- **Compact Bone:** The thick layer under periosteum is made of hard material and is called compact bone. It makes up the majority of the bone tissue (Fig.).
- **Haversian System:** The basic structural units of compact bone are called **Haversian Systems**.
- **A Haversian system is made of:**
  - **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, on the other hand, is flexible but weak. As a result, bone is both strong and flexible.
  - **ii. Lacunae and Osteocyts:**
    - The lamellae are separated by small spaces called **lacunae**.
    - **Osteocytes:** Osteocytes which are mature bone cells, are located in the lacunae.
    - **Canaliculi:** 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 in Bones:** In addition to these structures, there are **small channels** that run perpendicular to the Haversian canals and connect them with each other and with the periosteum.
- These channels also contain **blood vessels**, nerves, and **lymphatic vessels.** Collagen fibres anchor the periosteum to the underlying **bone tissue**, providing additional **strength and stability** to the bone.
- Beneath the compact bone there is **spongy bone** (Fig.). It has a lattice work structure consisting of bony spikes that make it light and strong.

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

Check Understanding!
1. Both bones and cartilage consist of living cells embedded in the matrix of protein known as:
(A) Collagen (B) Keratin
(C) Insulin (D) Fibrinogen

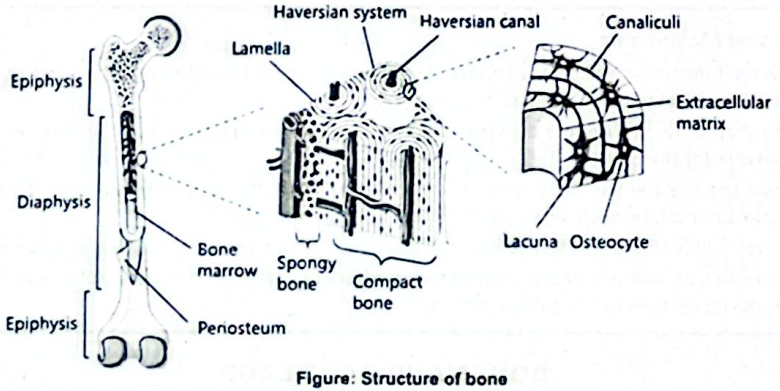


Figure: Structure of bone

Bone Marrow:

- **Bone Marrow:** Many bones also contain a **soft tissue called bone marrow.**
- Bone marrow can be either red or yellow.
- **Red Bone Marrow:** Red bone marrow is found in spongy bone, the ends of long bones, ribs, vertebrae, the sternum, and the pelvis.
- **Yellow bone Marrow:** It produces red blood cells, platelets, and white blood cells. 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.

Types of Bone Cells:

- There are three types of cells:
  (a) Osteoblasts (b) Osteocytes (c) Osteoclasts
- The bone cells are involved in the development, growth and remodelling of bones.

- 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.

(a) Osteoblasts: These are bone forming cells that synthesize and secrete unmineralized ground substance. Once the osteoblasts are surrounded by matrix, they become the osteocytes.

(b) Osteocytes: These are mature bone cells which maintain healthy bone tissue by secreting enzymes and bone mineral content.

- **Function:** They also regulate the calcium release from bone tissue to blood.

(c) Osteoclasts: They develop from macrophages and are involved in bone resorption, i.e., they break down bone and release calcium and phosphate in blood.

- **Function:** The work of osteoclasts is important to the growth and repair of bone.

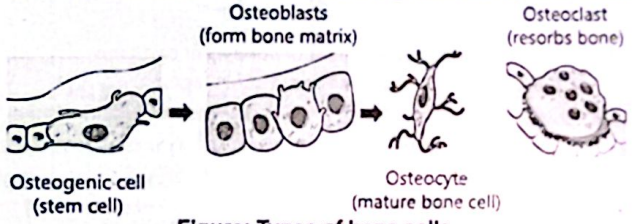


Figure: Types of bone cells

Bone Development:

- **Osteogenesis:** The process of bone formation is also called osteogenesis, it begins during **embryonic development** and continues throughout life, playing a vital role in growth, maintenance, and repair of bones.

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

Pathways of Osteogenesis:

There are two primary pathways of osteogenesis.

(1) 1st Pathway Formation Hardening of Bones with Forming Cartilage:

- The formation of long bones like **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.
- Blood vessels penetrate these cavities and introduce osteoblasts and osteoclasts.
- Osteoblasts (bone-forming cells) start building bone tissue, replacing the cartilage with new bone. The step by which cartilage is replaced by bone by the deposition of minerals is called ossification (Fig.).
- 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.

Check Understanding!
2. Define Bone.

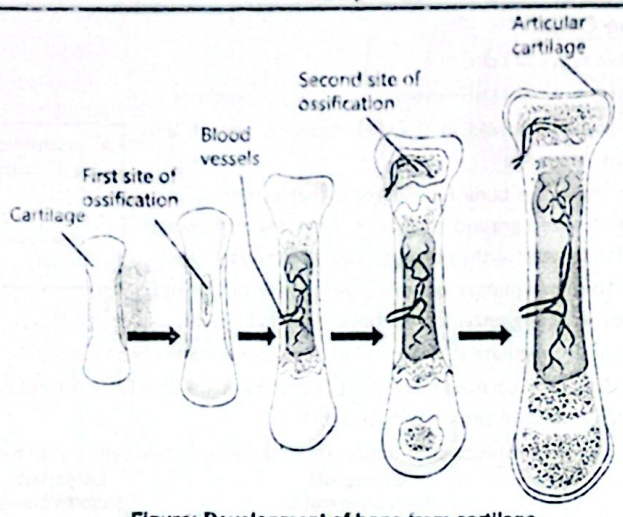


Figure: Development of bone from cartilage

(2) 2nd Pathway Formation Hardening of without Forming Cartilages:

- A few bones like some bones of the skull, develop directly into hard bone **without forming cartilage first**.
- **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.

➲ Structure of Cartilage:

- As described in the previous paragraph, 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.

Check Understanding

3. The living cells of cartilage are called:
(A) Chondrocytes (B) Chondrocytes
(C) Nematocytes (D) Blastocytes

- **Perichondrium:** A layer of connective tissue called perichondrium surrounds the cartilage. It contains **blood vessels, lymphatic vessels,** and **nerves** that supply the cartilage tissue.
- **Inside perichondrium** is the cartilage matrix which is composed of **collagen, elastin, proteoglycans,** and **other fibres**.
- Use it gives the tissue its strength, flexibility, and resistance to compression.
- **No Blood Vessels in Cartilage:** 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.
- **Cells of Cartilage:** The cartilage cells, called chondrocytes are present within small spaces called lacunae, which are embedded in cartilage matrix.
- **Functions of Cartilage:** Chondrocytes are responsible for synthesizing and maintaining the matrix of cartilage (Fig.)

Q. Describe the structure of three types of cartilage. (Textbook LQ)

➢ Types of Cartilage:

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

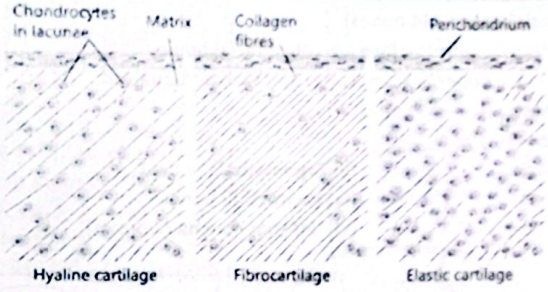


Figure: Cartilage types

Comparison between Bone and Cartilage

Feature	Bone	Cartilage
• **External covering**	• Periosteum	• Perichondrium
• **Cell types**	• Osteoblast, osteocytes and osteoclasts	• Chondrocytes
• **Extracellular matrix**	• Contains calcium crystals and collagen fibres	• Contains collagen and other fibres
• **Blood vessels**	• Present	• Absent
• **Growth & repair**	• Have the ability to grow and repair themselves throughout life	• Has limited ability to repair itself, as it has no direct blood supply

HUMAN SKELETON

➢ Parts of Human Skeleton:

- **The human skeleton can be divided into two parts.**
- **There are 206 bones** in adult human body.
  1. Axial Skeleton 2. Appendicular Skeleton

Check Understanding

4. Describe Pelvic Girdle and Hind Limb in human skeleton.

(I) Axial Skeleton: (80 bones)

- **The part of skeleton which consists of the skull vertebrae sternum ribs is called axial skeleton.**
- **Axial skeleton consists of total 80 bones.**

➢ Components of Axial Skeleton:

- The different components of axial skeleton are as under:
  (A) Skull (B) Vertebrae (C) Ribs (D) Sternum

(A) Components of Skull:

- **Skull is a composite structure which is made up of cranium and facial bones.**
- **The cranium consists of 8 bones, 4 unpaired and 02 paired, these bones protect the brain.**
- **Bones of Cranium: (8 bones)**

Paired Bones:

- There are two paired bones in cranium: (i) Parietal bones (ii) Temporal bones

Unpaired Bones:

- There are four unpaired bones in cranium:
  (i) Frontal bone (ii) Occipetal bone
  (iii) Sphenoid bone (iv) Ethmoid bone

- **Bones of Face/Facial Bones: (14 bones)**
  - The bones which support the **face** are called **facial bones**.
  - There are **14 facial bones**. Six are paired and two are **unpaired**.
- **Paired Facial Bones:**

The paired facial bones are:

(i) Maxilla (2 bones) **(ii) Zygomatic** (2 bones)
(iii) Nasal (2 bones) **(iv) Lacrimal** (2 bones)
(v) Palatine (2 bones) **(vi) Inferior concha** (2 bones)

