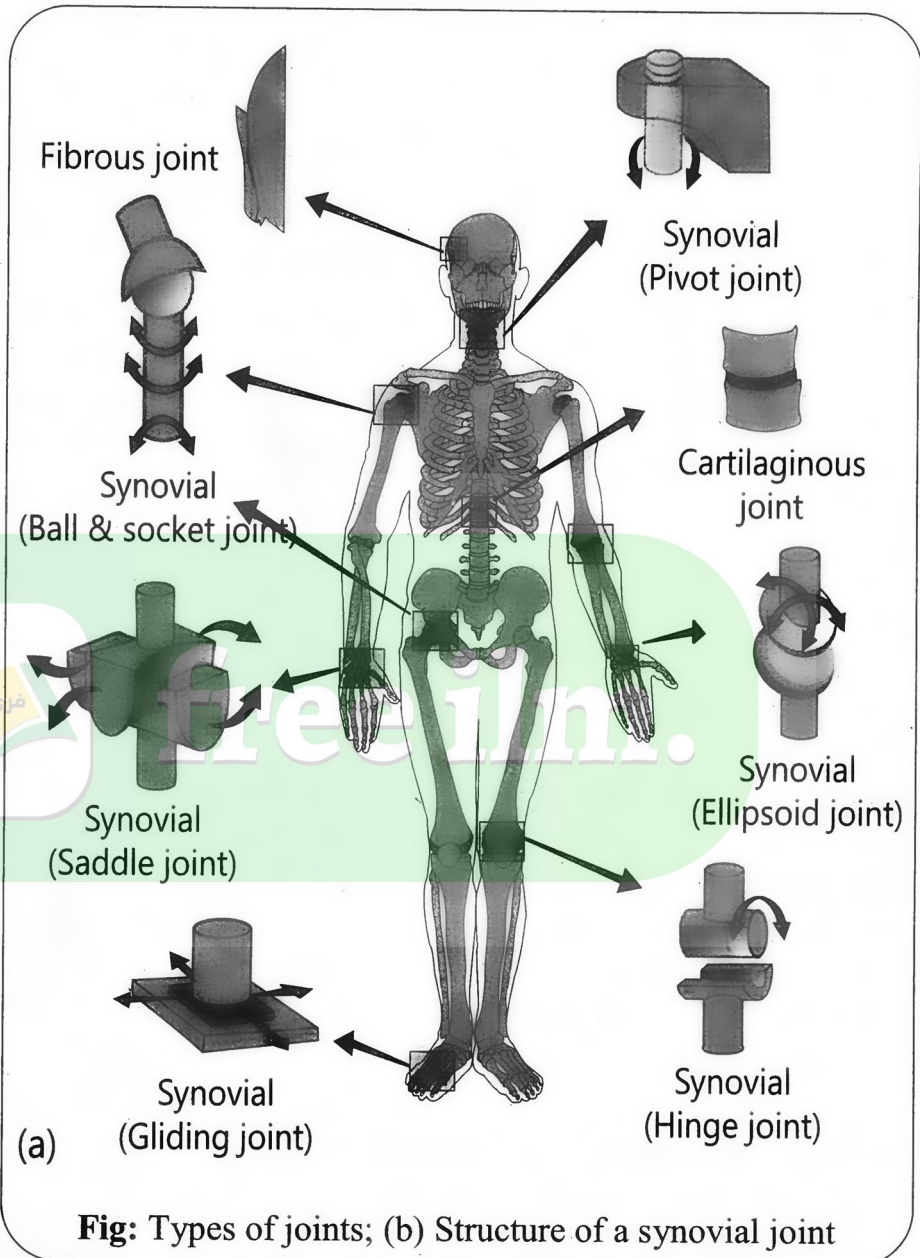
Fibrous Capsule: A **fibrous capsule** surrounds the synovial joint and helps to hold the bones together. The fibrous capsule is composed of an outer layer of ligaments and an inner lining of synovial membrane.

Synovial Fluid: Synovial membrane secretes **synovial fluid**, which lubricates the joint.

Ligaments: Strong bands of connective tissue that connect the bones in the joint are called **ligaments**.

Classification: There are six main types of synovial joints based on the range of motion.

- Ball-and-socket joint** allow motion in all directions e.g., shoulder and hip joints.
- Hinge joint** allow movement in only one plane, like a door hinge e.g., **elbow and knee** joints.
- Pivot joint** allow rotational movement around a single axis e.g., joint between the first (**Atlas-C1**) and second (**Axis-C2**) vertebrae of the neck.



- iv. **Ellipsoidal joint** allow movement in two planes, but not rotation e.g., joint of wrist with radius.
- v. **Saddle joint** allow movement in two planes because one bone has a concave surface and the other has a convex surface e.g., **thumb**, **sternoclavicular** and **incudomalleolar joints** (joint between malleus and incus of middle ear ossicles).
- vi. **Gliding (Plane) joint** allow gliding movements between bones e.g., joints between the vertebrae and the joints between the bones in wrist (inter-carpal) and ankle (inter-tarsal).

★Q8. What is joint transplantation/Arthroplasty? Describe most common types of joint transplantation.

Ans. Joint Transplantation: It is a surgical procedure in which a damaged joint is replaced with a healthy natural joint (from donor) or an artificial joint.

Types: The most common types of joint transplantation are:

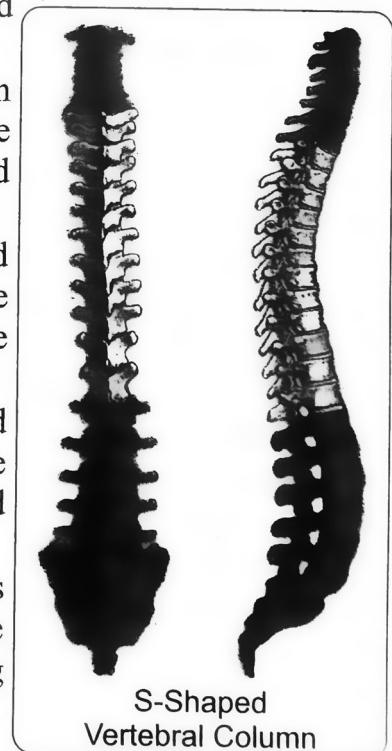
1. **Total arthroplasty / Total joint replacement:** In this procedure, the entire damaged joint is replaced with an artificial joint made of metal, plastic, or ceramic.
2. **Partial arthroplasty / Partial joint replacement:** In this procedure, only the damaged part of the joint is replaced with an artificial component. This is often used in the knee joint.
3. **Allograft transplantation:** In this procedure, a healthy joint from a donor is transplanted to replace the damaged joint. This technique is often used in the ankle and knee joints.
4. **Chondrocyte implantation:** In this procedure, chondrocytes from patient's own joint are implanted into the damaged joint. This technique is often used in the knee joint.

