Unit 12

Human Skeletal & Muscular Systems

STUDENTS LEARNING OUTCOMES (SLO's)

After studying this unit, the students will be able to

- Describe the structure of bone and compare it with that of cartilage.
- Explain the functions of osteoblasts, osteoclasts and osteocytes.
- Describe three types of joints i.e. fibrous joints, cartilaginous joints and synovial joints and give example of each.
- Describe the disorders of human skeleton (disc-slip, spondylosis, sciatica, arthritis, osteoporosis) and their causes.
- Describe the injuries in joints (dislocation and sprain) and their first aid treatment.
- Compare smooth muscles, cardiac muscles and skeletal muscles.
- Describe the ultrastructure of the skeletal muscle.
- Explain the sliding filaments model of muscle contraction.
- Describe the action of antagonistic muscles in the movement of knee joint.
- Explain muscle fatigue, cramps and tetany.
- Differentiate between tetanus and muscle tetany.

INTRODUCTION

Support and movement are fundamental aspects of human biology, enabling us to perform a wide range of activities from basic locomotion to complex tasks. This chapter delves into the structure of bones and cartilage, which provide the necessary support framework for the body. We will explore the various types of joints, and examine the unique features of the three types of muscles—skeletal, smooth, and cardiac—that drive motions. The sliding filament model will be discussed to understand muscle contraction at a molecular level. Additionally, we will look at common disorders affecting the skeletal and muscular systems, highlighting their impact on human health and mobility.

12.1 BONES AND CARTILAGE

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

Q 1. Describe the structure of bone in detail?

Ans. The structure of bone is complex and highly organized to fulfil its roles of support, protection, movement, mineral storage, and blood cell formation. Bones are made of connective tissue that is reinforced with calcium and specialized bone cells. The structure of bone can be described under the following subheadings:

1. Outer Membrane: Periosteum

The surface of a bone is covered by a tough membrane called the **periosteum**. This membrane serves as a protective layer and is the site for the attachment of tendons and ligaments.

2. Compact Bone

Beneath the periosteum lies a thick layer of hard material known as **compact bone**, which forms the majority of the bone tissue. It provides strength and rigidity to the bone.

i: Haversian Systems

The basic structural units of compact bone are called **Haversian systems**. Each Haversian system is composed of:

- **Lamellae:** These are concentric layers of mineralized extracellular matrix. The matrix contains **collagen fibres** and small, needle-shaped crystals of **calcium phosphate**.
  - Calcium phosphate crystals are **brittle but rigid**, contributing to the bone's **great strength**.
  - Collagen is **flexible but weak**, so the combination of both materials results in a bone that is **both strong and flexible**.
- **Lacunae and Osteocytes:** The **lamellae** are separated by small spaces known as **lacunae**.
  - Within the lacunae are **osteocytes**, which are **mature bone cells**.
  - Osteocytes are connected to each other and to the Haversian canal through tiny channels called **canaliculi**.
- **Haversian Canal:** The concentric layers of lamellae surround a central canal called the **Haversian canal**.
  - This canal contains **blood vessels**, **nerves**, and **lymphatic vessels**, all of which are essential for the nourishment and function of bone tissue.

ii. Perpendicular Channels

In addition to the main Haversian canals, there are **small channels that run perpendicular** to them.

- These channels connect Haversian canals with each other and with the periosteum.
- They also contain blood vessels, nerves, and lymphatic vessels, aiding in the supply and communication within the bone.
- Collagen fibres anchor the periosteum to the underlying bone tissue, giving additional strength and stability to the bone.

3. Spongy Bone

Underneath the compact bone lies **spongy bone**.

- It has a **latticework structure** made up of **bony spikes**, which make the bone **light and strong** at the same time.

- This structure helps to absorb impact and reduce the overall weight of the bone.

Bone Marrow

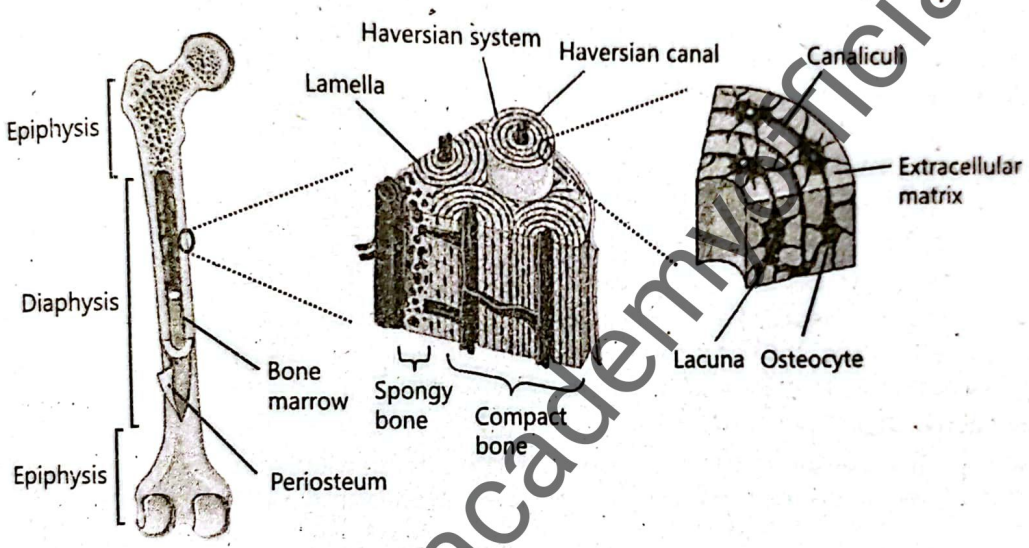
4. Many bones contain a soft tissue called **bone marrow**, which can be classified as **red bone marrow** or **yellow bone marrow**.

Red Bone Marrow

i.
- Found in **spongy bone**, particularly at the ends of **long bones**, **ribs**, **vertebrae**, **sternum**, and **pelvis**.
- It is responsible for producing:
  - Red blood cells
  - White blood cells
  - Platelets

Yellow Bone Marrow

ii.
- Occupies the shafts of long bones.
- It is primarily made up of **fat cells** and functions as an **energy reserve**.
- Under conditions of **severe blood loss**, yellow bone marrow can be **converted into red bone marrow** to produce blood cells.



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

Fig. 12.1: Structure of Bone

For Board Exam & MDCAT

MCQs

1. **What type of tissue are bones primarily made of?**
   A) Muscular tissue B) Epithelial tissue
   C) Connective tissue ✓ D) Nervous tissue
2. **What reinforces the connective tissue in bones?**
   A) Iron and collagen
   B) Potassium and elastin
   C) Calcium and specialized bone cells ✓
   D) Sodium and enzymes
3. **What is the name of the tough membrane that covers the surface of a bone?**
   A) Pericardium B) Peritoneum
   C) Perichondrium D) Periosteum ✓
4. **What is the thick layer under the periosteum called?**
   A) Spongy bone B) Cartilage
   C) Compact bone ✓ D) Bone marrow
5. **What is the majority of the bone tissue composed of?**
   A) Spongy bone B) Compact bone ✓
   C) Cartilage D) Marrow cavity
6. **What are the basic structural units of compact bone?**
   A) Osteons B) Haversian systems ✓
   C) Canaliculi D) Osteocytes
7. **Which of the following are concentric layers of mineralized matrix?**
   A) Lacunae B) Canaliculi
   C) Lamellae ✓ D) Spicules
8. **What do lamellae contain?**
   A) Only calcium
   B) Collagen fibres and calcium phosphate crystals ✓
   C) Blood and fat cells D) Only nerves
9. **What gives bone both strength and flexibility?**

A) Bone marrow and nerves
B) Osteocytes and osteoblasts
C) Collagen and calcium phosphate crystals ✓
D) Fat and calcium

10. What separates the lamellae in compact bone?
A) Lacunae ✓ B) Trabeculae
C) Blood vessels D) Fat cells

11. What are osteocytes?
A) Bone-forming cells B) Cartilage cells
C) Mature bone cells found in lacunae ✓
D) Fat-storing cells

12. What connects osteocytes to each other and to the Haversian canal?
A) Trabeculae B) Capillaries
C) Canaliculi ✓ D) Spicules

13. What does the Haversian canal contain?
A) Only nerves B) Only blood
C) Blood vessels, nerves, and lymphatic vessels ✓
D) Cartilage and fat

14. What lies beneath the compact bone and gives bones their light but strong structure?
A) Cartilage B) Yellow marrow
C) Spongy bone ✓ D) Ligament

15. What type of bone marrow produces red blood cells, white blood cells, and platelets?
A) Yellow bone marrow B) White bone marrow
C) Red bone marrow ✓ D) Soft bone marrow

SQ

1. What are bones made of?
Ans. Bones are made of connective tissue reinforced with calcium and specialized bone cells.

2. What is the periosteum, and what is its function?
Ans. The bone's surface is covered by a tough membrane called periosteum. It serves as a protective outer covering of the bone and also provides a site for the attachment of tendons and ligaments.