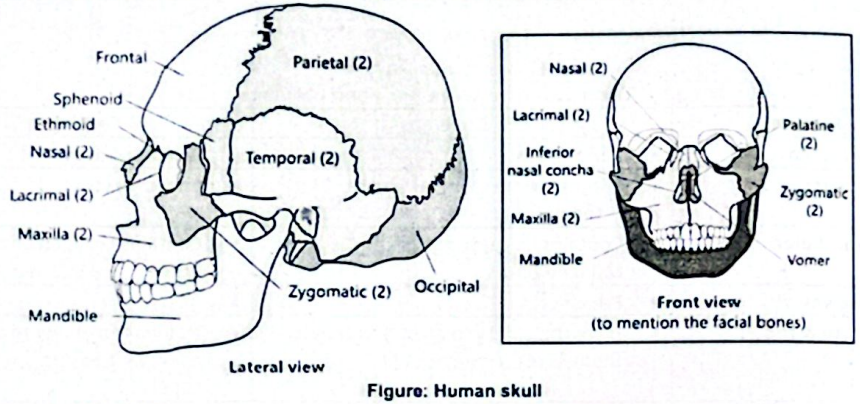


Figure: Human skull

- **Unpaired Facial Bones:**

The unpaired facial bones are as under:

(i) Mandible **(ii)** Vomer

Check Understanding!
5. Number of bones in the human skull is:
(A) 22, 6 paired, 10 unpaired
(B) 22, 4 paired, 14 unpaired
(C) 22, 8 paired, 6 unpaired
(D) 22, 10 paired, 2 unpaired

(B) Vertebral Column (33 Vertebrae)

- The back bone is called vertebral column it **is also called spine**.
- The vertebral column extends from the **skull to the pelvic region**.
- It gives protection to the **spinal cord**.
- Normally the vertebral column has **4 curvatures**. It provides more strength than the straight column.
- The vertebrae column consists of **33 vertebrae**, last nine vertebrae are fused.

Note
- Mandible is the only bone of skeleton, which is movable.

➢ Types of Vertebrae:

The vertebrae are named according to **their location.**

(i) Cervical vertebrae (ii) Thoracic vertebrae
(iii) Lumber vertebrae (iv) Pelvic vertebrae

(i) Cervical Vertebrae: (07 Bones)
- The vertebrae which lie in the **neck region are** called cervical vertebrae.
- They are seven (7) in number the first two vertebrae are named as atlas & axis respectively.

Note
- **Last 9 vertebrae** are fused into 5 **sacral** and 4 **coccyx** vertebrae, they are considered as 2 vertebrae so total vertebrae are **26 not 33**.

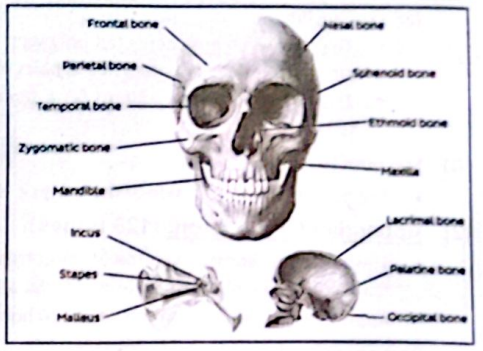
(ii) Thoracic Vertebrae: (12 Bones)
- The vertebrae which lie in the **thoracic region** are called thoracic vertebrae.
- They are 12 in number.

(iii) Lumber Vertebrae: (05 Bones)
- The **vertebrae** which lie in the lower back are called lumber vertebrae.
- They are five (5) in number.

(iv) Pelvic Vertebrae: (02 Bones)
- They are lie in hip region.
- They are **nine (9)** in number and divided in two sets.

(a) Sacrum: The vertebrae which comprise **sacrum** are called **sacral vertebrae.**
- They are **5 in numbers** they are fused.

(b) Coccyx: (Cok-Six): The vertebrae which comprise **coccyx or tail** are called coccyx vertebrae they are 4 fused vertebrae.



(C) Ribs (24 Bones)

- It is composed of 12 pairs (24) of ribs.
- The ribs articulate posteriorly **with thoracic vertebrae**.
- There are three types of ribs:

(i) True ribs **(ii)** False ribs **(iii)** Floating ribs

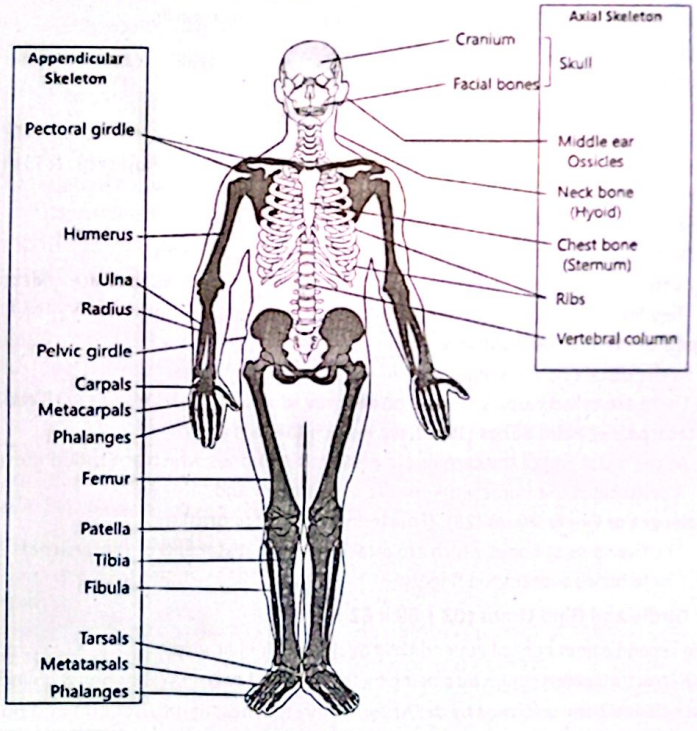


Figure: Human skeleton

(i) True Ribs:
- The ribs which are independently connected with sternum through their separate coastal arches.
- The first 7 pairs of ribs are true ribs.

Check Understanding!
6. How many ribs do not attach with the sternum?

(ii) False Ribs:
- The ribs which are connected with **sternum through** single common costal arch are called false ribs.
- Three pairs of ribs i.e. 8th, 9th, 10th pairs of ribs.

(iii) Floating Ribs:

- The ribs which are connected only with the thoracic vertebrae posteriorly but not attached with sternum are called floating ribs. **2 pairs of ribs** i.e. **11th and 12th pairs of ribs.**
- The rib cage **provides support** for a semivacuum chamber called the chest cavity and protects the heart and lungs.

(D) Sternum (01 Bone)

- The bone of the ventral side of the thorasic is called **sterum or breast bone.**

(2) Appendicular Skeleton: (126 bones)

- The part of **vertebratal skeleton** which consists of **pectoral girdles,** pelvic girdles and appendage i.e. fore limbs and hind limbs is called appendcular skeleton.
- Appendicular skeleton composed of 126 bones.

Check Understanding!
7. The clavicle connects scapula with:
(A) Skull (B) Sternum
(C) Femur (D) Tibia

➢ Components of Appendicular Skeleton:

(A) Pectoral girdle & fore limbs **(B)** Pelvic girdle & hind limbs

(A) Pectoral Girdle and Fore Limbs (04 + 60 = 64 Bones)

- The bones which join **fore arm with spine** is called pectoral girdle
- The pectoral girdle comprises of scapula and clavicle.
- In human clavicle connects **scapula with sternum.**

Bones of Fore Arms: (60 Bones)

(i) Humerus (02): (One in each fore arm)

- The single bone which is present in the upper arm is called humerus. It forms ball and socket joint with scapula.

(ii+iii) Radius & Ulna (04):

- Radius (One in each fore arm) & Ulna (One in each fore arm)
- At the distal end of the humerus are present two long bones they are called **radius and ulna.**
- They form hinge joint with **humerus.**

(iv) Carpals or Wrist Bones (16): (Eight in each fore arm)

- At the distal end the radius and ulna are present on bones.
- There are called carpals or wrist bones they form a multistage joint with radius ulna.

(v) Metacarpals or Palm Bones (10): (Five in each fore arm)

- At the distal end of the carpals are present long bones which are called metacarpals.
- It constitutes the frame work for the plan of the hand.

(v) Phalanges or Finger Bones (28): (Fourteen in each fore arm)

- The five rows of bones which are attached at the distal end of metacarpals are called phalanges.
- These bones support the fingers.

(B) Pelvic Girdle and Hind Limbs (02 + 60 = 62 Bones)

- The second component of appendicular skeleton is pelvic girdle.
- The structure which comes into being by the union of two coaxal bones is called pelvic girdle.
- Each Coaxal bone is formed by the fusion of three bones; ileum, ischium and pubis.
- These bones are called hip bones

Check Understanding!
8. Describe Pelvic Girdle.

Bones of Hind Limbs: (60 Bones)

- The forelimb consists of:
  (i) Femur (02) (ii) Tibia (02) (iii) Fibula (02) (iv) Tarsals (14)
  (v) Metatarsels (10) (vi) Phalanges (28) (vii) Knee Caps (Patella) (02)
- The hind – limb consists of 1 femur, 1 tibia and 1 fibula, 7 tarsals 5 meta – tarsals and 14 phalanges

(i) Femur:

- Femur is the proximal bone which forms a hip joint with the hipbone, it is a ball and socket joint

(ii+iii) Tibia And Fibula:

- At the distal end, the femur knee joint with the proximal end of two parallel bones called tibia and fibula.

(iv+v) Tarasals and Metatarsai:

- The distal end of the tibia and finula forms a joint with eight tarsals, which are also distally attached to five metatarsal bones of ankle.

(vi) Phalanges:

- Five rows of the fourteen phalanges of the toes are attached to metatarsals.

Arrangement of Bones in Skeleton:

- Human **skeletal system** consists of **206 bones.** Skeleton has **two main divisions:**
  (1) Axial Skeleton (2) Appendicular Skeleton

Joints:

- A joint is a place where two bones or bone and cartilage come together.
- There are three major kinds of joints are found in human body:
  (1) Fibrous (immoveable) Joints
  (2) Cartilaginous (slightly moveable) joints
  (3) Synovial (freely moveable) joints

Check Understanding!
9. The joint that allows the movements in two directions is called:
(A) Cartilaginous joints
(B) Synovial joints
(C) Hinge joints
(D) Ball and socket joints

➢ Types of Joints on the Basis of Range of Motion:

1. Fibrous Joints: (Immoveable)

- 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:
  - 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: (Slightly Moveable)

- In these joints, the bones are connected by a layer of cartilage.
- Cartilaginous joints allow little movement of the bones.
- **There are two main types of cartilaginous joints:**
  - In some cartilaginous joints, the bones are connected by hyaline cartilage. For example, the joint between the first rib and sternum.
  - In some cartilaginous joints, the bones are connected by fibrocartilage. For example, pubic symphysis in the pelvic girdle and intervertebral discs.