★Q9. How the bipedal posture of humans is linked to skeleton and musculature? Which problems can arise due to improper posture?

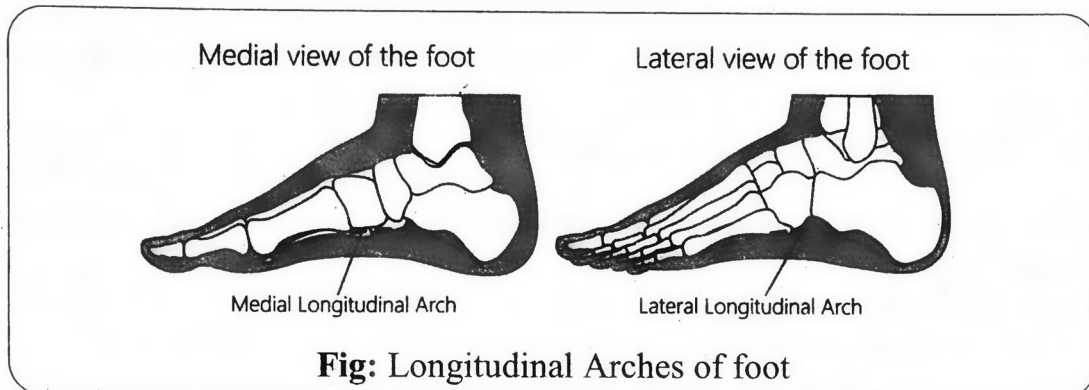
Ans. Human Skeleton & Musculature helps in Bipedal Posture

(a) The bipedal posture of humans is linked to skeleton and musculature in several ways.

- **S-Shaped Vertebral Column:** The human vertebral column has a distinctive S-shaped curve, which helps to distribute weight evenly and maintain balance while standing and walking.
- **Broad and Short Pelvis:** Human pelvis is shorter and broader, which helps to stabilize the torso (body excluding the head, neck and limbs, also called trunk) and support the body's weight on two legs.
- **Angled Femur:** The human femur is also angled inward towards the knee joint, which helps to keep the body's centre of mass over the feet. It allows stability while standing and walking.
- **Gluteal Muscles:** The muscles are located in the buttocks (gluteus maximus, gluteus medius and gluteus minimus), are much larger in humans. They play a crucial role in stabilizing the torso and propelling the body forward while walking.



- **Calf Muscles:** The calf muscles (gastrocnemius and soleus) are also well-developed in humans, providing power for walking and running.



- **Longitudinal Arches of Foot:** Human foot has a longitudinal arches (medial and lateral) that helps to absorb shock and distribute weight evenly across the foot.
- **Short and Less Prehensile Toes:** The toes are shorter and less prehensile (not adapted for grasping or holding), allowing the foot to function more effectively as a lever during walking and running.

(b) Problems due to Improper Posture

Improper posture can negatively affect bones and joints, causing:

- Vertebral Misalignment:** This can lead to back and neck pain, and herniated discs by putting pressure on vertebrae and nerves.
- Joint Strain:** Poor posture can strain neck, shoulders, hips, and knees, leading to pain, inflammation, and potentially arthritis.
- Muscle Imbalance:** Overused and underused muscles from poor posture can pull bones and joints out of alignment.

Disorders of the Skeleton

Q10. Describe the causes and symptoms of disc-slip.

Ans. Disc Slip: The intervertebral discs between vertebrae act as shock absorbers and help in movement. A herniated or slipped disc occurs when the outer layer of the intervertebral disc tears or ruptures, causing the inner gel-like substance to leak out and press against nearby nerves or spinal cord.

Causes: It may be caused due to

- **Trauma**
- Degenerative changes due to **aging**.
- **Repetitive strain** on vertebral column.

Symptoms: Symptoms of slipped disc include **pain**, **numbness**, or **tingling** in the affected area, **weakness** or loss of **muscle function**, and in severe cases, bowel or **bladder dysfunction**.

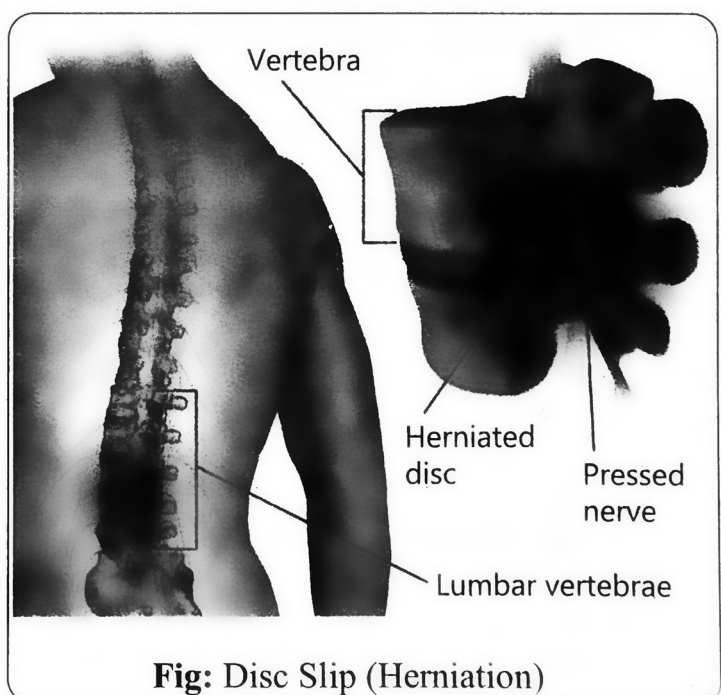


Fig: Disc Slip (Herniation)

Q11. Write causes and symptoms of Spondylosis and Sciatica.

Ans. Spondylosis: Spondylosis means degeneration of vertebrae, intervertebral discs, ligaments or cartilage of vertebral column. It may result in **narrowing** and **fusion** of intervertebral disc and development of bone outgrowths. It puts pressure on the nerves or spinal cord. Spondylosis is most common in the lower back (lumbar vertebrae) and neck (cervical vertebrae).