3. What is compact bone, and where is it located?
Ans. The thick layer under the periosteum is made of hard material and is called compact bone. It makes up the majority of the bone tissue.

4. What are Haversian systems in compact bone?
Ans. The basic structural units of compact bone are called Haversian systems. A Haversian system is made of lamellae, lacunae with osteocytes, and a central Haversian canal.

5. What are lamellae, and what materials do they contain?
Ans. Lamellae 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.

6. What are lacunae and osteocytes?
Ans. 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.

7. What is the Haversian canal, and what does it contain?
Ans. The concentric layers of lamellae surround a central canal called the Haversian canal. It contains blood vessels, nerves, and lymphatic vessels.

8. What is the function of the small channels that run perpendicular to the Haversian canals?
Ans. There are small channels that run perpendicular to the Haversian canals and connect them with each other and with the periosteum. They 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.

9. What is spongy bone, and what is its structure like?
Ans. Beneath the compact bone there is spongy bone. It has a latticework structure consisting of bony spikes that make it light and strong.

10. What is bone marrow, and what are the types and their functions?
Ans. Many bones also contain a soft tissue called bone marrow, which can be either red or yellow.
- Red bone marrow is found in spongy bone, the ends of long bones, ribs, vertebrae, the sternum, and the pelvis. 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.

Q. 2. Describe the different types of bone cells involved in the development, growth, and remodelling of bones.

Ans. 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.

1. Osteoblasts

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

2. 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.

3. Osteoclasts

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.

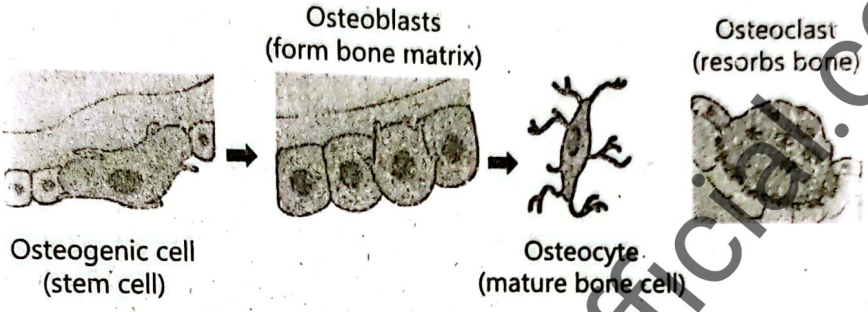


Fig. 12.2 - Types of bone cells

For Board Exam & MDCAT MCQs

1. **How many types of bone cells are involved in bone development, growth, and remodelling?**
   A) Two B) Three✓
   C) Four D) Five
2. **What is the primary function of osteoblasts?**
   A) Destroying old bone tissue
   B) Storing calcium in bones
   C) Synthesizing and secreting unmineralized ground substance✓
   D) Transporting blood through bones
3. **What do osteoblasts become when they are surrounded by the matrix?**
   A) Macrophages B) Osteoclasts
   C) Osteocytes✓ D) Red bone marrow cells
4. **Which bone cells maintain healthy bone tissue by secreting enzymes and bone mineral content?**
   A) Osteoclasts B) Osteoblasts
   C) Osteocytes✓ D) Fibroblasts
5. **What is the function of osteoclasts?**
   A) Form new bone cells
   B) Transport blood cells
   C) Break down bone and release calcium and phosphate✓
   D) Convert fat into bone tissue

SQ

1. **How many types of bone cells are involved in the development, growth, and remodelling of bones?**
   Ans. There are three types of cells i.e., **osteoblasts, osteocytes, and osteoclasts** involved in the development, growth and remodelling of bones.
2. **What are osteoblasts and what is their function in bone formation?**
   Ans. Osteoblasts are bone forming cells that synthesize and secrete unmineralized ground substance. Once the osteoblasts are surrounded by matrix, they become the osteocytes.
3. **What are osteocytes and what role do they play in bone tissue maintenance?**
   Ans. 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.
4. **From which cells do osteoclasts develop and what is their function?**
   Ans. Osteoclasts develop from macrophages and are involved in bone resorption, i.e., they break down bone and release calcium and phosphate in blood.

5. Why is the function of osteoclasts important in the skeletal system?

Ans. The work of osteoclasts is important to the growth and repair of bone.

Q 3. Explain the process of bone development / formation (osteogenesis) in detail?

Ans. Introduction to Osteogenesis

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

Primary Pathways of Osteogenesis

There are two primary pathways of osteogenesis:

1. Formation of Long Bones (Endochondral Ossification)

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.
- **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. 12.3).

Osteoclasts (bone-resorbing cells) **break down the calcified cartilage**, making room for more bone tissue to form.

1. 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 bone except some cartilage that remains only at the articular (joint) surfaces of the bones.

2. Formation of Some Skull Bones (Intramembranous Ossification)

A few bones, e.g., some bones of the skull, develop directly into hard bone without forming cartilage first.

2. 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.

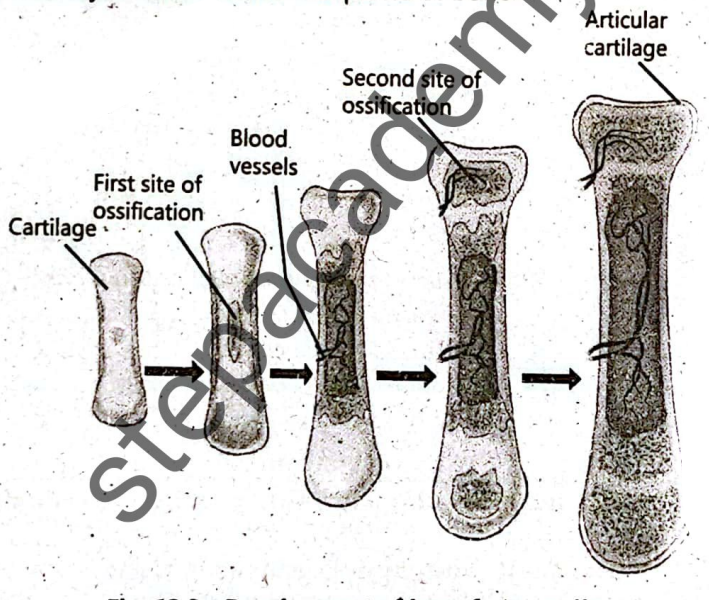


Fig. 12.3 - Development of bone from cartilage

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.

For Board Exam & MDCAT MCQs

1. What is the process of bone formation called?
A. Calcification
B. Osteolysis
C. Osteogenesis ✓
D. Chondrogenesis

2. During long bone formation, what happens to chondrocytes in the center of the cartilage?
A. They multiply rapidly
B. They become osteoblasts
C. They die and leave cavities ✓
D. They turn into blood vessels

3. What is the role of osteoclasts in bone formation?
A. Secreting unmineralized matrix
B. Resorbing calcified cartilage ✓

C. Maintaining bone tissue ✓
D. Fusing into bone plates

4. **What remains as cartilage after the bone is fully formed?**
A. Shaft of the bone
B. Ends of the bone
C. Articular (joint) surfaces ✓
D. Entire bone

5. **How do some skull bones form differently from long bones?**
A. By forming blood vessels first
B. By forming cartilage first
C. By direct transformation into hard bone ✓
D. By turning into muscle tissue

SQ

1. What is osteogenesis and when does it begin?

Ans. 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.

2. How are long bones formed during osteogenesis?

Ans. 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. Blood vessels penetrate these cavities and introduce osteoblasts and osteoclasts.

3. What is the role of osteoblasts and osteoclasts in bone formation?

Ans. 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. Osteoclasts (bone-resorbing cells) break down the calcified cartilage, making room for more bone tissue to form.

4. How are osteocytes formed and what is their function?

Ans. 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.

5. How do some skull bones form differently during osteogenesis?

Ans. A few bones, e.g., 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.

Q 4. Describe the structure of cartilage and its types?

Ans. Structure of Cartilage

Most of the cartilage of the fetus 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.

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. 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.

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 (Fig. 12.4).

Cartilage Types

Cartilage can be classified into **three types**:

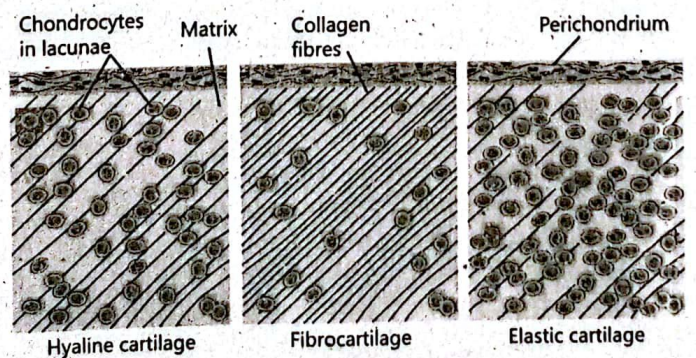


Fig. 12.4 - Cartilage types

- 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.