3. Synovial Joints: (Freely Moveable)

- Synovial joints are the most common type of joint in the human body, and they allow a wide range of movement.
- 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.
- 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, which secretes synovial fluid, which lubricates the joint.
- Strong bands of connective tissue that connect the bones in the joint are call ligaments.
- There are six main types of synovial joints based on the range of motion.
  i. **Ball-and-Socket Joints:** They allow motion in all directions e.g., shoulder and hip joints.
  ii. **Hinge Joints:** They allow movement in only one plane, like a door hinge e.g., elbow and knee joints.
  iii. **Pivot Joints:** They allow rotational movement around a single axis e.g., joint between the first and second vertebrae of the neck.
  iv. **Ellipsoidal Joints:** They allow movement in two planes, but not rotation e.g., joint of wrist with radius.

v. **Saddle Joints:** They allow movement in two planes because one bone has a concave surface and the other has a convex surface e.g., thumb joint.

vi. **Gliding Joints:** They allow gliding movements between bones e.g., joints between the vertebrae and the joints between the bones in wrist and ankle.

Check Understanding!
10. Differentiate between immovable and slightly movable joints.

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. The most common types of joint transplantation are:

- **Total joint re placement:** In this procedure, the entire damaged joint is replaced with an artificial joint made of metal, plastic, or ceramic.
- **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.
- **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.
- **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.

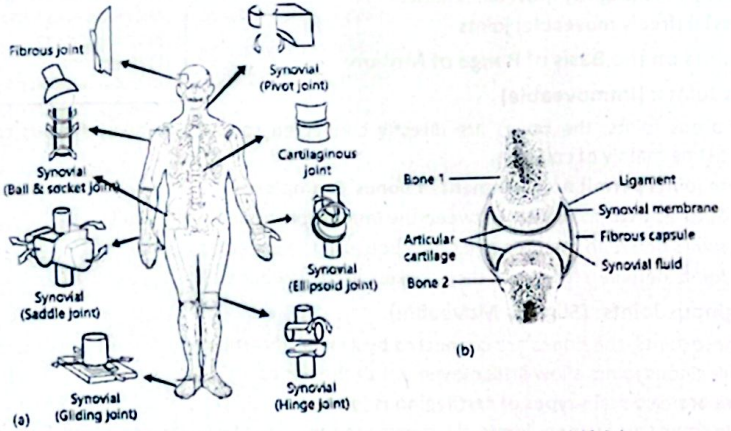


Figure: (a)- Types of joints; (b)- Structure of a synovial joint

Human Skeleton & Musculature helps in Bipedal Posture

The **bipedal posture** of humans is linked to skeleton and musculature in **several ways.**

i. The human vertebral column has a distinctive **S-shaped curve**, which helps to distribute weight evenly and maintain balance while standing and walking.
ii. Human pelvis is **shorter and broader**, which helps to stabilize the torso and support the body's weight on two legs.
iii. 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.
iv. The muscles are located in the buttocks, are much larger in humans. They play a crucial role in stabilizing the torso and propelling the body forward while walking.
v. The calf muscles are also well-developed in humans, providing power for walking and running.
vi. Human foot has a longitudinal arch that helps to absorb shock and distribute weight evenly across the foot.
vii. The toes are shorter and less prehensile, allowing the foot to function more effectively as a lever during walking and running.

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 Imbalances:** Overused and underused muscles from poor posture can pull bones and joints out of alignment.

DISORDERS OF SKELETAL SYSTEM

- Skeletal system is susceptible to a **wide range of disorders** that can impact its structure and function.
- These disorders can affect any part of the **skeletal system, including bones, joints, and connective tissues.**

Disorders of the Skeleton:

(1) 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.
- **Cause:** It may be due to a **trauma**, degenerative changes **due to aging**, or repetitive strain on vertebral column.
- **Symptoms:** Symptoms of slipped disc include **pain, numbness, and tingling** in the affected area, weakness or loss of muscle function, and in severe cases, bowel or bladder dysfunction.

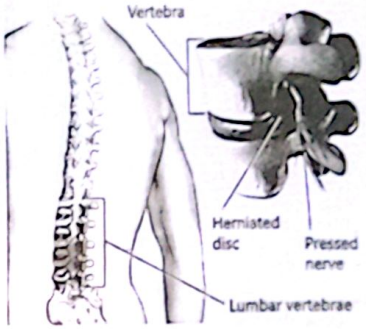


Figure : Disc slip (herniation)

Q. **Write the cause and symptoms of joint dislocation, spondylosis, and sciatica.** Exercise L.Q.3

(2) Spondylosis:

- Spondylosis means degeneration of **vertebrae, intervertebral discs**, ligaments or cartilage of vertebral column.
- **Cause:** 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).
- 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.

Check Understanding!
11. The disease which causes immobility and fusion of vertebral joints is called:
(A) Arthritis (B) Rickets
(C) Sciatica (D) Spondylosis

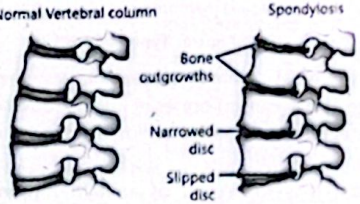


Figure: Spondylosis

(3) 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.

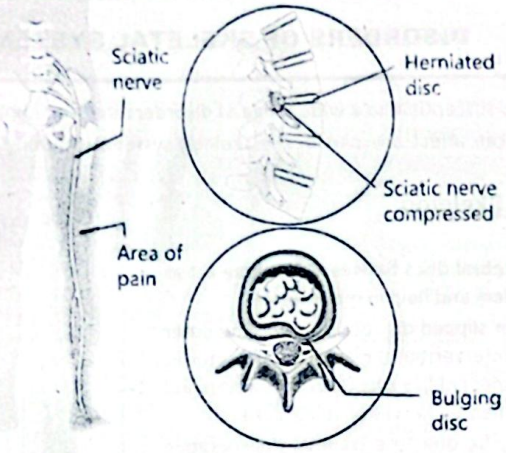


Figure: Sciatica and its causes

Q. Describe the types of arthritis, with their causes, symptoms and treatments. (Exercise Q.6)

(4) Arthritis:

- Arthritis include different **inflammator** conditions that affect the joints.
- **Symptoms:** Symptoms of all type include joint pain an stiffness. Other symptor may include redness, **warmth, swelling** in affected joints.

Check Understanding!
12. What is Sciatica?

➢ **Types of Arthritis:**

- The following are important types of arthritis.

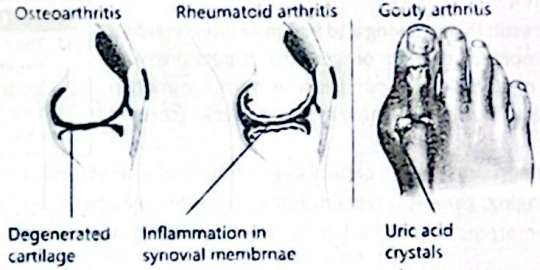


Figure: Types of arthritis

(a) Osteoarthritis: It 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.

(b) Rheumatoid Arthritis: It is the result of an autoimmune disorder in which synovial membrane becomes inflamed. Most commonly, the wrist and hands are involved.

(c) Gouty arthritis (or gout): It 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.

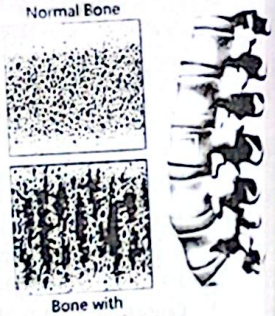


Figure: Normal bone and osteoporosis

(5) Osteoporosis:

- A condition characterized by **weakened** bones that are more easy to fractures and breaks is called **Osteoporosis**.
- **Causes:** It occurs when bone **density decreases**, making the bones fragile and porous.
- **Age Factors:** As people become aged, bone mass naturally decreases. But it can be more pronounced in some individuals.
- In women, a drop in oestrogen levels after menopause accelerates bone loss.
- **Vitamin D-Defficiency:** 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.
- **Effects:** Lack of weight-bearing can lead to weakened bones.
- **Treatment:** Certain treatments such as long-term use of corticosteroids, can contribute to bone loss.
- Smoking and alcohol consumption can also increase the risk of osteoporosis.

Check Understanding!
13. Disease in which bone resorption outpaces bone deposit:
(A) Osteoporosis (B) Osteomalacia
(C) Rickets (D) Spondylosis

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:

(1) Dislocations:

- A condition in which the bones in a joint are **forced out** of their normal or original positions is called dislocation. This can happen as a result of a sudden impact or trauma.
- A **severe dislocation** can cause tearing of the muscles, ligaments and tendons.
- **Symptoms:** Symptoms include **swelling, intense pain**, and **immobility** of the affected joint.
- **Examples:** Rheumatoid arthritis can also cause joint dislocation. A dislocated joint can only be successfully corrected by a physiotherapist. Surgery may be needed to repair or tighten the stretched ligaments.

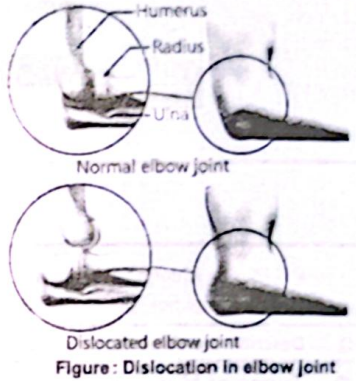


Figure: Dislocation in elbow joint

(2) Sprain:

- A injury to the ligaments that connect bones in a joint is called **sprain.**
- Commonly **injured** ligaments are in the ankle, knee and wrist.
- **Causes:** Sprain can happen when the joint is forced beyond its normal range of motion, causing the ligaments to stretch or tear.
- **Treatment:** Sprains are usually treated with physical therapy. Dressings is done to immobilize the sprain and provide support.