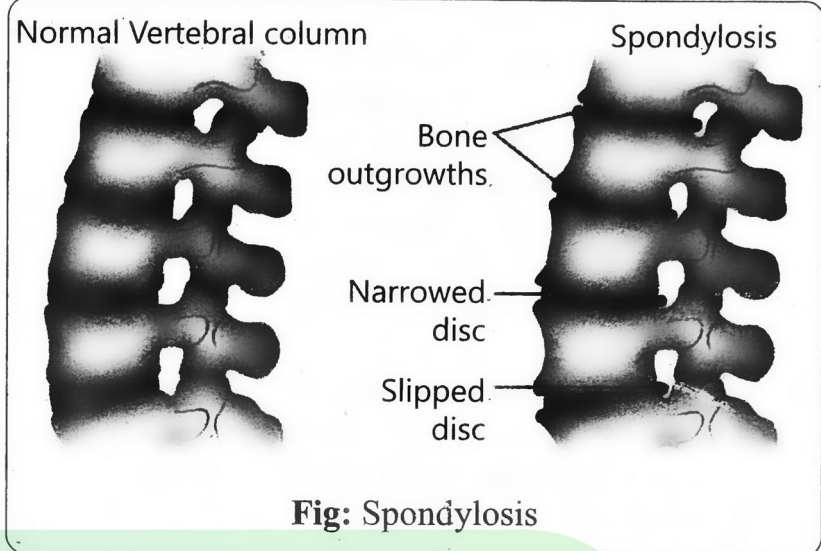
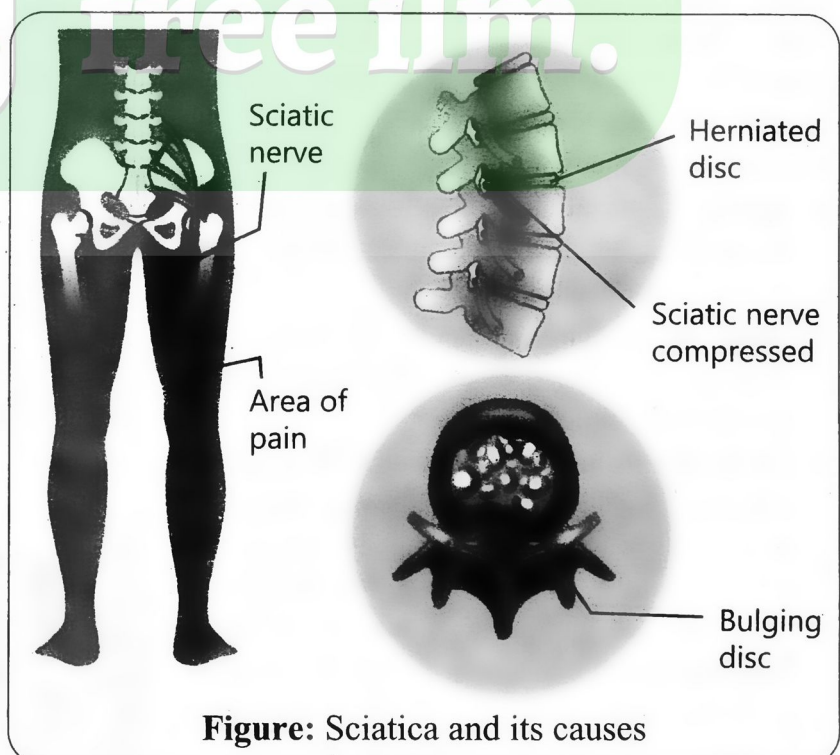
Causes: The most common cause is the natural degeneration of intervertebral discs. It occurs with **aging, genetic factors, trauma**, and prolonged periods of **poor posture** and obesity.

Symptoms: Symptoms include **back or neck pain, stiffness, and reduced range of motion.**

Sciatica: Sciatica means compression or irritation of the sciatic nerve. The sciatic nerve starts from lower back and goes down through the buttocks into each leg.

Causes: Sciatica is often caused by a **herniated disc** or bulging disc, which can put pressure on the sciatic nerve. Other causes of sciatica include **trauma, infection, inflammation**, and spondylosis.

Symptoms: Symptoms include pain or discomfort in the lower back, buttocks, legs, or feet, **tingling** or numbness in the legs or feet, **weakness** or difficulty moving the legs or feet, most precisely flexion off leg is lost gradually.

**Fig: Spondylosis****Figure: Sciatica and its causes****Q12. Describe the types of arthritis with their causes, symptoms and treatment.**

Ans. Definition: The inflammation of joints or its components is called arthritis. Arthritis includes different inflammatory conditions that affect the joints.

Symptoms: Symptoms include **pain, stiffness, redness, warmth** and swelling in affected joints.

Types: The following are important types of arthritis.

1. **Osteoarthritis:** Osteoarthritis is the **most common** type. It occurs when the **articular cartilage** at the ends of bones in joints **gradually softens and disintegrates**. It affects knee, hip and intervertebral joints.

2. **Rheumatoid arthritis:**

Rheumatoid arthritis is the result of an **autoimmune disorder** in which synovial membrane becomes inflamed. Most commonly, the wrist and hands are involved.

3. **Gouty Arthritis:**

Gouty arthritis (or gout) occurs when there is a **build-up of uric acid** in the blood, which can form crystals in the joints and cause inflammation. The most common joint affected is the joint of the **big toe**. Other joints (knees, wrists and fingers) may also be affected.

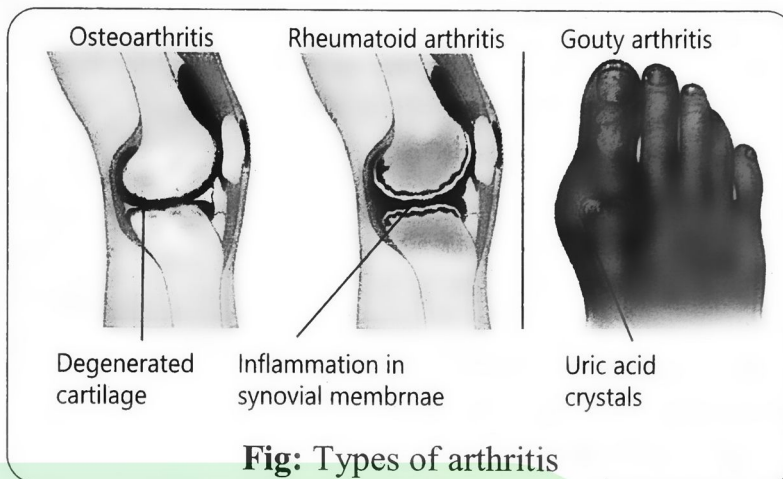


Fig: Types of arthritis

Q13. Write a note on osteoporosis.

Ans. Osteoporosis: Osteoporosis literally means '**porous bones**' it is a condition characterized by **decreased density**, amount and thickness of bone tissue, leading to weak, fragile and thin bones.

Causes: Its causes include.