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 fibers	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

MCQs

1. **What is the role of the perichondrium in cartilage?**
   a) It forms the cartilage matrix
   b) It contains blood vessels, lymphatic vessels, and nerves that supply the cartilage tissue✓
   c) It contains chondrocytes inside lacunae
   d) It replaces cartilage with bone
2. **What components make up the cartilage matrix?**
   a) Collagen, elastin, proteoglycans, and other fibres✓
   b) Calcium phosphate and collagen fibers
   c) Osteoblasts and osteoclasts
   d) Blood vessels and lymphatic vessels
3. **Why does cartilage heal very slowly?**
   a) Because it contains no chondrocytes
   b) Because it has no blood vessels inside the cartilage matrix and is supplied by diffusion✓
   c) Because it has a thick periosteum
   d) Because osteocytes maintain the cartilage matrix
4. **Where are chondrocytes located in cartilage?**
   a) Inside the Haversian canals
   b) Within small spaces called lacunae embedded in cartilage matrix✓
   c) Inside the periosteum
   d) In the spongy bone
5. **Which of the following is NOT a type of cartilage?**
   a) Hyaline cartilage b) Fibrocartilage
   c) Elastic cartilage d) Compact cartilage✓

SQ

1. What happens to most of the cartilage of the foetus during development, and where does cartilage remain throughout life?

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

2. What is the perichondrium and what structures does it contain?

Ans. The perichondrium is a layer of connective tissue that surrounds the cartilage. It contains blood vessels, lymphatic vessels, and nerves that supply the cartilage tissue.

3. What composes the cartilage matrix, and what properties does it give to the cartilage tissue?

Ans. The cartilage matrix is composed of collagen, elastin, proteoglycans, and other fibres. This composition gi he tissue its strength, flexibility, and resistance to compression.

4. Why does cartilage heal very slowly compared to other connective tissues?

Ans. Unlike other connective tissues, there are no blood vessels inside the cartilage matrix. The cells of cartilage are supplied by diffusion, which makes the healing process very slow.

What are chondrocytes, where are they found, and what is their function?

Chondrocytes are cartilage cells that are present within small spaces called lacunae, which are embedded in the cartilage matrix. Chondrocytes are responsible for synthesizing and maintaining the matrix of cartilage.

5. Write a detailed note on the arrangement of bones in the human skeleton (Axial & Appendicular)?

Arrangement of Bones in Skeleton

The human skeletal system consists of **206 bones**. The skeleton has two main divisions, i.e., **axial skeleton** and **ppendicular skeleton (Fig. 12.5).**

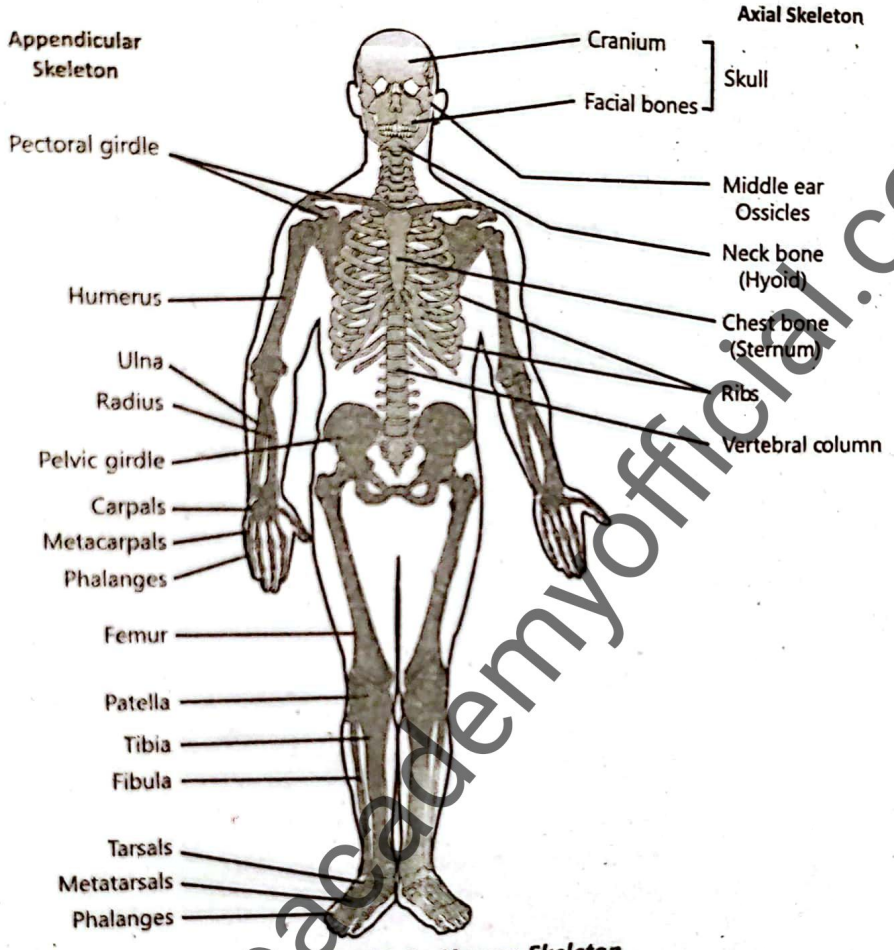


Fig. 12.5 – Human Skeleton

1. Axial Skeleton

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

a). Skull

The skull consists of **22 bones**.

- Eight cranial bones form the cranium (brain box). The 2 paired bones are **parietal bones** and **temporal bone**. The 4 unpaired bones are **frontal bone, occipital bone, ethmoid bone**, and **sphenoid bone.**
- Fourteen facial bones are attached to the cranium. The 6 paired bones are **lacrimal, zygomatic, nasal bones, inferior nasal concha, maxilla**, and **palatine**. The 2 unpaired bones are **mandible (jaw bone)** and **vomer.**

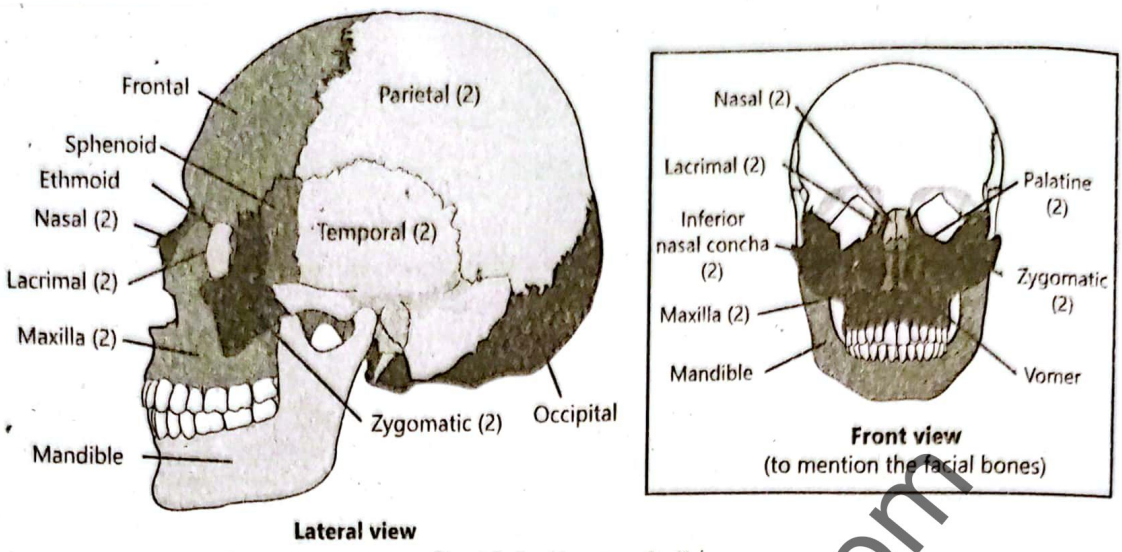


Fig. 12.6 - Human skull

b). Middle Ear

There are **6 bones (3 pairs)** in the middle ears.

- These are called ossicles and include malleus, incus, and stapes.

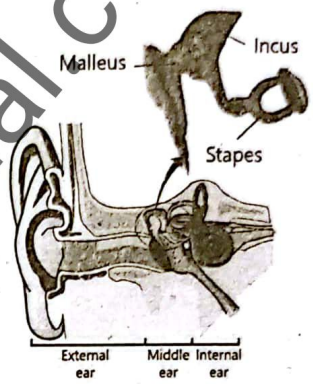


Fig. 12.7 - Middle ear ossicles

c). Neck Bone

The **hyoid bone** is a small single bone which lies at the base of the skull below the tongue. It does not articulate with any other bone of the head.

d). Vertebral Column

The vertebral column consists of **33 bones** called **vertebrae**. The vertebrae make five groups:

- **Seven cervical vertebrae**: These are the vertebrae of the neck. The first one is called **atlas** and the second one is called **axis**.
- **Twelve thoracic vertebrae**: These are rib-carrying vertebrae and are found in the chest region.
- **Five lumbar vertebrae**: These are present in the abdominal region.
- **Five sacral vertebrae**: These are five fused vertebrae forming the **sacrum**. The sacrum articulates with the iliac bones of the hip to form the back of the pelvis.
- **Four coccygeal vertebrae** or **coccyx**: these vertebrae are fused in adults. 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.
- On the anterior side, 7 pairs of ribs attach directly with the sternum by means of separate costal cartilages. These are called true ribs.
- The 8th, 9th, and 10th pairs attach to the sternum by means of a common costal cartilage and are called false ribs.
- The last 2 pairs of ribs (11th and 12th) are known as floating ribs, because they do not attach to sternum.