Figure: Ankle sprain

Steps Involve For First Aid Treatment for Dislocation and Sprain:

First aid treatment for dislocation and sprain includes the following steps (Fig.):

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

MUSCLES

- 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.

Q. Describe the three types of muscles. Exercise L.Q.5

Types of Muscles:

Human body has three types of muscle tissues: skeletal, smooth, and cardiac (Fig.).

(1) Skeletal Muscles

- The muscles which are responsible for moving parts of the body, such as the limbs, trunk, and face are called skeletal muscles.
- The muscle fibres of skeletal muscles are elongated cells with striations.
- **Voluntary In Action:** Because their contractions are usually consciously controlled, skeletal muscles are called as voluntary muscles.

(2) Smooth Muscles:

- The muscles which are present in the walls of the stomach, intestines, blood vessels, and other internal organs.
- **Shape:** Smooth muscle fibres are spindle-shaped, have a single nucleus and lack striations. Smooth muscle fibres are surrounded by connective tissue.
- **Involuntary In Action:** Because most of their movements cannot be consciously controlled, smooth muscle is referred to as involuntary muscle.

Check Understanding!
14. Give two characters of smooth muscles.

- Muscles' ability to contract and relax not only enables the body to move, but also provides the force that pushes substances, such as blood and food, through the body.

- Although our focus in this chapter is on humans, it is important to realize that essentially all animals employ muscles.
- For example, when a mosquito flies, its wings are moved rapidly through the air by quickly contracting flight muscles.
- When an earthworm burrows through the soil, its movement is driven by strong muscles pushing its body past the surrounding soil.

(3) Cardiac Muscles

- These are found only in the walls of the heart.
- Their fibres branch extensively.
- The muscle fibres of cardia muscles are striated like skeletal muscle, but each cell usually contains one nucleus located near the centre.

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

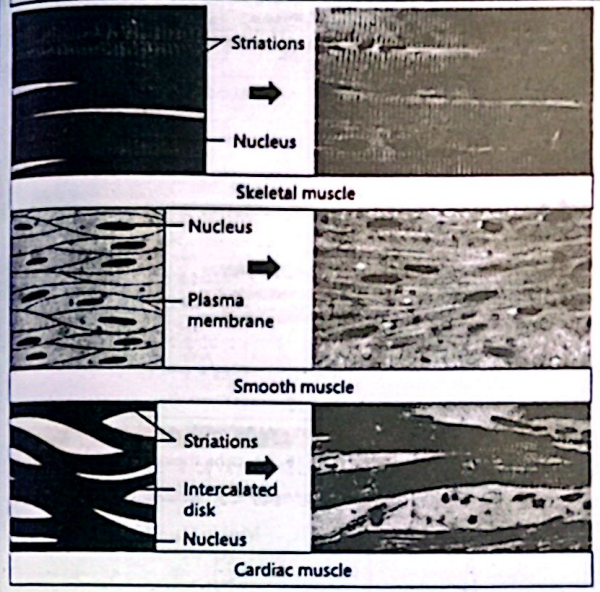


Figure : Types of muscles

Check Understanding!
15. What is not true about skeletal muscle fibers?
(A) 10-100 µm dia (B) Store glycogen
(C) Store myoglobin (D) 10-100 nm dia

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.

Q. Explain the ultrastructure of skeletal muscle. Exercise L.Q.6

Ultrastructure of Skeletal Muscles

- Each skeletal muscle cell i.e., muscle fibre is a cylindrical multinucleated cell, enclosed by a plasma membrane called sarcolemma (Fig.). Its cytoplasm is called sarcoplasm and it contains sarcoplasmic reticulum (SR). 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.

- 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 and thin filaments composed of actin. The thick filaments create dark bands called A-bands, while the thin filaments create light bands called Ibands. These alternating dark and light bands give skeletal muscle its striped (striated) appearance.
- The thin actin filaments are attached to protein discs called Zlines. 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-band, where no overlap occurs (Fig.).

- We can summarize the structural organization of a skeletal muscle as:
- A skeletal muscle is made of groups of cells called muscle fibres.
- Each muscle fibre contains bundles of myofibrils in its cytoplasm.
- Each myofibril is made of 2 types of myofilaments (myosin and actin).

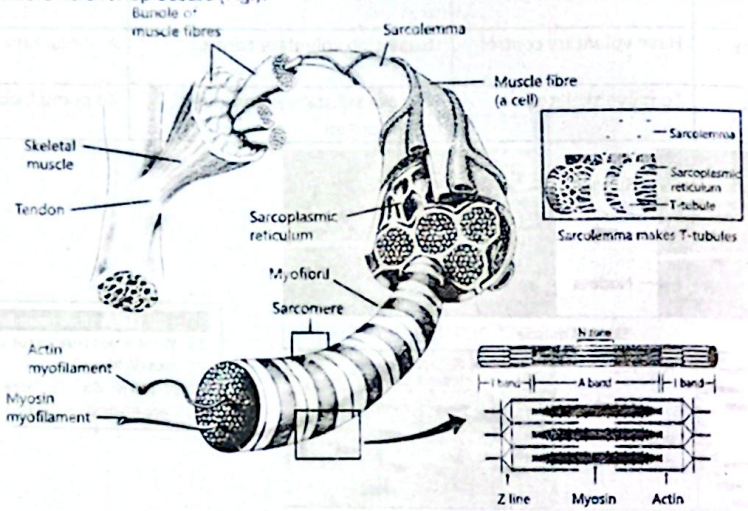


Figure : Ultrastructure of skeletal muscle

- 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.

Check Understanding!
16. Describe the role of Ca^{+2} and ATP in muscle contraction?

Biochemistry of 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 a[illegible] during muscle contraction (Fig. 12.21).
- Thin myofilaments, 7-8 nm in diameter, are made of three proteins: (i) Core is made of two twisted strands of actin. (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 and binds to actin; second polypeptide binds to tropomyosin to keep it in place. The third polypeptide binds to calcium ions.

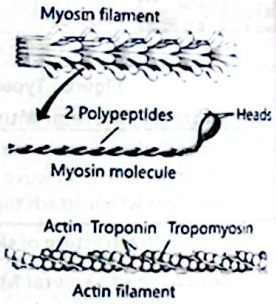
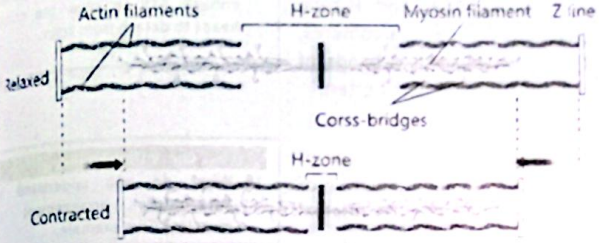


Figure: Structure of myofilaments

Q Write a detailed note on the sliding filament model of muscle contraction Exercise Q.3

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. It occurs in the following steps (Fig.):



- When a nerve impulse reaches sarcolemma, a neurotransmitter (acetylcholine) is released by motor neuron at the synapse.
- It stimulates the sarcolemma to produce its own electrochemical impulses which are carried into the muscle fibre to the T tubules.

Figure : Sliding filament model of muscle contraction

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 Pi.

Check Understanding!
17. Cyclic activity of cross bridges is regulated by:
(A) Calcium ions (B) Troponin
(C) ATP (D) Action

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.

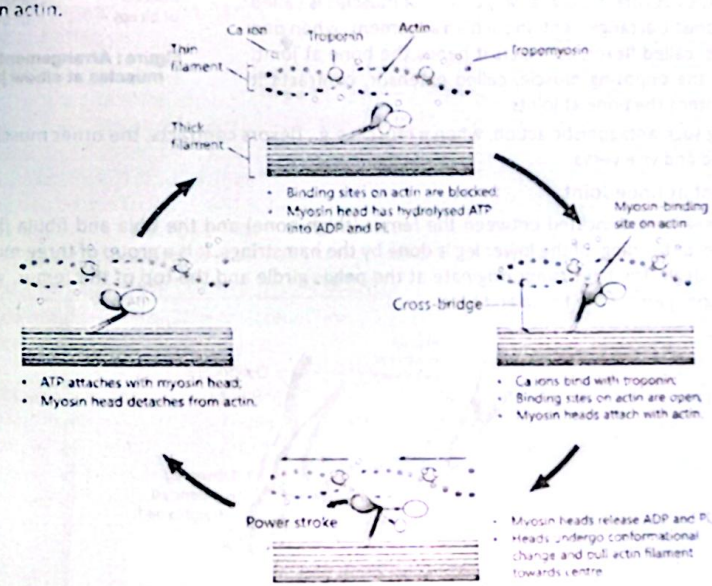


Figure : Steps of a power-stroke (cross bridge cycle)

3. Crossbridges 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 Pi, 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.

- After death, the cells can no longer produce ATP and therefore the cross-bridges cannot be broken.
- It causes the muscle stiffness of death, or rigor mortis.
- A living cell, however, always has enough ATP to allow the myosin heads to detach from actin.

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 Pi puts the head into its original conformation, allowing the cross-bridge cycle to begin again.

Check Understanding!
18. What do you understand by antagonistic arrangement of muscles? Give example.

Q. Explain the action of antagonistic muscles in the movement of knee joint. Exercise L.Q.5

➲ Arrangement of Skeletal Musclesat Moveable Joints

- Skeletal muscles are attached to bones by tough connective tissues called tendons. 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 (Fig.).