- **Aging:** Due to aging bone mass naturally decreases. But it can be more pronounced in some individuals.
- **Drop in oestrogen levels:** In women, a drop in oestrogen levels after menopause accelerates bone loss.
- **Lack of calcium and vitamin D:** Lack of calcium and vitamin D in the diet can impair bone health. Calcium is crucial for bone strength, while vitamin D helps the body absorb calcium. **Lack of weight-bearing exercise:** Lack of weight-bearing exercise can lead to weakened bones especially in post-menopausal women.
- **Long-term use of corticosteroids:** Certain treatments such as long-term use of corticosteroids, can contribute to bone loss.

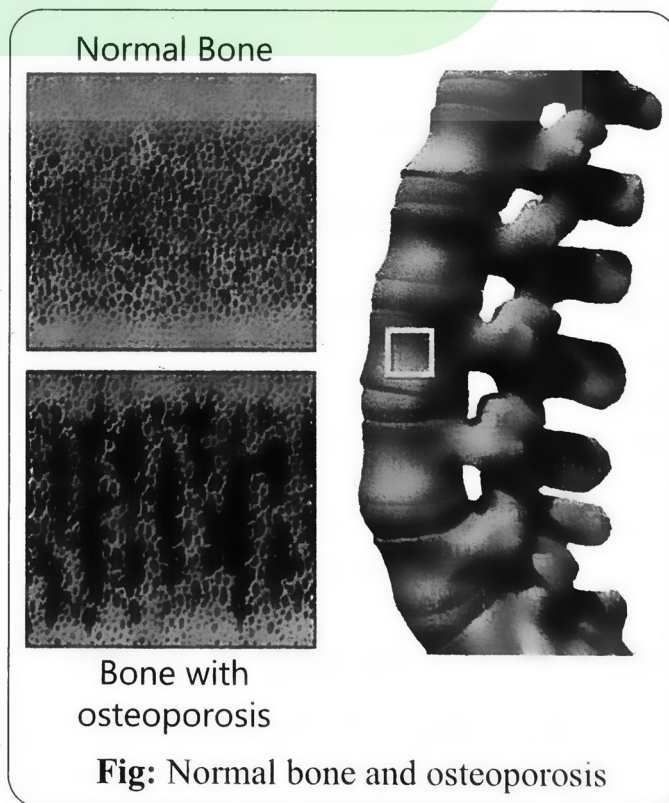


Fig: Normal bone and osteoporosis

- **Smoking and alcohol consumption:** Smoking and alcohol consumption can also increase the risk of osteoporosis.
- **Treatment:** Osteoporosis is treated according to its cause e.g., Estrogen replacement therapy (ERT) in case of drop in estrogen levels in postmenopausal women.

Q14. Describe some common injuries to joints. / Describe dislocation and sprain in context of joint injuries. Also describe their first aid treatment.

Ans. Injuries to Joints: Joints can be subject to a variety of injuries, which can result in pain, swelling, and reduced motion. Here are some common injuries to joints:

Dislocations: Dislocation or **luxation** refers to a medical term for abnormal separation or disruption of the normal position of bones at joint.

Causes

- Its causes include **natural degeneration** of intervertebral discs.
- This can happen as a result of a sudden impact or **trauma**.
- A severe dislocation can cause **tearing** of the **muscles**, **ligaments** and **tendons**.
- Rheumatoid arthritis can also cause **joint dislocation**.

Symptoms

- Symptoms include swelling, **intense pain**, and **immobility** of the affected joint.

Treatment: Surgery may be needed to repair or tighten the stretched ligaments. A dislocated joint can only be successfully corrected by a physiotherapist.

Sprain: A sprain is an injury to the ligaments that connect bones in a joint. Commonly injured ligaments are in the ankle, knee and wrist.

Causes: This can happen when the joint is forced beyond its normal range of motion, causing the ligaments to over stretch or tear.

Treatment: Sprains are usually treated with physical therapy. Dressings is done to immobilize the sprain and provide support.

First aid Treatment for Dislocation and

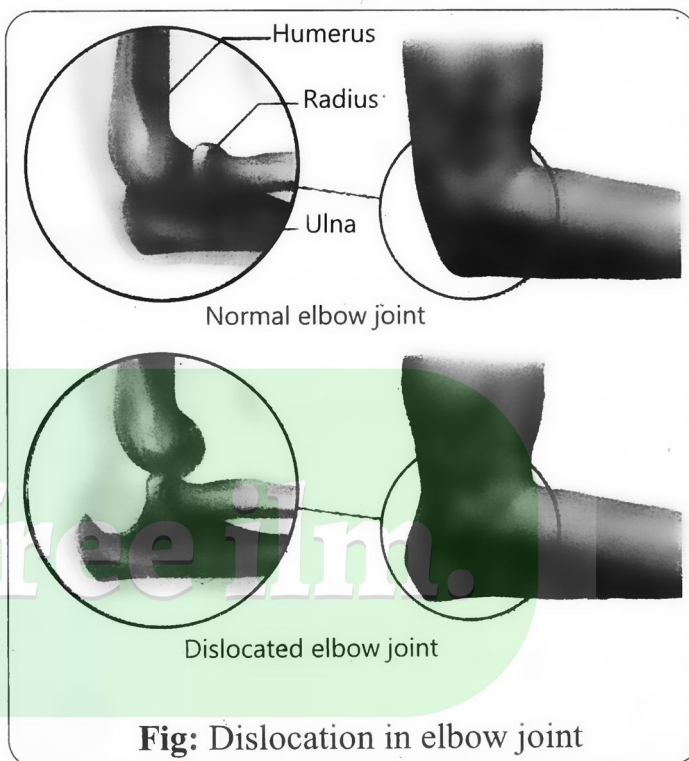


Fig: Dislocation in elbow joint

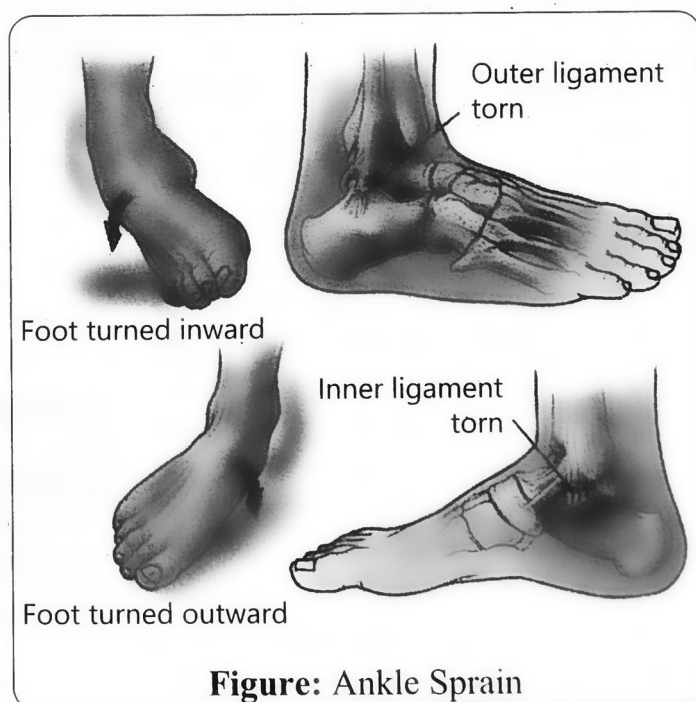


Figure: Ankle Sprain

Sprain

First aid treatment for dislocation and sprain includes the following steps:

i. **Immobilize the affected area:** Keep the affected area immobile and do not attempt to re-align the dislocated joint. Use a sling or splint to support the limb.