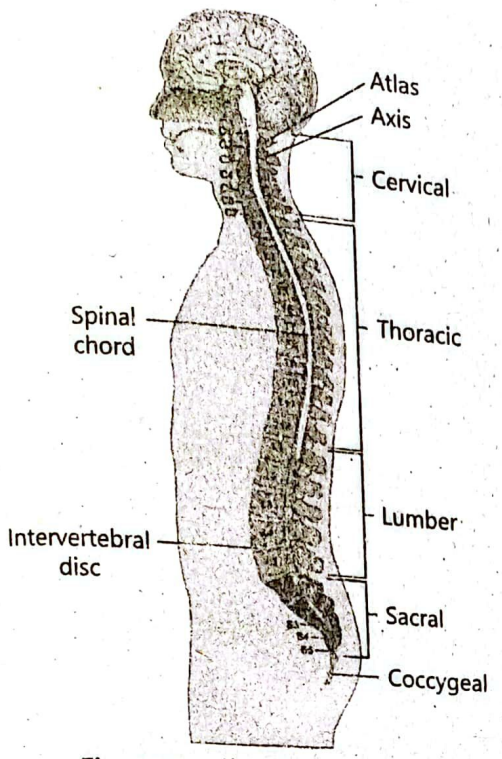


Fig. 12.8 – Vertebral Column

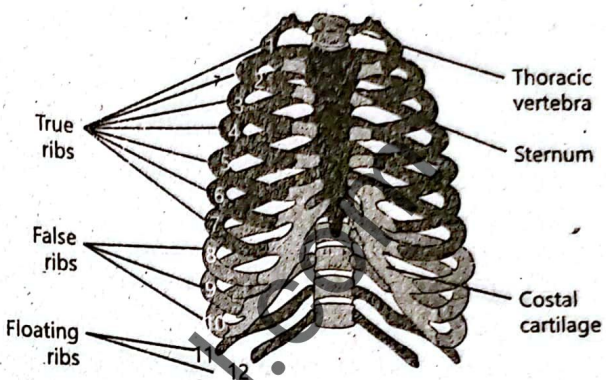


Fig. 12.9 – Rib Cage

2. Appendicular Skeleton

The appendicular skeleton includes the bones present in the appendages (arms and legs). These are the **pectoral girdle**, **pelvic girdle**, **forelimbs**, and **hindlimbs**.

a). 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 each clavicle articulates with the sternum. The other end articulates with the scapula.

b). Forelimbs

Each forelimb (arm, wrist, hand, fingers) consists of the following **30 bones**:

- One humerus: It is a long bone, the end of which has a spherical head, which fits into the glenoid cavity.
- One ulna and one radius: These are long bones. Ulna is on the inner side of the arm while radius is on the outer side (thumb side). Ulna is slightly bigger than radius.
- Eight carpals: These are short bones present in two rows and form the wrist. The upper row articulates with the radius and forms the wrist joint.
- Five metacarpals: These bones make up the palm of the hand.
- Fourteen phalanges: Each finger has 3 phalanges while the thumb has 2 phalanges.

c) Pelvic Girdle

It is made up of two **hip bones**. Each hip bone contains 3 bones, i.e., **ileum, ischium**, and **pubis**. In each hip bone, there is a bony socket, called **acetabulum** that is composed of the fusion of these 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) Hindlimbs

Each hindlimb (leg, ankle, foot, toes) consists of **30 bones**:

- One **femur**: It is a long thigh bone. Its head fits into the acetabulum of the pelvic girdle.
- One **patella** or kneecap: It is embedded in a long tendon which runs over the knee joint.
- 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.
- Seven **tarsals**: These are short bones which are tightly attached to form the ankle.
- Five **metatarsals**: These bones articulate with the tarsal and phalanges to form the sole of the foot.
- Fourteen **phalanges**: Each toe has 3 phalanges while the big toe comprises 2 phalanges.

MCQs

1. **How many bones are in the human skeletal system?**
   A) 206✓ B) 208
   C) 201 D) 212
2. **What are the two main divisions of the human skeleton?**
   A) Axial and Appendicular✓
   B) Cranial and Facial
   C) Vertebral and Pelvic
   D) Thoracic and Lumbar
3. **Which bones form the axial skeleton?**
   A) Skull, ribs, spine, sternum✓
   B) Clavicle, scapula, humerus
   C) Femur, tibia, fibula
   D) Pelvic bones and skull
4. **How many cranial bones are in the skull?**
   A) 14 B) 8✓
   C) 6 D) 10
5. **Which of the following is NOT an unpaired cranial bone?**
   A) Frontal bone B) Temporal bone✓
   C) Occipital bone D) Sphenoid bone
6. **How many facial bones are attached to the cranium?**
   A) 12 B) 14✓
   C) 16 D) 10
7. **Which bones are paired facial bones?**
   A) Mandible and vomer
   B) Lacrimal and zygomatic✓
   C) Frontal and occipital
   D) Ethmoid and sphenoid
8. **How many bones are in the middle ear on each side?**
   A) 1 B) 2
   C) 3✓ D) 4
9. **What is unique about the hyoid bone?**
   A) It is the largest bone in the body
   B) It does not articulate with any other bone✓
   C) It is a paired bone
   D) It forms the lower jaw
10. **How many vertebrae are there in total?**
    A) 32 B) 33✓
    C) 34 D) 31
11. **What are the first two cervical vertebrae called?**
    A) Atlas and Axis✓ B) Thoracic and Lumbar
    C) Sacrum and Coccyx D) Femur and Tibia
12. **How many thoracic vertebrae are present?**
    A) 7 B) 5
    C) 12✓ D) 14
13. **The sacrum is formed by the fusion of how many vertebrae?**
    A) 3 B) 4
    C) 5✓ D) 6
14. **How many pairs of ribs are called true ribs?**
    A) 5 B) 7✓
    C) 3 D) 2
15. **Which ribs are called floating ribs?**
    A) 1st and 2nd pairs
    B) 11th and 12th pairs✓
    C) 8th and 9th pairs D) 3rd and 4th pairs
16. **The pectoral girdle consists of which bones?**
    A) Femur and tibia
    B) Clavicle and scapula✓
    C) Ilium and ischium D) Sternum and ribs
17. **How many bones are in each forelimb?**
    A) 25 B) 30✓
    C) 35 D) 40
18. **What are the three bones that form each hip bone?**
    A) Femur, tibia, fibula
    B) Ilium, ischium, pubis✓
    C) Clavicle, scapula, humerus
    D) Radius, ulna, carpals
19. **What is the name of the socket in the hip bone?**
    A) Acetabulum✓ B) Glenoid cavity
    C) Pubic symphysis D) Patella
20. **How many bones are in each hindlimb?**
    A) 25 B) 28
    C) 30✓ D) 32

SQ

1. **How many bones are there in the human skeletal system and how is the skeleton divided?**
   Ans. The human skeletal system consists of 206 bones. The skeleton has two main divisions, i.e., axial skeleton and appendicular skeleton.
2. **What is the axial skeleton and what is its primary function?**
   Ans. The axial skeleton forms the axis of the body. Its bones support and protect the organs of the head, neck, and chest. It consists of the skull, ribs, spine, and sternum.
3. **How many bones make up the skull and how are they categorized?**
   Ans. The skull consists of 22 bones. Eight cranial bones form the cranium (brain box) and fourteen facial bones are attached to the cranium.

4. **Which are the paired and unpaired cranial bones in the skull?**
Ans. The 2 paired cranial bones are parietal bones and temporal bone. The 4 unpaired cranial bones are frontal bone, occipital bone, ethmoid bone, and sphenoid bone.

5. **What are the facial bones attached to the cranium?**
Ans. Fourteen facial bones are attached to the cranium. The 6 paired bones are lacrimal, zygomatic, nasal bones, inferior nasal concha, maxilla, and palatine. The 2 unpaired bones are mandible (jaw bone) and vomer.

6. **How many bones are found in the middle ear and what are they called?**
Ans. There are 6 bones (3 pairs) in the middle ears, called ossicles. These include malleus, incus, and stapes.

7. **What is the hyoid bone and what is unique about it?**
Ans. The hyoid bone is a small single bone which lies at the base of the skull below the tongue. It does not articulate with any other bone of the head.