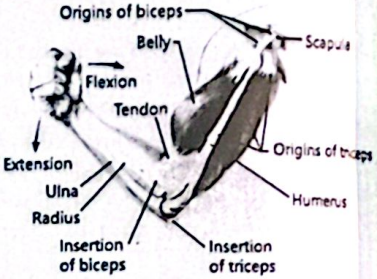


Figure: Arrangement of skeletal muscles at elbow joint

- 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. In such arrangement, when one muscle, called flexor, contracts it bends the bone at joint. When the opposing muscle, called extensor, contracts it straightens the bone at joints.
- 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

- The knee joint is located between the femur (thigh bone) and the tibia and fibula (lower leg bones). 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. The hamstrings originate at the pelvic girdle and the top of the femur, with insertions at the upper parts of the fibula and tibia.

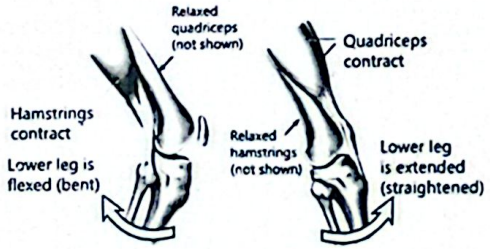


Figure: Movement at knee joint

- 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. The quadriceps originate at the ilium (part of the pelvic girdle) and femur, with insertions at the patella (kneecap) 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.

Q. Describe causes and symptoms of muscle fatigue, cramps and tetany. Exercise L.Q.10

➲ 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. Its symptoms include pain, decreased muscle strength, and reduced endurance. The following factors contribute to muscle fatigue:

Check Understanding!
19. Muscle fatigue is caused by
(A) CO_2 (B) Fumaric acid
(C) Ethyl alcohols (D) Lactic acid

- During exercise, the muscles use ATPs to contract. When the supply of ATPs is depleted, the muscle is no longer able to contract.
- As muscles work, they produce metabolic wastes e.g., lactate, hydrogen ions, and reactive oxygen. These wastes contribute to muscle fatigue.
- When muscle fibres are repeatedly activated, they are not able to effectively handle calcium ions, which can impair muscle function.
- Prolonged or intense exercise can cause small amounts of damage to muscle fibres, leading to inflammation and reduced muscle function.
- Muscle fatigue typically improves with rest. If it is severe, it requires medical attention.

2. Muscle Cramps

Muscle 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. Common causes include dehydration, an imbalance of salts, overuse or injury of the muscle, certain medications (like diuretics), and medical conditions such as diabetes, liver disease, and nerve damage. 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. The most common cause of tetany is hypocalcaemia (low level of calcium in blood) which may be due to vitamin D deficiency, renal failure, or thyroid disorders. Tetany may also be due to other salts imbalances, such as low level of magnesium in blood. Treatment for tetany depends on the underlying cause. If tetany is caused by salts imbalances, treatment may involve calcium or magnesium supplements or intravenous fluids to restore electrolyte balance.

➲ Difference between Tetany and Tetanus

Tetany and tetanus are different conditions often confused due to their similar names:

Check Understanding!
20. What is the difference between tetanus and muscle tetany?

1. Tetany involves increased muscle tone and overactive nerves, causing involuntary muscle contractions or spasms. Tetanus is a severe bacterial infection caused by Clostridium tetani, which produces a toxin affecting the nervous system, leading to muscle stiffness and spasms.
2. Tetany can affect various body parts like the hands, feet, face, or larynx. Tetanus mainly affects the jaw and neck muscles.
3. Tetany can result from issues like electrolyte imbalances or nerve problems. Tetanus is caused by a specific bacterial infection.
4. Tetanus is more serious and potentially life-threatening compared to tetany.

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

Q. Justify why do the muscles pull but do not push.

Muscles pull but do not push.	Skeleton is a system of rods and levers
• 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.	• 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.

Check Understanding (Solutions)

Sr. #	Option	Explanation
1.	A	• It is a strong, fibrous protein found in the matrix of both bones and cartilage, providing structural support, strength, and flexibility.
2.	S.Q	• Most rigid form of connective tissue, consists of matrix of collagen fibers hardened by calcium phosphate is called bone.
3.	B	• The living cells of cartilage are called chondrocytes because they are specialized to maintain and secrete the cartilaginous matrix, which consists mainly of collagen and proteoglycans.
4.	S.Q	**Pelvic Girdle:** • **Pelvic girdle attaches the** hind limb with the **vertebral column.** • Pelvic girdle consists of **two coxal bones.** • Each coxal bone is formed by the fusion of three bones, **ilium, ischium and Pubis.** • The pelvic girdle supports the pelvic region. **Hind Limb:** Each, hind limb is formed of following bones. • **Femur, Tibia and Fibula, Tarsals, Metatarsals and Phalanges.**
5.	C	The human skull has a total of 22 bones, which are divided as: **1. Paired Bones (8 pairs = 16 bones):** These occur on both the left and right sides. • Facial Bones (6 paired): • Maxilla (2) • Zygomatic (2) • Nasal (2) • Lacrimal (2) • Palatine (2) • Inferior nasal conchae (2) • Cranial Bones (2 paired): • Parietal (2) • Temporal (2) Total paired bones: 8 × 2 = 16 bones **2. Unpaired Bones (6 bones):** These are single bones in the midline. • Cranial (2 unpaired) • Frontal • Occipital • Sphenoid • Ethmoid • Facial (2 unpaired) • Mandible • Vomer Total unpaired bones: 6

6.	S.Q	**Floating Ribs: (Ribs Not Attached with Sternum)** • The ribs which are connected only with the thoracic vertebrae posteriorly but not **attached with sternum** are called floating ribs. 2 pairs of ribs i.e. 11th and 12th pair of ribs are not attached with sternum.
7.	B	• The clavicle (collarbone) connects the scapula to the sternum, forming part of the shoulder girdle and supporting arm movement.
8.	S.Q	**Pelvic Girdle:** • **Pelvic girdle attaches the** hind limb with the **vertebral column.** • Pelvic girdle consists of **two coxal bones.**
9.	C	• A hinge joint allows movement in two directions — forward (flexion) and backward (extension) — just like a door moves open and closed, as seen in the elbow and knee joints. • So yes, since the question refers to forward and backward movement (not side-to-side or rotation), hinge joint is correct.
10.	S.Q	**Immovable Joints** • The joints which show no movement at all and they connect the ends of the bones by a tough fibrous tissue. • **Example:** Joints found between bones of skull. **Slightly Movable Joints** • The joints which show little movement and these joints are mostly cartilaginous joints. • **Example:** Joints present between the vertebrae.
11.	D	• Spondylosis is the degeneration of the spinal discs and vertebrae causing stiffness and pain, but it does not typically cause fusion or complete immobility of the vertebral joints.
12.	S.Q	• It is **characterized** stabbing pain which radiates over the course of sciatic nerve is called sciatica e.g. **buttock** i.e. back of thigh, calf and foot.
13.	B	• Osteoporosis is the disease where bone resorption outpaces bone deposition, leading to weakened, porous bones and increased fracture risk. • Osteomalacia, on the other hand, involves softening of bones due to vitamin D deficiency, not increased resorption.
14.	S.Q	**Smooth Muscles:** • They are **non-striated** muscles. • They are long and spindle shape. • Each cell **contains a single** nucleus. • Their **contraction is spontaneous,** through nervous system & hormones so they are **involuntary** in action.
15.	D	• Skeletal muscle fibres have a diameter of about 10 – 100 micrometers (μm), not nonometers (nm); 10 – 100 nm is far too small for an entire muscle cell.
16.	S.Q	**Role of Calcium Ions in Muscle Contraction:** Calcium ions (Ca^{2+}) trigger muscle contraction by: • Binding to troponin and tropomyosin, exposing actin's binding sites • Allowing myosin heads to bind and pull actin filaments • Initiating sliding filament theory
17.	C	• The cyclic activity of cross-bridges in muscle contraction is regulated by troponin, which binds calcium ions and shifts tropomyosin, exposing actin binding sites for myosin attachment.
18.	S.Q	**Antagonistic Pair of Muscles:** • In the antagonistic pairs, **one muscle** reverses the **effect of the other** and they do not contract simultaneously.

		• If one muscle contracts, other relaxes and vice versa. • This action of muscles is called **antagonistic action of muscles.** **Example:** • **Biceps (flexor):** Contracts to bend the elbow. • **Triceps (extensor):** Contracts to straighten the elbow.
19.	D	• During intense or prolonged exercise, insufficient oxygen leads to anaerobic respiration, producing lactic acid, which lowers pH and interferes with muscle contraction, causing fatigue.
20.	S.Q	**Tetanus** • It is an **acute infectious disease** caused by anaerobic bacterium ***Clostridium tetani.*** • It results in persistent painful spasms of some skeletal muscles. Initially it causes lock jaw, then spasm of trunk and limb muscle, usually fatal due to respiratory failure. • It is major killer in developing countries where mortality rate is 40%. **Muscle Tetany** • It is the disease caused by low calcium in blood. • It increases the **excitability** of neurons and results in loss of **sensation.** • Muscle twitches and convulsions occur. • If untreated, may lead to spasm of larynx, **respiratory** paralysis and ultimately death occurs.