ii. **Apply ice:** Apply an ice pack or cold compress to the affected area to reduce swelling and pain.

iii. **Elevate the affected limb:** In the case of dislocation, if possible, elevate the affected limb above to help reduce swelling.

iv. **Seek medical attention:** Dislocations and sprain require medical attention, so call for emergency medical services 1122 or take the person to the hospital for further evaluation and treatment.

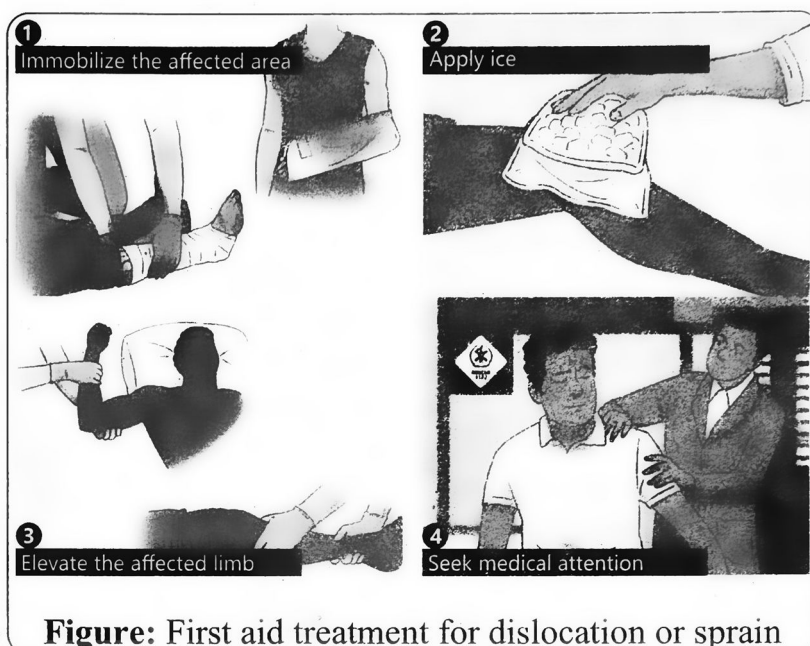


Figure: First aid treatment for dislocation or sprain

Q15. Describe the three types of muscles.

Ans. Definition: Muscle is defined as the tissue that can contract in a coordinated way to produce movements of body parts or whole body. The individual cells of muscle are called **muscle fibres** or **myofibres** or **myocytes**.

Types of Muscles: Human body has three types of muscle tissues: skeletal, smooth, and cardiac.

i. **Skeletal Muscles:** Skeletal muscles are responsible for **moving parts of the body**, such as the limbs, trunk, and face. The muscle fibres of skeletal muscles are elongated cells with **striations** have **many nuclei per cell**. Because their contractions are usually consciously controlled, skeletal muscles are called as **voluntary muscles**.

ii. **Smooth Muscles:** Smooth muscles are present in the walls of the stomach, intestines, blood vessels, and other internal organs.

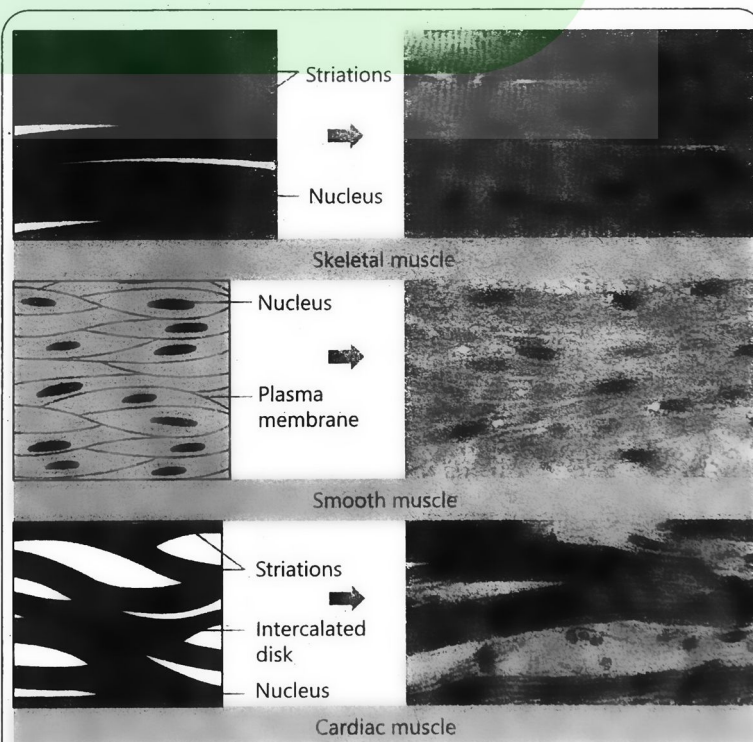


Figure: Types of muscles

Smooth muscle fibres are **spindle-shaped**, have a **single nucleus** and **lack striations**. Smooth muscle fibres are surrounded by connective tissue. Because most of their movements cannot be consciously controlled, smooth muscle is referred to as **involuntary muscle**.

- iii. **Cardiac Muscles:** These are found **only in the walls of the heart** (myocardium). Their fibres branch extensively. The muscle fibres of cardiac muscles are **striated** like skeletal muscle, but each cell usually contains **one nucleus** located near the centre and is **involuntary in control**.

Comparison of three types of muscle tissues			
Property	Skeletal Muscle	Smooth Muscles	Cardiac Muscles
Appearance	Regular striped	Un-striped	Irregular striped
Cell shape	Spindle or cylindrical	Spindle	Branched
Number of nuclei	Many per cell	One per cell	One per cell
Voluntary control	Have voluntary control	Usually, no voluntary control	No voluntary control
Function	To move skeleton	To move substances through hollow organs	To pump blood

Q16. Explain the ultrastructure of skeletal muscle.