8. **How many vertebrae make up the vertebral column and how are they grouped?**
Ans. The vertebral column consists of 33 bones called vertebrae. These vertebrae make five groups: cervical, thoracic, lumbar, sacral, and coccygeal.

9. **What are the characteristics of the seven cervical vertebrae?**
Ans. The seven cervical vertebrae are the vertebrae of the neck. The first one is called atlas and the second one is called axis.

10. **What is the role of the twelve thoracic vertebrae?**
Ans. The twelve thoracic vertebrae are rib-carrying vertebrae and are found in the chest region.

11. **Where are the five lumbar vertebrae located?**
Ans. The five lumbar vertebrae are present in the abdominal region.

12. **What is the sacrum and how is it formed?**
Ans. The sacrum is formed by the fusion of five sacral vertebrae. It articulates with the iliac bones of the hip to form the back of the pelvis.

13. **What are coccygeal vertebrae and how are they grouped with sacral vertebrae?**
Ans. The four coccygeal vertebrae or coccyx are fused in adults. Sacral and coccygeal vertebrae are together called pelvic vertebrae.

14. **What constitutes the rib cage and what is the structure of the sternum?**
Ans. The rib cage consists of 24 bones (12 pairs) called ribs and a sternum. The sternum is a long flat bone located in the central part of the chest.

15. **How do the ribs attach to the sternum and how are they classified?**
Ans. The ribs articulate posteriorly with the thoracic vertebrae. On the anterior side, 7 pairs of ribs attach directly to the sternum by separate costal cartilages and are called true ribs. The 8th, 9th, and 10th pairs attach via a common costal cartilage and are called false ribs. The last 2 pairs (11th and 12th) are floating ribs as they do not attach to the sternum.

16. **What bones form the pectoral girdle?**
Ans. The pectoral girdle consists of 2 pairs: a pair of clavicles (collar bones) and a pair of scapulae (shoulder bones). One end of each clavicle articulates with the sternum and the other end with the scapula.

17. **What bones make up each forelimb?**
Ans. Each forelimb consists of 30 bones: one humerus, one ulna and one radius, eight carpals, five metacarpals, and fourteen phalanges.

18. **Describe the bones of the pelvic girdle?**
Ans. The pelvic girdle is made up of two hip bones, each containing three bones: ileum, ischium, and pubis. Each hip bone has a socket called the acetabulum formed by fusion of these three bones. The two hip bones are joined in front by the pubic symphysis.

19. **What bones are included in each hindlimb?**
Ans. Each hindlimb has 30 bones: one femur, one patella, one tibia and one fibula, seven tarsals, five metatarsals, and fourteen phalanges.

20. **What are the characteristics of the femur, tibia, and fibula in the hindlimb?**
Ans. The femur is a long thigh bone with its head fitting into the acetabulum. The patella is embedded in a tendon over the knee joint. The tibia (shin bone) is the large bone in the leg, while the fibula is a thin outer bone joining the tibia just below the knee and above the ankle.

Q 6. What is a joint, and what are the major kinds of joints found in the human body?

Ans. A **joint** is a place where two bones or a bone and cartilage come together. Three major kinds of joints are found in the human body, i.e., fibrous (immoveable) 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 **cartilaginous 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.

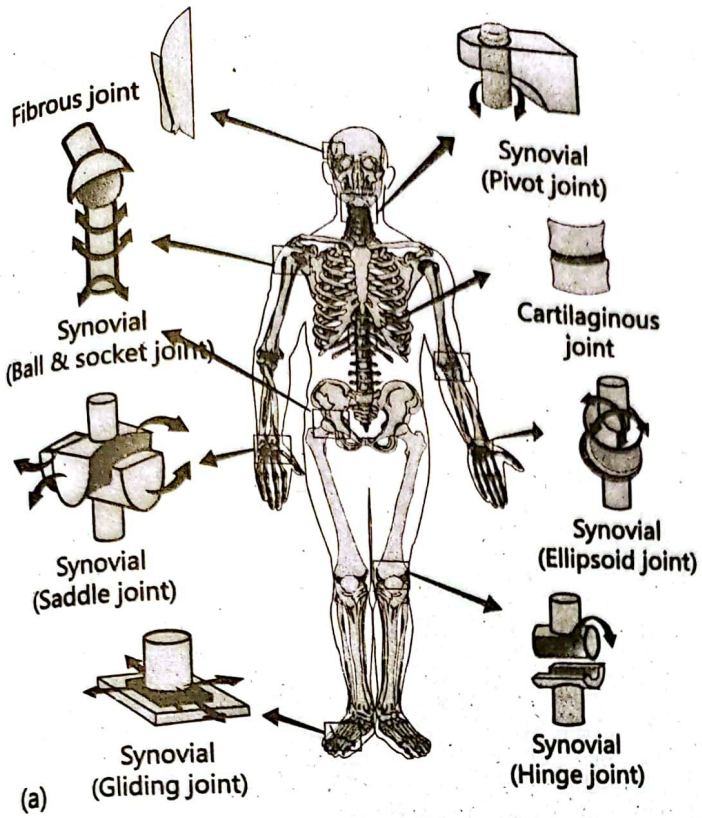
3. Synovial Joints

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 called ligaments.

Types of Synovial Joints

- **Ball-and-socket joints:** These allow motion in all directions. Examples include the shoulder and hip joints.
- **Hinge joints:** These allow movement in only one plane, like a door hinge. Examples include the elbow and knee joints.
- **Pivot joints:** These allow rotational movement around a single axis. An example is the joint between the first and second vertebrae of the neck.
- **Ellipsoidal joints:** These allow movement in two planes, but not rotation. An example is the joint of the wrist with the radius.
- **Saddle joints:** These allow movement in two planes because one bone has a concave surface and the other has a convex surface. An example is the thumb joint.
- **Gliding joints:** These allow gliding movements between bones. Examples include the joints between the vertebrae and the joints between the bones in the wrist and ankle.

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 replacement: 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.



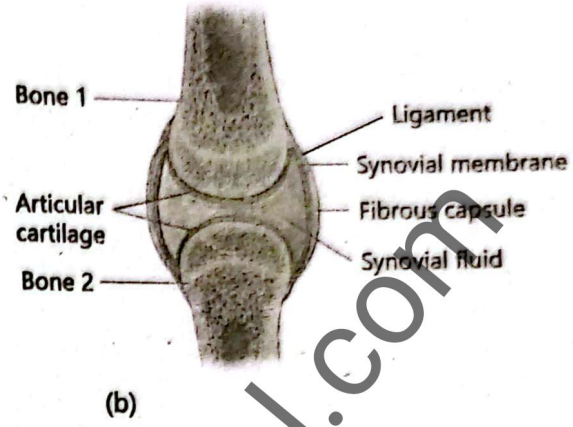


Fig. 12.10 - (a)- Types of joints; (b)- Structure of a synovial joint

Human Skeleton & Musculature helps in Bipedal Posture The bipedal posture of humans is linked to skeleton and musculature in several ways.

1. The human vertebral column has a distinctive S-shaped curve, which helps to distribute weight evenly and maintain balance while standing and walking.
2. Human pelvis is shorter and broader, which helps to stabilize the torso and support the body's weight on two legs.
3. The human femur is also angled inward towards the knee joint, which helps to keep the body's center of mass over the feet. It allows stability while standing and walking.
4. 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.
5. The calf muscles are also well-developed in humans, providing power for walking and running.
6. Human foot has a longitudinal arch that helps to absorb shock and distribute weight evenly across the foot.
7. 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.

MCQs

1. **What is a joint?**
   a) A place where muscles connect
   b) A place where two bones or bone and cartilage come together✓
   c) A type of muscle tissue
   d) A ligament connecting bones
2. **Which type of joint permits no movement?**
   a) Synovial joints b) Cartilaginous joints
   c) Fibrous joints✓ d) Ball-and-socket joints
3. **What connects bones in fibrous joints?**
   a) Cartilage b) Ligaments
   c) Fibrous connective tissue mainly of collagen✓
   d) Synovial fluid.
4. **Which of the following is an example of a fibrous joint?**
   a) Elbow joint
   b) Sutures between skull bones✓
   c) Pubic symphysis
   d) Hip joint
5. **Cartilaginous joints allow?**
   a) No movement b) Slight movement✓
   c) Free movement in all directions
   d) Rotation only
6. **Bones connected by hyaline cartilage in cartilaginous joints can be found in?**
   a) Knee joint
   b) Joint between the first rib and sternum✓
   c) Joints between vertebrae
   d) Teeth sockets
7. **Which cartilage type connects bones in the pubic symphysis?**
   a) Hyaline cartilage b) Fibrocartilage✓
   c) Elastic cartilage d) No cartilage
8. **What is the most common type of joint in the human body?**
   a) Fibrous joints b) Cartilaginous joints
   c) Synovial joints✓ d) Pivot joints
9. **What covers the ends of bones in synovial joints?**
   a) Fibrous capsule
   b) Articular cartilage (hyaline cartilage)✓
   c) Synovial membrane
   d) Ligaments
10. **The fibrous capsule surrounding synovial joints is made up of?**
    a) Outer synovial membrane and inner ligaments
    b) Outer ligaments and inner synovial membrane✓
    c) Cartilage and synovial fluid
    d) Muscle tissue
11. **What is the function of synovial fluid?**
    a) Connect bones
    b) Provide nourishment to muscles
    c) Lubricate the joint✓
    d) Strengthen ligaments
12. **Ligaments are?**
    a) Bands of muscle connecting bones
    b) Connective tissue connecting bones in a joint✓
    c) Cartilage layers between bones
    d) Synovial fluid producing membranes
13. **Which synovial joint allows motion in all directions?**
    a) Hinge joint
    b) Ball-and-socket joint✓
    c) Pivot joint d) Saddle joint
14. **A hinge joint allows movement in?**
    a) Multiple planes and rotation
    b) One plane only✓
    c) Rotation only d) No movement
15. **Which joint type allows gliding movements between bones?**
    a) Ball-and-socket joint b) Gliding joint✓
    c) Pivot joint d) Ellipsoidal joint