Exercise

Exercise **MULTIPLE CHOICE QUESTIONS (MCQs)** **Section 01**

1. **Which structures are part of the appendicular skeleton?**
   (a) Ethmoid bone (b) Floating ribs (c) Lumber vertebrae (d) Humerus bone
2. **The term muscle fibre or myofibre refers to;**
   (a) A cellular organelle (b) A cell (c) A tissue (d) An organ
3. **Which of these extends the entire length of a muscle fibre?**
   (a) Sarcomere (b) Myofibril (c) Myosin filament (d) Actin filament
4. **Actin filaments are made of proteins;**
   (a) Myosin and troponin (b) Actin and troponin
   (c) Actin and myosin (d) Actin, tropomyosin and troponin
5. **In a muscle, the Z-line are the proteins for the attachment of the ends of;**
   (a) Actin filaments (b) Myosin filaments
   (c) Both actin and myosin filaments (d) Sarcomeres
6. **Sarcomere is a part between;**
   (a) Two H-lines (b) Two A-bands (c) Two Z-lines (d) Two I-bands
7. **Which part of muscle fibre releases calcium ions which trigger contraction?**
   (a) Sarcolemma (b) Sarcoplasm (c) T-tubules (d) Sarcoplasmic reticulum
8. **Which statement is correct to describe sliding filament model of muscle contraction?**
   (a) Myosin filaments pull on the sarcomere so that actin filaments are shortened.
   (b) Myosin filaments pull on actin filaments so that sarcomere is shortened.
   (c) Actin filaments pull on myosin filaments so that sarcomere is shortened.
   (d) Actin filaments pull on sarcomere so that myosin filaments are shortened.
9. **When a muscle fibre shortens, which of the following also shortens?**
   (a) Actin filament (b) Myosin filament (c) Sarcomere (d) Z-line

10. **Which statement correctly describes an event of muscle contraction?**
    (a) Myosin heads bind to troponin. (b) ATP binds to the actin binding site.
    (c) ATP is used to detach the myosin head from actin. (d) Troponin blocks the binding sites.
11. **Tendons connect bone and;**
    (a) Bone (b) Ligaments (c) Muscle (d) Cartilage
12. **What is true about antagonistic pair of muscles?**
    (a) It provides a backup if one of the muscles is injured (b) One muscle pushes while other pulls
    (c) It allows muscles to produce opposing movements (d) It doubles the strength of contraction

Answer Key with Explanations

Sr.No.	Option	Answer	Explanations
1.	(b)	Floating ribs	• Floating ribs are the last two pairs of ribs (11th and 12th) in the human ribcage. • They are called "floating" because they are not attached to the sternum or to other ribs in the front — only connected to the vertebrae at the back.
2.	(b)	A cell	• A muscle fibre, also known as a **myofibre**, is a long, multinucleated cell that contains the contractile units of muscle tissue.
3.	(b)	Myofibril	• Myofibrils are rod-like structures within muscle fibres that contain the contractile units called sarcomeres. They extend the entire length of a muscle fibre.
4.	(d)	Actin, tropomyosin and troponin	• Actin filaments are composed of actin proteins, and they are associated with regulatory proteins tropomyosin and troponin, which play crucial roles in muscle contraction regulation.
5.	(a)	Actin filaments	• Z-lines (or Z-disks) are darkly staining structures within muscle fibres that anchor the actin filaments, marking the boundaries of a sarcomere.
6.	(c)	Two Z-lines	• A sarcomere is the functional unit of striated muscle tissue and is defined as the segment between two neighbouring Z-lines.
7.	(c)	Sarcoplasmic reticulum	• The sarcoplasmic reticulum is a type of smooth endoplasmic reticulum found in muscle cells that stores and releases calcium ions, which are essential for initiating muscle contraction.
8.	(b)	Myosin filaments pull on actin filaments so that sarcomere is shortened.	• The sliding filament theory states that muscle contraction occurs when myosin heads pull on actin filaments, causing them to slide past the myosin filaments and shortening the sarcomere.
9.	(c)	Sarcomere	• When a muscle fibre contracts, the sarcomeres within it shorten, leading to the overall shortening of the muscle fibre.
10.	(c)	ATP is used to detach the myosin head from actin.	• ATP binding to the myosin head causes it to detach from the actin filament, allowing the cycle of muscle contraction to continue.
11.	(c)	Muscle	• Tendons are strong, fibrous cords that connect muscles to bones, enabling the transmission of forces generated by muscle contraction to move the skeleton.
12.	(c)	It allows muscles to produce opposing movements	• Antagonistic pairs of muscles are groups of muscles that work in opposition to each other, allowing for controlled movement in opposite directions.

Exercise

SHORT ANSWER QUESTIONS

Section 02

Q.1 Name three types of cells associated with bone and write their functions.

Ans. Three Types of Cells Associated with Bone:

- **Osteoblasts:** Bone-forming cells that synthesize and secrete bone matrix.
- **Osteocytes:** Mature bone cells that maintain bone tissue and regulate mineral balance.
- **Osteoclasts:** Bone-resorbing cells that break down bone tissue for remodeling and calcium release.

Q.2 Name the bones of cranium.

Ans. Bones of Cranium:

Paired Bones (2)	Unpaired Bones (4)
• Parietal bones (2) • Temporal bones (2)	• Frontal bone • Occipital bone • Sphenoid bone • Ethmoid bone

Q.3 Enlist the bones in the five groups of vertebrae.

Ans. Five Groups of Vertebrae:

- **Cervical vertebrae (7):** Support the neck (e.g., C1: Atlas, C2: Axis).
- **Thoracic vertebrae (12):** Articulate with ribs.
- **Lumbar vertebrae (5):** Support the lower back.
- **Sacrum (5 fused):** Forms the posterior pelvic wall.
- **Coccyx (4 fused):** Tailbone, remnant of vestigial tail.

Q.4 What bones make the rib cage?

Ans. Bones Make the Rib Cage:

- **Sternum:** *(breastbone)*
- **12 pairs of ribs:** *(attached to thoracic vertebrae)*
- **Costal cartilages:** *(connect ribs to sternum)*

Q.5 Name the bones of pectoral girdle and pelvic girdle.

Ans. Bones of Pectoral Girdle and Pelvic Girdle:

- **Pectoral Girdle:** Scapula (shoulder blade) and clavicle (collarbone).
- **Pelvic Girdle:** Ilium, ischium, and pubis (fused as hip bones).

Q.6 Name the bones of forelimbs and hindlimbs.

Ans. Bones of Forelimbs and Hindlimbs:

- **Forelimbs:** Humerus, radius, ulna, carpals, metacarpals, phalanges.
- **Hindlimbs:** Femur, patella, tibia, fibula, tarsals, metatarsals, phalanges.

Q.7 What is fibrous joint? Give examples.

Ans. Fibrous Joint:

- **Definition:** Immovable joints held by dense connective tissue.
- **Examples:** Sutures (skull), syndesmosis (between tibia-fibula), gomphosis (teeth in sockets).

Q.8 Name the steps involved in bone repair.

Ans. Steps involved in Bone Repair:

1. **Hematoma formation:** Blood clot at fracture site.
2. **Fibrocartilaginous callus:** Soft callus formation.
3. **Bony callus:** Hard callus replaces soft tissue.
4. **Remodeling:** Bone restored to original shape.

Q.9 What skeletal structures are affected from the osteoarthritis?

Ans. Osteoarthritis:

- It 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.

Q.10 List the major parts of skeletal muscle fibre.

Ans. Major Parts of Skeletal Muscle Fibre:

- **Sarcolemma:** *(cell membrane).*
- **Sarcoplasm:** *(cytoplasm).*
- **Myofibrils:** *(contractile units)*
- **Sarcoplasmic reticulum:** *(stores Ca^{2+}).*
- **T-tubules:** *(conduct electrical signals).*

Q.11 What do you mean by I-band, A-band and H-zone?

Ans.

- **I-band:** Light region with only actin filaments.
- **A-band:** Dark region with overlapping actin and myosin.
- **H-zone:** Central region of A-band with only myosin.

Q.12 Describe the antagonistic arrangement of skeletal muscles.

Ans. Antagonistic Pair of Muscles:

- In the antagonistic pairs, one muscle reverses the effect of the other and they do not contract simultaneously.
- If one muscle contracts, other relaxes and vice versa.
- This action of muscles is called antagonistic action of muscles.

Example:

- **Biceps (flexor):** Contracts to bend the elbow.
- **Triceps (extensor):** Contracts to straighten the elbow.

Q.13 Ligaments are elastic while tendons are hard. Justify.

Ans. Here are three logical points explaining why ligaments are elastic but tendons are hard:

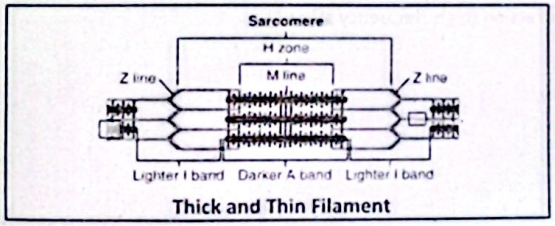
i. **Different Functions:**
   - Ligaments connect bone to bone and need to allow slight movement at joints, so they are elastic.
   - Tendons connect muscle to bone and must transmit force during muscle contraction, so they are strong and stiff.

ii. **Fiber Composition:**
   - Ligaments contain more elastin fibers, giving them stretchability.
   - Tendons are made mostly of collagen fibers arranged in parallel, making them less flexible but very strong.

iii. **Structural Arrangement:**
   - The looser fiber arrangement in ligaments allows for some elasticity.
   - The dense and tightly packed fibers in tendons make them hard and resistant to stretching.

Q.14 Draw a diagram of sarcomere and label its parts.

Ans.



Thick and Thin Filament

Q.15 Differentiate between:

i. Compact and spongy bone
ii. Axial skeleton and appendicular skeleton
iii. True ribs, false ribs and floating ribs
iv. Rheumatoid arthritis and osteoarthritis
v. Fibrous and cartilaginous joints
vi. Cartilaginous and synovial joint
vii. Osteoblasts and osteocytes
viii. Tropomyosin and troponin
ix. Ligament and tendon
x. Tetany and tetanus

Ans. i. **Compact vs. Spongy Bone**

- **Compact:** Dense, strong, forms outer layer.
- **Spongy:** Porous, lightweight, found in epiphyses.

ii. **Axial vs. Appendicular Skeleton**

- **Axial:** Skull, vertebrae, ribs (central support).
- **Appendicular:** Limbs and girdles (movement).

iii. **True Ribs (1–7), False Ribs (8–10), Floating Ribs (11–12)**

- **True:** Directly attach to sternum.
- **False:** Indirectly attach via cartilage.
- **Floating:** No sternal attachment.

iv. **Rheumatoid Arthritis (RA) vs. Osteoarthritis (OA)**

- **RA:** Autoimmune, affects synovium.
- **OA:** Degenerative, affects cartilage.

v. **Fibrous vs. Cartilaginous Joints**

- **Fibrous:** Immovable (e.g., sutures).
- **Cartilaginous:** Slightly movable (e.g., Intervertebral discs).

vi. **Cartilaginous vs. Synovial Joints**

- **Cartilaginous:** Hyaline/fibrocartilage, limited movement.
- **Synovial:** Fluid-filled cavity, free movement (e.g., knee).

vii. **Osteoblasts vs. Osteocytes**

- **Osteoblasts:** Build bone.
- **Osteocytes:** Maintain bone.

viii. **Tropomyosin vs. Troponin**

- **Tropomyosin:** Blocks actin-myosin binding at rest.
- **Troponin:** Binds Ca^{2+} to shift tropomyosin.

viii. **Ligament and tendon**

- **Ligaments:** Ligaments are tough but elastic bands of connective tissues that hold the bones together at a joint.
- **Example:** ligaments holding ulna and radius with the humorous.
- **Tendons:** Tendons are bundle of collagen, non-elastic fibers.
- **Example:** Each end of the entire muscle is attached to bones by these tendons.

x. **Tetany vs. Tetanus**

- **Tetany:** Muscle spasms (low Ca^{2+}).
- **Tetanus:** Sustained contraction (high-frequency stimuli).