Ans. Structure of Skeletal Muscles: The cells of skeletal muscles i.e., muscle fibres (myofibres) are in the form of bundles which are enclosed by collagen fibres and connective tissue. At the ends of a skeletal muscle, the collagen and connective tissue forms **tendons** which attach the muscle to bones.

Ultrastructure of Skeletal Muscles: Each skeletal muscle cell i.e., muscle fibre is a cylindrical multinucleated cell, enclosed by a plasma membrane called **sarcolemma**. Its cytoplasm is called **sarcoplasm** (have organelles, enzymes and glycogen) and it contains sarcoplasmic reticulum (SR), SER of skeletal muscles have stored Ca^{++} and no **ribosomes**. The sarcolemma penetrates deep into the cell to form hollow elongated tubes, the **transverse tubules** (T-tubules). The T-tubules reach the ends of SR.

Myofibrils: Each muscle fibre contains a bundle of **4 to 20 elongated threadlike structures** called **myofibrils**. Myofibrils are made up of two types of filaments.

- Thick filaments** composed of myosin. The thick filaments create dark bands called **A-bands**.
 - The thin filaments** are composed of actin. create light bands called **I-bands**. These alternating dark and light bands give skeletal muscle its striped (striated) appearance.
- Z-lines:** The thin actin filaments are attached to protein discs called Z-lines. The section between two **Z-lines** is a sarcomere, the smallest unit of muscle contraction. Within a sarcomere, the thin filaments extend from the Z-line toward the center, where they overlap with thick filaments. This overlap creates the **A-band**, with a lighter central region called the **H-zone/H-band** where no overlap occurs.

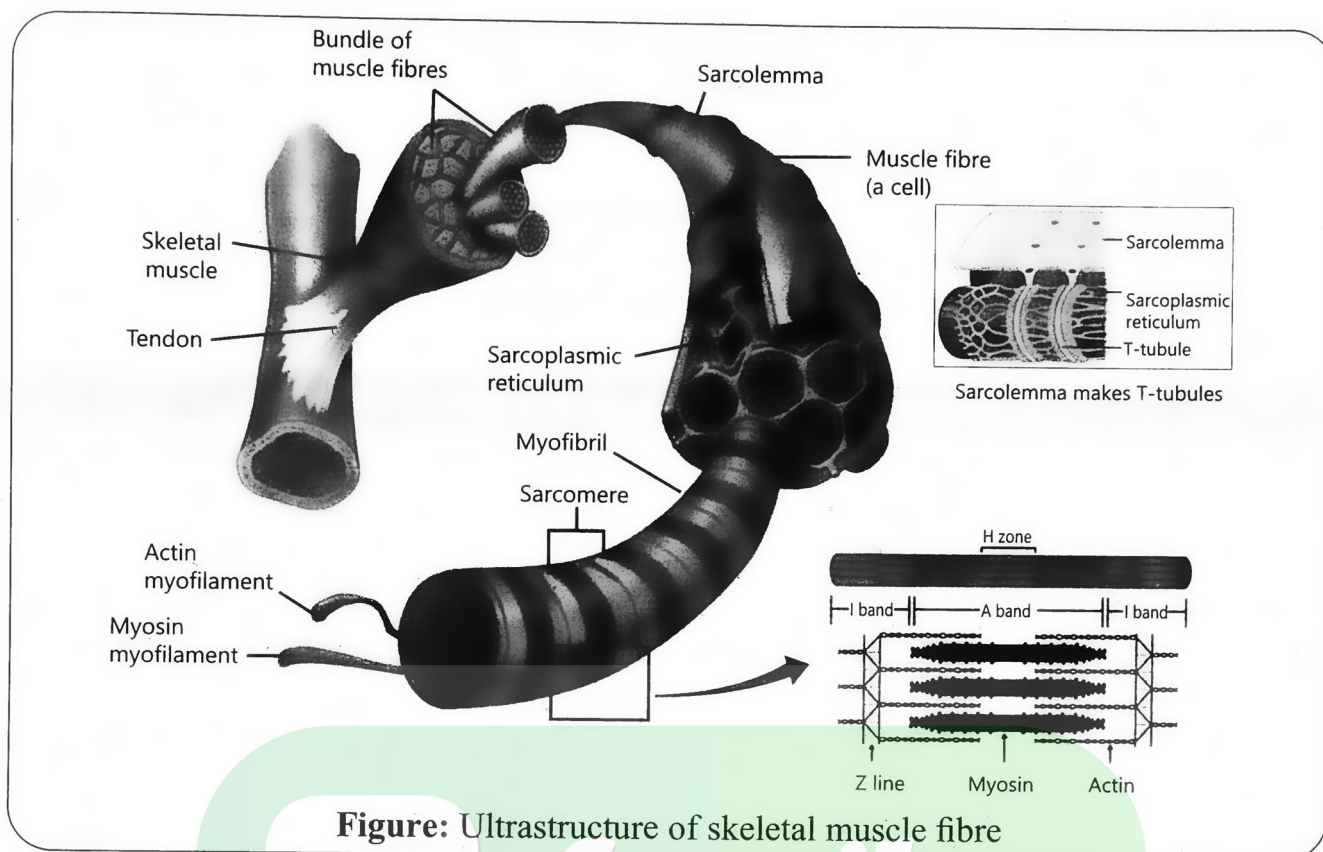


Figure: Ultrastructure of skeletal muscle fibre

During muscle contraction, the thin filaments slide deeper into the A-band, causing the H-band and I-band to narrow. The A-bands are pulled closer together, shortening the muscle. The center of the H-band may have a dark line called the **M-line** which helps stabilize the thick filaments.

Q17. Describe the biochemistry of myofilaments.

Ans. Biochemistry of Myofilaments

Thick myofilaments: Thick myofilaments, about **16 nm in diameter**, are made up of many myosin proteins. Each myosin protein consists of **two intertwined polypeptide chains**, ending in a **globular "head"**. These myosin heads extend from the thick filaments and connect to actin during muscle contraction.

Thin myofilaments: Thin myofilaments, **7-8 nm in diameter**, are made of three proteins: i.e. **actin tropomyosin and troponin**.

(i) **Core** is made of two twisted strands of **actin**.