SQ

1. **What is a joint?**
   Ans. A joint is a place where two bones or a bone and cartilage come together.
2. **How many major kinds of joints are found in the human body?**
   Ans. Three major kinds of joints are found in the human body: fibrous (immoveable) joints, cartilaginous (slightly moveable) joints, and synovial (freely moveable) joints.
3. **What connects the bones in fibrous joints?**
   Ans. In fibrous joints, the bones are directly connected to each other by fibrous connective tissue consisting mainly of collagen.
4. **Do fibrous joints allow movement?**
   Ans. No, fibrous joints permit no movement of bones.
5. **Give examples of fibrous joints.**
   Ans. Examples of fibrous joints include sutures between the immovable bones of the skull, joints between the tibia and fibula bones in the lower leg, and joints between teeth and their sockets in the jawbone.

How are bones connected in cartilaginous joints?
Ans. In cartilaginous joints, the bones are connected by a layer of cartilage.
What type of movement do cartilaginous joints allow?
Ans. Cartilaginous joints allow little movement of the bones.
What are the two main types of cartilaginous joints?
Ans. The two main types are those connected by hyaline cartilage and those connected by fibrocartilage.
Give an example of a cartilaginous joint connected by hyaline cartilage?
Ans. The joint between the first rib and sternum is connected by hyaline cartilage.
Give examples of cartilaginous joints connected by fibrocartilage?
Ans. Examples include the pubic symphysis in the pelvic girdle and intervertebral discs.
Which type of joint is the most common in the human body?
Ans. Synovial joints are the most common type of joint in the human body.
What type of movement do synovial joints allow?
Ans. Synovial joints allow a wide range of movement.
What covers the ends of bones in synovial joints, and what is its function?
Ans. 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.
What surrounds synovial joints and what is its role?
Ans. A fibrous capsule surrounds the synovial joint and helps to hold the bones together.
What are the two layers of the fibrous capsule in synovial joints?
Ans. The outer layer is made up of ligaments, and the inner lining is the synovial membrane, which secretes synovial fluid.
What is the role of synovial fluid in joints?
Ans. Synovial fluid lubricates the joint.
What are ligaments?
Ans. Ligaments are strong bands of connective tissue that connect the bones in the joint.
How many main types of synovial joints are there based on the range of motion?
Ans. There are six main types of synovial joints based on the range of motion.
What type of movement do ball-and-socket joints allow and where are they found?
Ans. Ball-and-socket joints allow motion in all directions. They are found in the shoulder and hip joints.
Describe hinge joints and give examples?
Ans. Hinge joints allow movement in only one plane, like a door hinge. Examples include the elbow and knee joints.

12.2 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.

7. Write a detailed note on the disorders of skeleton?

Ans. The **human skeletal system** may be affected by a variety of disorders. These disorders can compromise the integrity, function, and overall health of the bones, joints, and associated structures. The major disorders of the skeleton include disc slip, spondylosis, sciatica, arthritis, and osteoporosis. These are discussed below:

1. Disc Slip

Structure and Function of Intervertebral Discs

The intervertebral discs are located between the vertebrae and function as shock absorbers. They also aid in the movement of the vertebral column.

Cause of Disc Slip

A herniated or slipped disc occurs when the outer layer of the intervertebral disc tears or ruptures. This causes the inner gel-like substance to leak out and press against nearby nerves or the spinal cord.

Reasons for Occurrence

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

Symptoms of a Slipped Disc

- Pain
- Numbness and tingling in the affected area
- Weakness or loss of muscle function
- In severe cases, bowel or bladder dysfunction

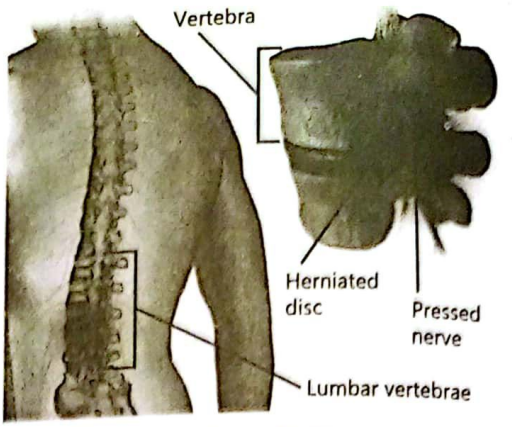


Fig. 12.11 - Disc slip (herniation)

2. Spondylosis

Definition

Spondylosis refers to the degeneration of the vertebrae, intervertebral discs, ligaments, or cartilage of the vertebral column.

Pathological Changes

- Narrowing and fusion of intervertebral discs
- Development of bone outgrowths
- Pressure on the nerves or spinal cord

Common Sites

- Lower back (lumbar vertebrae)
- Neck (cervical vertebrae)

Causes of Spondylosis

- Natural degeneration with aging
- Genetic factors
- Trauma
- Prolonged periods of poor posture
- Obesity

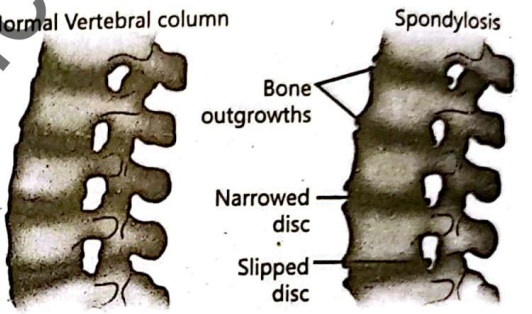


Fig. 12.12 - Spondylosis

Symptoms

- Back or neck pain
- Stiffness
- Reduced range of motion

3. Sciatica

Definition

Sciatica refers to the compression or irritation of the sciatic nerve.

Anatomy of the Sciatic Nerve

The sciatic nerve originates from the lower back and runs through the buttocks into each leg.

Causes of Sciatica

- Herniated disc or bulging disc (most common)
- Trauma
- Infection
- Inflammation
- Spondylosis

Symptoms

- 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

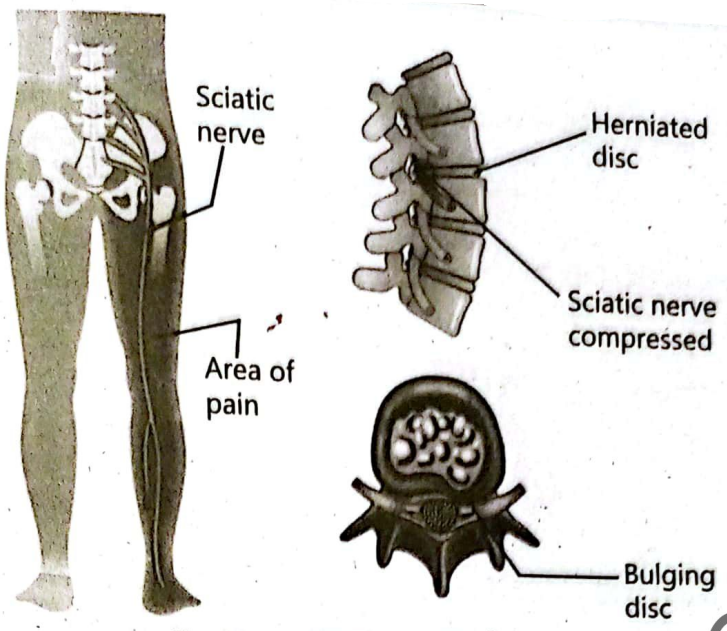


Fig. 12.13 - Sciatica and its causes

4. Arthritis

Definition

Arthritis includes various inflammatory conditions that affect the joints.