Exercise

LONG ANSWER QUESTIONS

Section 03

Q.1 Explain the structure of bone.
Ans. See Page No. (341)

Q.2 Describe the structure of three types of cartilage.
Ans. See Page No. (344)

Q.3 Write the cause and symptoms of joint dislocation, spondylosis, and sciatica.
Ans. See Page No. (351)

Q.4 Describe the types of arthritis, with their causes, symptoms and treatments.
Ans. See Page No. (352)

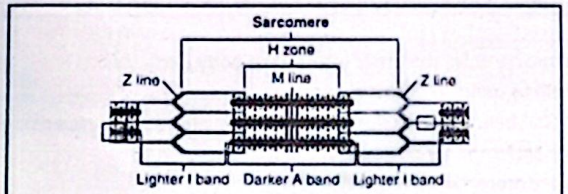
Q.5 Describe the three types of muscles.
Ans. See Page No. (354)

Q.6 Explain the ultrastructure of skeletal muscle.
Ans. See Page No. (355)

Q.7 Write a detailed note on the sliding filament model of muscle contraction.
Ans. See Page No. (357)

Q.8 Explain the action of antagonistic muscles in the movement of knee joint.
Ans. See Page No. (358)

Q.9 Draw a diagram of sarcomere and label its parts.
Ans.



Thick and Thin Filament

Q.10 Describe causes and symptoms of muscle fatigue, cramps and tetany.
Ans. See Page No. (359)

Q.11 Justify how the main functions of the skeleton are to act as a system of rods and levers.
Ans. See Page No. (360)

Q.12 Justify why do the muscles pull but do not push.
Ans. See Page No. (360)

Exercise

INQUISITIVE ANSWER QUESTIONS

Q.1 Why is calcium essential for both the structural integrity of bones and the process of muscle contraction?

Ans. Importance of Calcium for bones and Muscle Contraction:

- **Makes bones strong:** Calcium helps bones stay hard and strong.
- **Builds bone structure:** It supports the shape and strength of the skeleton.
- **Helps muscles move:** Muscles need calcium to contract (tighten).
- **Carries nerve signals:** Calcium helps send messages from nerves to muscles.
- **Stops bleeding:** It helps blood clot if you get hurt.
- **Repairs bones:** It helps in bone growth and healing.
- **Low calcium = weak body:** Without enough calcium, bones get weak and muscles don't work well.

Q.2 Why is the human skeleton designed with both rigid bones and flexible joints instead of being made of a single solid structure?

Ans. Human skeleton designed with both rigid bones and flexible joints instead of being made of a single solid structure due to:

- **Easy to move:** Joints help us bend, walk, and do many activities.
- **Protects from injury:** Flexible joints reduce the shock if we fall.
- **Can grow:** Our skeleton can grow and repair itself easily.
- **Use less energy:** Moving joints takes less effort than moving a solid body.
- **More actions possible:** We can twist, turn, and stretch because of joints.
- **Strong and flexible:** Bones give strength; joints give movement.
- **Works better with muscles:** Joints allow muscles to move bones like levers.

Q.3 Why do muscles always work in pairs (antagonistic muscles) rather than alone?

Ans. Antagonistic Muscles:

- **Muscles can only pull:** One muscle pulls, the other returns the body part.
- **Smooth movement:** Pairs help us move in both directions.
- **Helps bend and straighten:** One bends (like biceps), the other straightens (like triceps).
- **Protects joints:** They balance each other and keep joints safe.
- **Better control:** Movements are more controlled and less jerky.
- **Keeps body posture:** Even at rest, muscles in pairs help us stand or sit straight.
- **Avoids injuries:** Pairs stop muscles from overworking alone.

Q.4 Why does prolonged inactivity or space travel lead to muscle atrophy and bone weakening?

Ans. Following reasons are responsible:

- **No Gravity or Load:** In space or during inactivity, muscles and bones don't bear weight, so they stop working hard and begin to weaken.
- **Muscle Use Drops:** Muscles aren't used regularly, so they shrink (atrophy) due to loss of protein and muscle fibres.
- **Bone Resorption Increases:** Without regular pressure or stress, bones break down faster than they rebuild, leading to bone loss.
- **Calcium Loss:** Bones lose calcium when not stressed, making them brittle and weak.
- **Reduced Blood Flow:** Less movement means lower blood supply to muscles and bones, reducing the nutrients they need to stay strong.

ADDITIONAL MCQs

1. **What is the primary function of osteoclasts in the human skeletal system?**
   A) To form new bone tissue B) To resorb bone tissue
   C) To maintain bone density D) To produce bone marrow
2. **Which type of joint is characterized by a space between bones that is filled with synovial fluid?**
   A) Fibrous joint B) Cartilaginous joint C) Synovial joint D) All of the above
3. **What is the term for a condition where the spine becomes abnormally curved?**
   A) Spondylosis B) Scoliosis C) Sciatica D) Osteoporosis
4. **Which muscle type is involuntary and found in the walls of hollow organs?**
   A) Skeletal muscle B) Cardiac muscle C) Smooth muscle D) All of the above
5. **What is the term for a condition where muscles become fatigued and cramped?**
   A) Tetanus B) Muscle tetany C) Muscle fatigue D) All of the above
6. **Which of the following is NOT a type of joint?**
   A) Fibrous joint B) Cartilaginous joint C) Synovial joint D) Muscular joint
7. **What is the function of osteoblasts in the human skeletal system?**
   A) To resorb bone tissue B) To form new bone tissue
   C) To maintain bone density D) To produce bone marrow
8. **Which condition is characterized by inflammation of the joints?**
   A) Arthritis B) Osteoporosis C) Sciatica D) Spondylosis
9. **What is the term for the sliding of filaments in muscle contraction?**
   A) Sliding filaments model B) Muscle contraction theory
   C) Filamentous theory D) None of the above
10. **Which muscle type is striated and voluntary?**
    A) Skeletal muscle B) Cardiac muscle C) Smooth muscle D) All of the above
11. **What is the term for a condition where a joint is dislocated?**
    A) Sprain B) Strain C) Dislocation D) Fracture
12. **Which of the following is a disorder of the human skeleton?**
    A) Disc-slip B) Spondylosis C) Sciatica D) All of the above

ANSWER KEY

1. B)	2. C)	3. B)	4. C)	5. D)	6. D)	7. B)	8. A)	9. A)	10. A)	11. C)	12. D)

ADDITIONAL SHORT ANSWER QUESTIONS

1. Write any two functions of skeleton.

Ans. Functions of Skeleton:

- **Support & Shape:** The bones support soft tissues. These are used as attachment site for most of the muscles these also provide shape to the body.
- **Protection:** Bones protect critical internal organs such as brain, spinal cord, heart, lungs and reproductive organs.
- **Movement:** The skeletal muscles are attached to the bone thus bones help in locomotion.
- **Mineral homeostasis:** Bones serve as store house for calcium phosphorus sodium and potassium.

2. Differentiate the compact bone and spongy bone. Give only two differences.

Ans.

Compact Bone	Spongy Bone
• It forms the **outer shell** of the bone. • It is dense and Strong. • It provides site for the attachment of muscle.	• It is present in the **interior of the bone**. • It is light, rich in blood capillaries and highly porous. • The cavities of the spongy bone contain bone marrows Blood cells are formed in bone marrow.

3. Differentiate between bone and cartilage.

Ans.

Bones	Cartilage
• Bones are the **most rigid form** of connective tissue. • It consists of matrix **of collagen fibers hardened by the deposition of** calcium phosphate.	• It is **comparatively soft** form of connective tissue. • It is much softer than bone. • It **covers the ends** of the bone at the joints, and also supports the flexible portion of nose and external ears. It is of two types: **(i) Hayline Cartilage** **(ii) Fibrocartilage**

4. Define Bone. Write the names of cells associated with the bone.

Ans. Bone:

- Most rigid form of connective tissue, consists of matrix of collagen fibers hardened by calcium phosphate is called bone.
- Three types of cell are responsible for bone formation.
  - **(i) Osteoblasts:** These are bone forming cells.
  - **(ii) Osteocytes:** These are mature bone cells.
  - **(iii) Osteoclasts:** These are bone dissolving cells.

5. Name the unpaired bones of skull.

Ans. There are four unpaired bones:

(i) Frontal bone **(ii)** Occipetal bone
(iii) Sphenoid bone **(iv)** Ethmoid bone

Unpaired Facial Bones:

- The unpaired facial bones are as under: **(i)** Mandible **(ii)** Vomer

6. Name unpaired facial bones.

Ans. Facial Bones (14):

- **Unpaired Facial Bones (02):** Vomer, Mandible
- **Paired Facial Bones (6 × 2 = 12):** Nasal, Lacrimal, Inferior concha, Palatine, Zygomatic Maxilla.

7. How many ribs do not attach with the sternum?

Ans. Floating Ribs: (Ribs Not Attached with Sternum)

- The ribs which are connected only with the thoracic vertebrae posteriorly **but not attached with sternum** are called **floating ribs.** 2 pairs of ribs i.e. 11th and 12th pair of ribs are not attached with sternum.