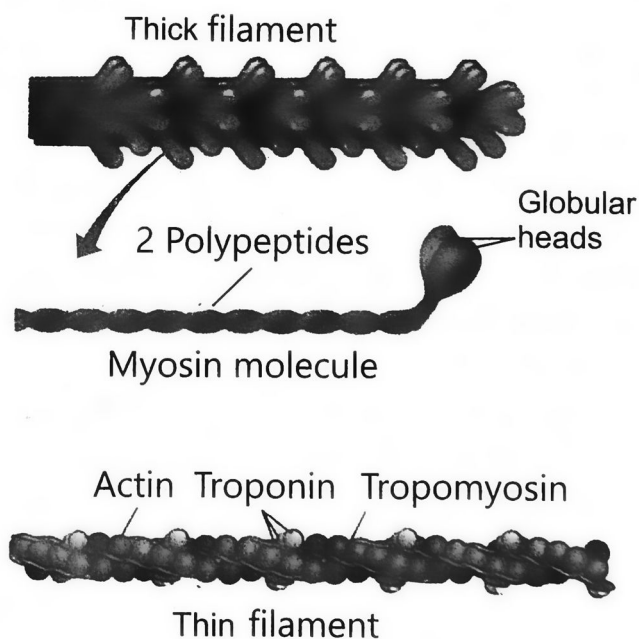


Figure: Structure of myofilaments

(ii) Two strands of **tropomyosin** wrap about actin core and stiffen it. In a relaxed muscle fibre, they block myosin binding sites on actin.

(iii) Troponin protein is present at regular intervals on thin myofilaments. It is made of three polypeptides.

- One polypeptide is **inhibitory (TnI)** and binds to actin.
- Second polypeptide **binds to tropomyosin (TnT)** to keep it in place.
- The third polypeptide **binds to calcium ions (TnC)**.

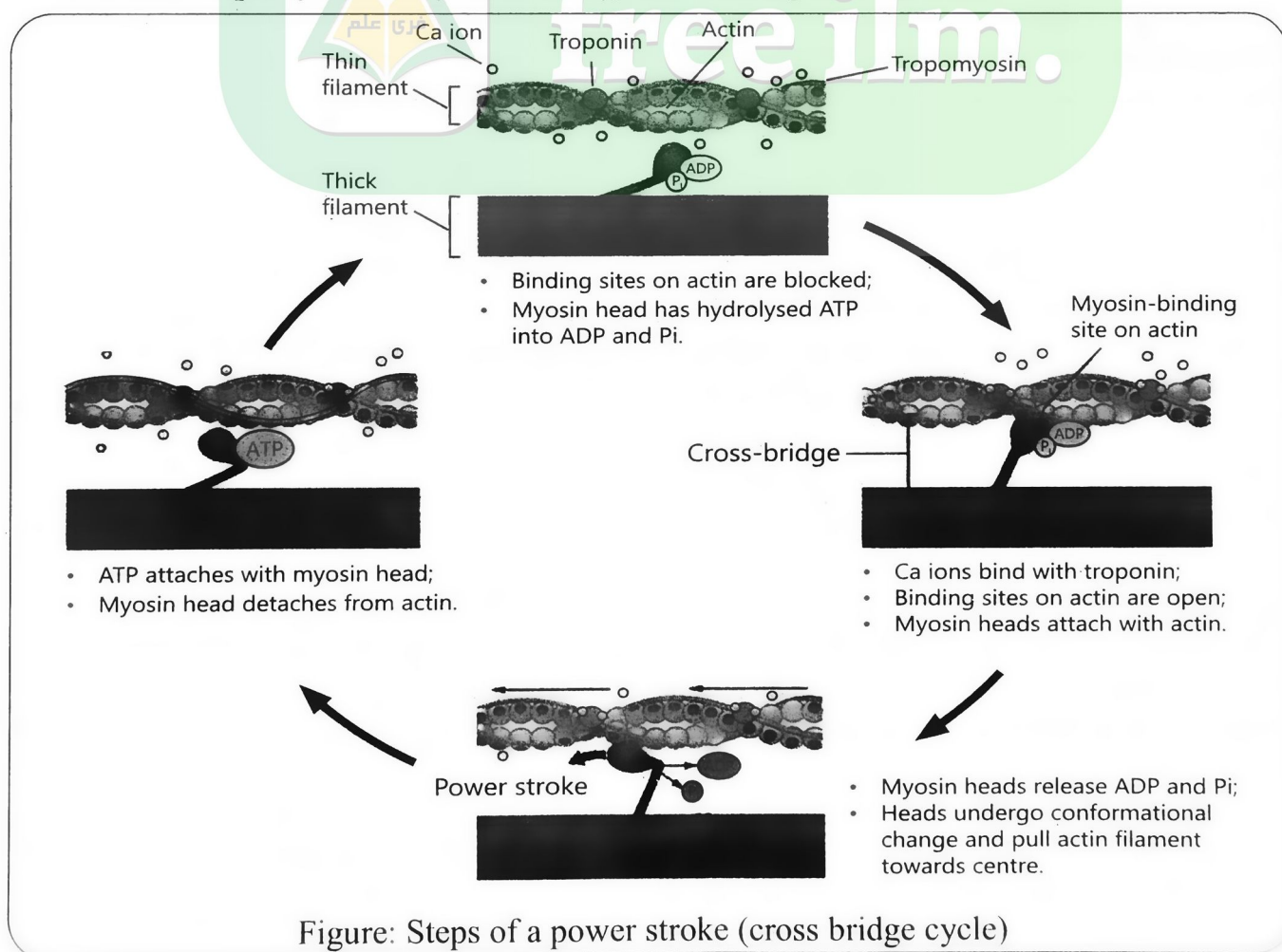
Q18. Write a detailed note on sliding filament model of muscle contraction.

Ans. Mechanism of Muscle Contraction - Sliding Filament Model

The sliding filament model explains how a muscle contracts. According to this model, a muscle contracts when its thin myofilaments slide past the thick ones so that they overlap to a greater degree.

Steps: It occurs in the following steps.

1. **Sarcomeres at relaxed state:** In a relaxed muscle, sarcomeres are at their normal length. The myosin heads are not bound to actin because the binding sites on actin are blocked by tropomyosin of thin filaments. Troponin, another protein, is attached to tropomyosin. Myosin heads have hydrolysed ATP into ADP and P_i .
2. **Arrival of Nerve Impulse:** When a nerve impulse reaches the muscle fibre, it travels along the sarcolemma to the T-tubules and then to the sarcoplasmic reticulum (SR). The SR releases **calcium ions into the cytosol**. These calcium ions bind to troponin, causing it to shift tropomyosin away from the myosin-binding sites on actin.



3. **Cross-bridges and Power-stroke:** When binding sites on actin are exposed, the myosin heads bind to them and form cross-bridges. Once the cross-bridges are formed, the myosin heads release the ADP and P_i , and undergo conformational change. They bend towards the centre of sarcomere, pulling actin filaments with them. This pulling action is called a **power stroke**.