General Symptoms of Arthritis

- Joint pain
- Stiffness
- Redness
- Warmth
- Swelling in affected joints

Types of Arthritis

a) Osteoarthritis

- Most common type of arthritis
- Occurs when the articular cartilage at the ends of bones in joints gradually softens and disintegrates
- Commonly affects knee, hip, and intervertebral joints

b) Rheumatoid Arthritis

- An autoimmune disorder
- The synovial membrane becomes inflamed
- Most commonly involves the wrist and hands

c) Gouty Arthritis (Gout):

- Caused by a build-up of uric acid in the blood
- Uric acid crystals form in the joints and cause inflammation
- Most commonly affects the joint of the big toe
- Other joints that may be affected include the knees, wrists, and fingers

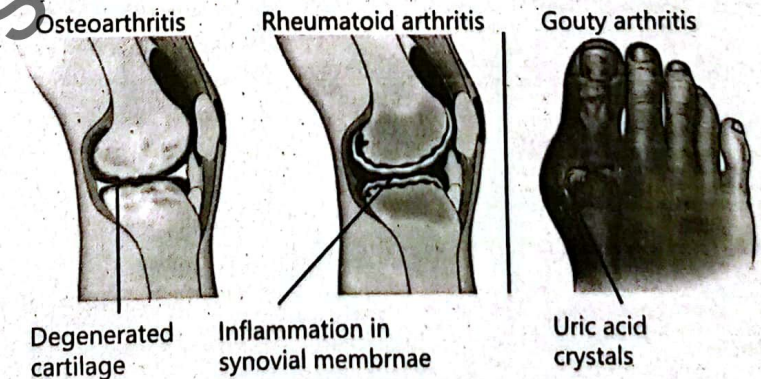


Fig. 12.14 - Types of arthritis

5. Osteoporosis

Definition

Osteoporosis is a condition characterized by weakened bones that are more prone to fractures and breaks.

Pathology

Bone density decreases, making bones fragile and porous.

Causes of Osteoporosis

- **Aging:** Bone mass naturally decreases with age, but it may be more pronounced in some individuals.
- **Menopause in Women:** A drop in oestrogen levels after menopause accelerates bone loss.
- **Nutritional Deficiency:**
- Lack of calcium impairs bone strength.
- Vitamin D deficiency reduces calcium absorption.
- **Physical Inactivity:** Lack of weight-bearing exercise weakens bones.
- **Medical Treatments:** Long-term use of corticosteroids contributes to bone loss.
- **Lifestyle Factors:** Smoking and alcohol consumption increase the risk of osteoporosis.

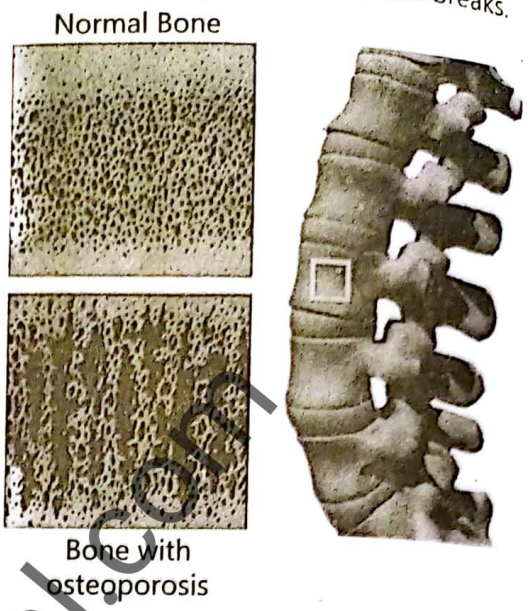


Fig. 12.15 - Normal bone and osteoporosis

MCQ's

1. **What is the primary function of intervertebral discs?**
   A. To store calcium
   B. To supply blood to vertebrae
   C. To act as shock absorbers and help in movement✓
   D. To fuse vertebrae together
2. **What happens in a slipped disc?**
   A. Vertebrae break completely
   B. Outer layer of intervertebral disc tears and inner substance presses nerves✓
   C. Bones get fractured
   D. Ligaments become loose
3. **Which of the following is NOT a cause of a slipped disc?**
   A. Trauma
   B. Degenerative changes due to aging
   C. Infection✓ D. Repetitive strain on vertebral column
4. **What is a common symptom of a slipped disc?**
   A. Redness of skin B. Fever
   C. Tingling and numbness✓
   D. Coughing
5. **What is spondylosis?**
   A. Infection of joints
   B. Inflammation of tendons
   C. Degeneration of vertebrae, discs, ligaments, or cartilage✓
   D. Swelling of bones
6. **Spondylosis can lead to?**
   A. Formation of kidney stones
   B. Narrowing and fusion of intervertebral discs✓
   C. Bleeding in spinal cord
   D. Weak vision
7. **Which vertebral regions are most commonly affected in spondylosis?**
   A. Thoracic and sacral
   B. Lumbar and cervical✓
   C. Coccyx and thoracic D. Sacral and lumbar
8. **The most common cause of spondylosis is?**
   A. Sudden injury
   B. Natural degeneration of intervertebral discs✓
   C. Lack of sunlight D. Viral infection
9. **What are common symptoms of spondylosis?**
   A. Headache and fever
   B. Back or neck pain, stiffness, reduced range of motion✓
   C. Vomiting and Diarrhea
   D. Breathing difficulty
10. **Sciatica is caused by compression of which nerve?**
    A. Ulnar nerve B. Cranial nerve
    C. Sciatic nerve✓ D. Facial nerve
11. **The sciatic nerve runs from the?**
    A. Neck to arms
    B. Lower back to each leg✓
    C. Chest to abdomen D. Brain to spinal cord
12. **Which of the following can cause sciatica?**
    A. Herniated disc✓ B. Skin infection
    C. Liver malfunction D. Loss of eyesight
13. **What is a symptom of sciatica?**
    A. Rash on the skin
    B. Pain in lower back, buttocks, legs or feet✓
    C. Hearing loss D. High fever
14. **Arthritis refers to?**
    A. Fractures in long bones

B. Inflammatory conditions affecting joints✓
C. Cancer of spinal cord
D. Pain in muscles

15. **General symptoms of arthritis include?**
A. Joint pain and stiffness, redness, warmth, swelling✓
B. Toothache and bleeding
C. Stomach cramps
D. Fainting and dizziness

16. **Osteoarthritis occurs when?**
A. Ligaments are torn
B. Articular cartilage softens and disintegrates✓
C. Bones become twisted
D. Red blood cells break down

17. **Rheumatoid arthritis is caused by?**
A. Calcium deficiency B. A viral infection
C. An autoimmune disorder causing inflammation of synovial membrane✓
D. Physical injury

18. **Which joints are commonly affected in rheumatoid arthritis?**
A. Knees and ankles B. Wrists and hands✓
C. Jaw and neck D. Elbows and shoulders

19. **What causes gouty arthritis?**
A. Build-up of uric acid forming crystals in joints✓
B. Lack of physical activity
C. Overuse of joints D. Deficiency of protein

20. **Osteoporosis is characterized by?**
A. Hardened and dense bones
B. Increased muscle mass
C. Weakened bones prone to fractures✓
D. Excessive growth of bones

SQ

1. **What is the function of intervertebral discs between vertebrae?**
Ans. The intervertebral discs between vertebrae act as shock absorbers and help in movement.

2. **What happens in a herniated or slipped disc?**
Ans. 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.

3. **What are the causes of a slipped disc?**
Ans. It may be due to a trauma, degenerative changes due to aging, or repetitive strain on the vertebral column.

4. **What are the symptoms of a slipped disc?**
Ans. 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.

5. **What is spondylosis?**
Ans. Spondylosis means degeneration of vertebrae, intervertebral discs, ligaments or cartilage of the vertebral column.

6. **What changes occur in the vertebral column due to spondylosis?**
Ans. It may result in narrowing and fusion of intervertebral disc and development of bone outgrowths. It puts pressure on the nerves or spinal cord.

7. **Where is spondylosis most commonly found?**
Ans. Spondylosis is most common in the lower back (lumbar vertebrae) and neck (cervical vertebrae).

8. **What are the causes of spondylosis?**
Ans. 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.

9. **What are the symptoms of spondylosis?**
Ans. Symptoms include back or neck pain, stiffness, and reduced range of motion.

10. **What is sciatica?**
Ans. Sciatica means compression or irritation of the sciatic nerve.

11. **Where does the sciatic nerve run in the body?**
Ans. The sciatic nerve starts from the lower back and goes down through the buttocks into each leg.

12. **What is the most common cause of sciatica?**
Ans. Sciatica is often caused by a herniated disc or bulging disc, which can put pressure on the sciatic nerve.

13. **What are some other causes of sciatica besides a herniated disc?**
Ans. Other causes of sciatica include trauma, infection, inflammation, and spondylosis.

14. **What are the symptoms of sciatica?**
Ans. Symptoms include pain or discomfort in the lower back, buttocks, legs, or feet, tingling or numbness in the legs or feet, and weakness or difficulty moving the legs or feet.

15. **What is arthritis?**
Ans. Arthritis includes different inflammatory conditions that affect the joints.

16. What are the general symptoms of all types of arthritis?

Ans. Symptoms of all types include joint pain and stiffness. Other symptoms may include redness, warmth, and swelling in affected joints.

17. What is osteoarthritis and which joints does it affect?

Ans. 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.