8. Name the bones of pectoral and pelvic girdle.

Ans. Bones of Pectoral Girdles: Scapula, Supra Scapula, Clavicle.
Bones of Pelvic Girdles: Two coxal bones, each formed by the Fusion of Ilium, Ischium & Pubis.

9. Describe Pelvic Girdle and Hind Limb in human skeleton.

Ans. Pelvic Girdle:

- Pelvic girdle attaches the **hind limb with the** vertebral column.
- Pelvic girdle consists of two coxal bones.
- Each coxal bone is formed by the fusion of three bones, ilium, Ischium and Pubis.
- The pelvic girdle supports the pelvic region.
- **Hind Limb:** Each, hind limb is formed of following bones.
- Femur, Tibia and Fibula, Tarsals, Metatarsals and Phalanges.

10. What are cartilaginous joints?

Ans. Cartilaginous joints:

- These joints allow a little or no movement.
- **Example:** These are found between vertebrae at the point where coaxal bones meet in front of the pelvic
- Hyaline cartilage joint is formed between growing bones.
- In these joints the bones are held together by fibrous cartilage.

11. How fibrous joints differ from synovial joints.

Ans.

Fibrous Joints	Synovial Joints
• **Joints which are held together** by short fibers embedded in the connective tissues. • Such joints are present in skull they fix the teeth with the jaws.	• These **joints contain** a cavity filled with fluid and are adapted to reduce **friction between** the moving joints. **e.g.,** Hinge joints.

12. What is osteoporosis? Why it occurs in aged women?

Ans. Osteoporosis:

- It is a condition in which bones become of **brittle and fragile.**
- In this case bone mass is **reduced and chemical** composition of the matrix remains normal.
- It mostly occurs in aged women due to **decreased level of Estrogen.**

13. Define spondylosis.

Ans. Spondylosis:

- Spondylosis is a skeletal deformity. This disease cause immobility and fusion of vertebral joint.
- It is the common cause of chronic neck pain.

14. Write a few lines about cardiac muscles.

Ans. Cardiac Muscles:

- These muscles have irregular stripes.
- They have Branched cells, with many nuclei in each cell.
- Their contraction is spontaneous.
- They pump blood, so they are involuntary in action.

15. Give two characters of smooth muscles.

Ans. Smooth Muscles:

- They are non-striated muscles.
- They are long and spindle shape.
- Each cell contains a single nucleus.
- Their contraction is spontaneous, through nervous system & hormones so they are involuntary in action

16. What is sliding filament model?

Ans. Sliding Filament Model:

- According to this model when a muscle contracts.
- The thin filaments slide past the thick filament, and as a result
- Z-line come close to each other. • H-Zone disappears • I-band shortens
- The length of sarcomere shortens.
- This model was "proposed A.F. Huxley, H. Huxley and their colleagues in 1954."

17. Compare sarcomere and sarcolemma.

Ans.

Sarcomere	Sarcolemma
• A sarcomere is the region of a **myofibril** between two successive Z-lines it is the smallest contractile unit of muscle fibre. • **The myofibril** contains **many myofilaments.** • The boundaries of **sarcomeres** are called **Z-lines.** It is the mid lines of I-bands is called Z-lines. • Z-stands for Zwishen means between.	• The membrane which surrounds the muscle fibre is called **sarcolemma** or **plasmalemma** • The cytoplasm of the muscle fibre is called **sarcoplam.** • Sarcoplasm contains usually large amount of stored **glycogen and myglobln.** • **Myoglobin is a unique oxygen bonding protein. It is a red pigment that** stores oxygen.

18. Differentiate between ligament and tendon.

Ans.

Ligaments	Tendons
• Ligaments are tough but **elastic bands of connective tissues** that hold the bones together at a joint. • **Example:** ligaments holding **ulna and radius** with the humorous.	• Tendons are bundle of collagen, non-elastic fibers. • Each end of the **entire muscle** is attached to **bones by these tendons.**

19. Define antagonistic movement of muscles.

Ans. Antagonistic Pair of Muscles:

- In the antagonistic pairs, one muscle reverses the effect of the other and they do not contract simultaneously.
- If one muscle contracts, other relaxes and vice versa.
- This action of muscles is called antagonistic action of muscles.

Example:

- **Biceps (flexor):** Contracts to bend the elbow.

SELF-ASSESSMENT Chapter # 12

Total Mark: 30

Q.1 Encircle the correct option. **(1 x 6 = 06)**

i. **Which type of joint is characterized by a space between bones that is filled with synovial fluid?**
(a) Fibrous joint (b) Cartilaginous joint (c) Synovial joint (d) All of the above

ii. **What is the term for a condition where muscles become fatigued and cramped?**
(a) Tetanus (b) Muscle tetany (c) Muscle fatigue (d) All of the above

iii. **Which condition is characterized by inflammation of the joints?**
(a) Arthritis (b) Osteoporosis (c) Sciatica (d) Spondylosis

iv. **Which muscle type is striated and voluntary?**
(a) Skeletal muscle (b) Cardiac muscle (c) Smooth muscle (d) All of the above

v. **The term muscle fibre or myofibre refers to:**
(a) A cellular organelle (b) A cell (c) A tissue (d) An organ

vi. **Sarcomere is a part between;**
(a) Two H-lines (b) Two A-bands (c) Two Z-lines (d) Two I-bands

Q.2 Write short answers of the following questions. **(2 x 8 = 16)**

i. Describe three types of joints and give an example of each.
ii. Explain the sliding filaments model of muscle contraction.
iii. Why do cartilage injuries often remain unnoticed for longer periods?
iv. Enlist the bones in the five groups of vertebrae.
v. Name the bones of forelimbs and hindlimbs.
vi. List the major parts of skeletal muscle fibre.
vii Write a few lines about cardiac muscles.
viii. Differentiate between ligament and tendon.

Q.3 Extensive Questions. **(4 x 2 = 8)**

(a) Explain the structure of bone.
(b) Describe causes and symptoms of muscle fatigue, cramps and tetany.

ENTRANCE TEST MCQs (UHS)

1. The total number of cervical and thoracic vertebrae in human vertebral column is:
   A. 7 B. 14 C. 19 D. 33
2. A sarcomere is the region of a myofibril between two successive
   A. M-lines B. I-bands C. Z-lines D. T-tubules
3. The sarcolemma of mucle fiber folds inwards and forms a system of tubes which runs through the sarcoplasm called
   A. Myofilament B. Z-lines C. Sarcoplasmic reticulum D. Transverse tubules
4. According to sliding filament theory, when muscle fibers are stimulated by nervous system, which of the following changes occurs?
   A. I-bands shorten B. Z-lines move further apart
   C. H-zone becomes more visible D. A-bands broaden
5. Longest bone in the human skeleton is:
   A. Ulna B. Tibia C. Fibula D. Femur
6. Hip and shoulder joints are examples of:
   A. Hinge joints B. Synovial joints C. Ball and socket joints D. Cartilaginous joints
7. In pelvic region of human body, sacrum is formed by the fusion of:
   A. 4 vertebrae B. 6 vertebrae C. 5 vertebrae D. 3 vertebrae
8. Each muscle fibre is surrounded by a modified cell membrane called:
   A. Sarcolemma B. Myosin filament C. Sarcomere D. Myofilament
9. Spongy bone is always surrounded by:
   A. Compact bone B. Osteoblast cells C. Cartilage D. Osteoclast cells
10. Bone matrix is hardened by the:
    A. Harversian canais B. Bone marrow tissue C. Canalicull D. Calcium phosphate
11. The number of bones forming skull in man is:
    A. 8 B. 29 C. 14 D. 22
12. The spine consists of a linear series of:
    A. 33 bones B. 12 bones C. 24 bones D. 07 bones
13. Which one of the following changes occurs when skeletal muscle contracts?
    A. I-band shortens only B. A-band shortens and Z-line moves farther apart
    C. I-band shortens and Z lines get closer D. Actin filament contracts
14. Skull, vertebral column, ribs and sternum forms:
    A. Appendicular skeleton B. Exoskeleton C. Hydrostatic skeleton D. Axial skeleton
15. Chitin which makes the exoskeleton in insects is further hardened by:
    A. Protein and sodium bicarbonate B. Protein and potassium carbonate
    C. Protein and calcium carbonate D. Protein and sodium carbonate
16. Scapula is a:
    A. Tail bone B. Skull bone C. Hip bone D. Shoulder bone
17. Which combination is the example of ball and socket joints?
    A. Hip and shoulder joints B. Shoulder and knee joints
    C. Hip and knee joints D. Hip and elbow joints
18. The function of calcium ions in muscle contraction is to:
    A. Bind to troponin molecule and cause them to move
    B. Aid in the transmission of nerve impulse
    C. Polarize visible light
    D. Bind to tropomyosin molecule and cause them to form cross bridges

19. The thick filaments in a myofibril of muscles are made of _____:
    A. Hemoglobin B. Actin C. Myoglobin D. Myosin
20. Thin filaments of muscles contain _____ chains of actin molecules:
    A. Four B. Three C. One D. Two
21. Coccyx vertebrae are located in:
    A. Cervical region B. Pelvic region C. Lumber region D. Thoracic region
22. The function of calcium ions in muscle contraction is to:
    A. Bind to troponin molecule and cause them to move
    B. Aid in the transmission of nerve impulse
    C. Polarize visible light
    D. Bind to tropomyosin molecule and cause them to form cross bridges
23. The thick filaments in a myofibril of muscles are made of _____:
    A. Hemoglobin B. Actin C. Myoglobin D. Myosin
24. Thin filaments of muscles contain _____ chains of actin molecules:
    A. Four B. Three C. One D. Two

ANSWERS KEY

1. C	2. C	3. D	4. A	5. D	6. C	7. C	8. A	9. A	10. D	11. D	12. A	13. C
14. D	15. C	16. D	17. A	18. A	19. D	20. D	21. B	22. A	23. D	24. D		

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