It shortens the sarcomere, bringing Z-lines closer together and H-zone disappears. It occurs simultaneously in all sarcomeres, causing the muscle to contract. The adjacent A-bands of sarcomeres come closer to each other but do not shorten.

4. **Separation of Myosin Heads from Actin:** After pulling, the myosin head receives a new molecule of ATP. This allows the head to detach from actin. Splitting of this ATP into ADP and P_i puts the head into its original conformation, allowing the cross-bridge cycle to begin again.

Q19. Elaborate the arrangement of skeletal muscles of moveable joints to aid various movements. / Describe the antagonistic arrangement of skeletal muscle with examples.

Ans. Skeletal muscles are attached to bones by tough connective tissues called **tendons**.

Parts of structural muscle: Typically, a muscle has two attachment points on different bones. The end attached to the stationary bone during contraction is called the **origin**, while the end attached to the bone that moves is the **insertion**. The middle part of the muscle is known as the **belly**.

Antagonism: For the movement of bones at a joint in two directions muscles work in pairs. They produce opposing actions when they contract. Such arrangement of muscles is called **antagonistic arrangement**.

Flexor: The muscle which bends the bone at joint upon contraction is called flexor.

Extensor: The muscle which straightens the bone at joint upon contraction is called extensor. During such antagonistic action, when a muscle e.g., flexors contracts, the other muscle i.e., extensor is relaxed and vice versa.

- **Movement at Knee Joint as an example of antagonistic movement:** The knee joint is located between the femur (thigh bone) and the tibia and fibula (lower leg bones).

Flexion: Flexion, or bending, of the lower leg is done by the **hamstrings**. It is a group of three muscles at the back of the thigh.

Origin of hamstrings: The hamstrings originate at the pelvic girdle and the top of the femur.

Insertion of hamstrings: It is inserted at the upper parts of the fibula and tibia.

Extensions: Extension, or straightening, of the lower leg is done by the **quadriceps**. It is a group of four muscles at the front of the thigh.

Origin of Quadriceps: The quadriceps originate at the ilium (part of the pelvic girdle) and femur.

Insertion of quadriceps: It is inserted at the patella (knee cap) and tibia. When the hamstrings contract, the lower leg bends and the quadriceps relax. When the **quadriceps contract**, the lower leg **straightens** and the hamstrings relax.

Q20. Describe causes and symptoms of muscle fatigue, cramps and tetany.

Ans. Muscle Disorders: The following are some common muscle disorders

1. **Muscle Fatigue:** Muscle fatigue means a decline in muscle performance that occurs after prolonged or intense physical activity or due to some disease.

Causes: The following factors contribute to muscle fatigue:

i. **Low ATP:** During exercise, the muscles use ATPs to contract. When the supply of ATPs is depleted, the muscle is no longer able to contract.

ii. **Metabolic Waste:** As muscles work, they produce metabolic wastes e.g., lactate, hydrogen ions, and reactive oxygen. These wastes contribute to muscle fatigue.

iii. **Ca⁺⁺ ion handling:** When muscle fibres are repeatedly activated, they are not able to effectively handle calcium ions, which can impair muscle function.

iv. **Damage to muscle fibres:** Prolonged or intense exercise can cause small amounts of damage to muscle fibres, leading to inflammation and reduced muscle function.

Symptoms: Its symptoms include **pain, decreased muscle strength, and reduced endurance**. Muscle fatigue typically improves with rest. If it is severe, it requires medical attention.

2. Muscle Cramps

Muscles cramps are **sudden, involuntary** and often **painful contractions of a muscle** or group of muscles. They usually last from a **few seconds to several minutes** and most commonly occur in the legs and feet.

Causes

i. **Dehydration**

ii. **Imbalance of salts**

iii. **Overuse or injury of the muscle**

iv. **Medications** (like diuretics)

v. Medical conditions such as **diabetes**

vi. **Liver disease**

vii. **Nerve damage**

Treatment: To relieve muscle cramps, gently stretch and massage the affected muscle. Applying heat or cold to the area and using pain-relieving medications can also help.

3. Tetany

Tetany is a condition characterized by **involuntary muscle contractions** or spasms due to **increased muscle tone** and **hyperexcitability of the nerves**. These contractions can occur in various parts of the body such as hands, feet, face or larynx.

Causes

(i) The most common cause of tetany is **hypocalcaemia** (low level of calcium in blood) which may be due to **vitamin D deficiency**.

(ii) **Renal failure or thyroid disorders**.

(iii) **Salts imbalances, such as low level of magnesium in blood**.

Treatment: Treatment for tetany **depends on the underlying cause**. If tetany is caused by salts imbalances, treatment may involve calcium or magnesium supplements or intravenous fluid to restore electrolyte balance.

Difference between Tetany and Tetanus

Tetany	Tetanus
• Tetany involves increased muscles tone and overactive nerves, causing involuntary muscle creations or spasms. • Tetany can affect various body parts like the hands, feet, face or larynx. • Tetany can result from issues like electrolyte imbalances or nerve problems. • Tetany is less serious and usually not life-threatening as compared to tetanus.	• Tetanus is a severe bacterial infection caused by <i>Clostridium tetani</i>, which produces a toxin affecting the nervous system, leading to muscle stiffness and spasms. • Tetanus mainly affects the jaw and neck muscles. • Tetanus is caused by a specific bacterial infection. • Tetanus is more serious and potentially life-threatening compared to tetany.

★Q20. Justify how the main functions of the skeleton are to act as a system of rods and levers.

Ans. Skeleton is a system of rods and levers: The skeleton works like a system of rods and levers. Bones act as the **rods**, giving structure and support to the body and protecting internal organs.

In this system, joints serve as **fulcrums** (pivot points) for the levers, allowing movement. Muscles generate the **effort** or force, while the weight or resistance being moved is the load. **For example**, when lifting a weight, the bicep muscle in the upper arm acts as a lever. The elbow joint is the fulcrum, the bicep provides the effort, and the weight is the load.

★Q21. Justify why do muscles pull but don't push?

Ans. Muscles can only pull: Muscles can only pull, not push. This is because muscle fibres are designed to contract and shorten, pulling on tendons and thus moving bones. When a muscle contracts, it pulls on the bone via the tendon, and when it relaxes, the bone moves back to its original position.

Muscles cannot push because they only generate force by pulling. If a muscle were to push, it would need to be attached to bones at both ends and make both ends move closer together, which is not possible in the body. Muscles are usually attached to bone at only one end.