18. What is rheumatoid arthritis and which joints are commonly involved?

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

19. What causes gouty arthritis and which joint is most commonly affected?

Ans. 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.

20. What is osteoporosis and what are its causes?

Ans. Osteoporosis is a condition characterized by weakened bones that are more prone to fractures and breaks. It occurs when bone density decreases, making the bones fragile and porous. Its causes include aging, drop in oestrogen levels after menopause in women, lack of calcium and vitamin D in the diet, lack of weight-bearing exercise, long-term use of corticosteroids, smoking, and alcohol consumption.

Q 8 Explain in detail the different types of injuries to joints, along with their causes, symptoms, and 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:

1. islocations

A dislocation is when the bones in a joint are forced out of their normal positions. 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

- Swelling
- Intense pain
- Immobility of the affected joint
- **Rheumatoid arthritis** can also cause joint dislocation.

Treatment

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

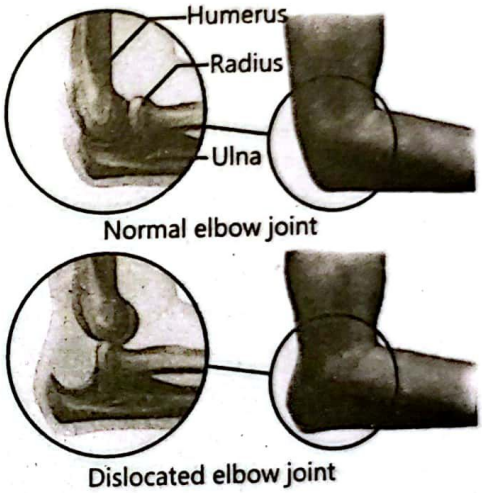


Fig.: 12.16 - Dislocation in elbow joint

2. prain

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

This can happen when the joint is forced beyond its normal range of motion, causing the ligaments to stretch or tear. Sprains are usually treated with physical therapy. Dressings are done to immobilize the sprain and provide support.

First Aid Treatment for Dislocation and Sprain

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

- 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.
- Elevate the affected limb:
- In the case of dislocation, if possible, elevate the affected limb above to help reduce swelling.
- Seek medical attention:
- Dislocations and sprains require medical attention, so call for emergency medical services 1122 or take the person to the hospital for further evaluation and treatment.

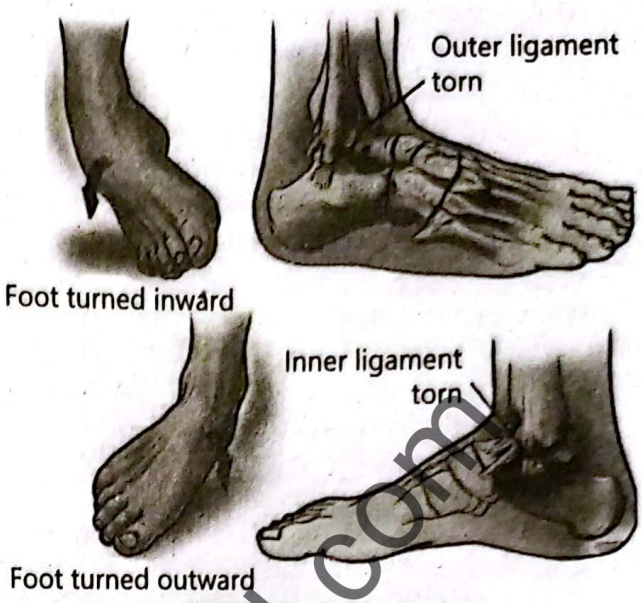


Fig. 12.17 - Ankle sprain

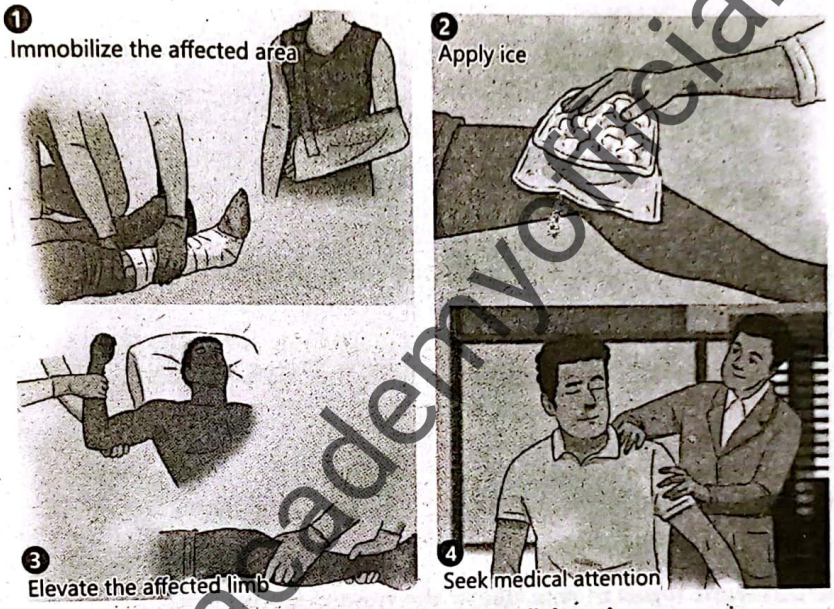


Fig. 12.18 - First aid treatment for dislocation or sprain

MCQs

1. **What is a dislocation?**
   A. Swelling of a joint
   B. Misalignment of bones in a joint ✓
   C. Tearing of ligaments
   D. Softening of cartilage
2. **Which of the following is NOT a symptom of joint dislocation?**
   A. Swelling
   B. Intense pain
   C. Increased motion ✓
   D. Immobility
3. **What can cause a joint dislocation?**
   A. Bacterial infection
   B. Lack of calcium
   C. Sudden impact or trauma ✓
   D. Poor posture
4. **Which medical condition can also cause joint dislocation?**
   A. Osteoporosis
   B. Rheumatoid arthritis ✓
   C. Gout
   D. Osteoarthritis
5. **Who can successfully correct a dislocated joint?**
   A. Surgeon
   B. Chiropractor
   C. Physiotherapist ✓
   D. General physician
6. **What may be required to repair stretched ligaments in severe dislocation?**
   A. Massage therapy
   B. Acupuncture
   C. Surgery ✓
   D. Injection
7. **What is a sprain?**
   A. Dislocation of bones
   B. Inflammation of tendons
   C. Injury to ligaments ✓
   D. Fracture of joint
8. **Which joints are commonly affected by sprains?**
   A. Elbow, shoulder, neck
   B. Ankle, knee, wrist ✓
   C. Hip, spine, foot
   D. Finger, toe, back
9. **How is a sprain usually treated?**
   A. Surgery
   B. Massage
   C. Physical therapy and dressings ✓
   D. Immobilization with metal plates

10. **What is the correct first aid step for dislocation or sprain?**
A. Rub the joint with oil
B. Forcefully align the joint
C. Immobilize the area and seek medical help ✓
D. Move the joint to check mobility

SQ

1. **What are joint injuries and what symptoms do they cause?**
Ans. Joints can be subject to a variety of injuries, which can result in pain, swelling, and reduced motion.
2. **What is a dislocation, and what causes it?**
Ans. A dislocation is when the bones in a joint are forced out of their normal positions. This can happen as a result of a sudden impact or trauma.
3. **What are the symptoms and complications of a dislocated joint?**
Ans. A severe dislocation can cause tearing of the muscles, ligaments and tendons. Symptoms include swelling, intense pain, and immobility of the affected joint. Rheumatoid arthritis can also cause joint dislocation.
4. **How is a dislocated joint treated?**
Ans. A dislocated joint can only be successfully corrected by a physiotherapist. Surgery may be needed to repair or tighten the stretched ligaments.
5. **What is a sprain and which joints are commonly affected?**
Ans. A sprain is an injury to the ligaments that connect bones in a joint. Commonly injured ligaments are in the ankle, knee, and wrist. This can happen when the joint is forced beyond its normal range of motion, causing the ligaments to stretch or tear.
6. **How are sprains usually treated?**
Ans. Sprains are usually treated with physical therapy. Dressings is done to immobilize the sprain and provide support.
7. **What are the first aid steps for dislocation and sprain?**
Ans. First aid treatment for dislocation and sprain includes the following steps:
   1. **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.
   2. **Elevate the affected limb**: In the case of dislocation, if possible, elevate the affected limb above to help reduce swelling.
   3. **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.

12.3 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. The human body has **three types of muscle tissues**: **skeletal**, **smooth**, and **cardiac**.

Q 9 **Explain the different types of muscles in the human body?**

Ans.

1. **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**.
   - Because their contractions are usually **consciously controlled**, skeletal muscles are called as **voluntary muscles**.
2. **Smooth Muscles**
   - Smooth muscles are present in the walls of the stomach, intestines, blood vessels, and other internal organs.
   - 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.
3. **Cardiac Muscles**
   - These are found only in the walls of the heart.
   - 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.

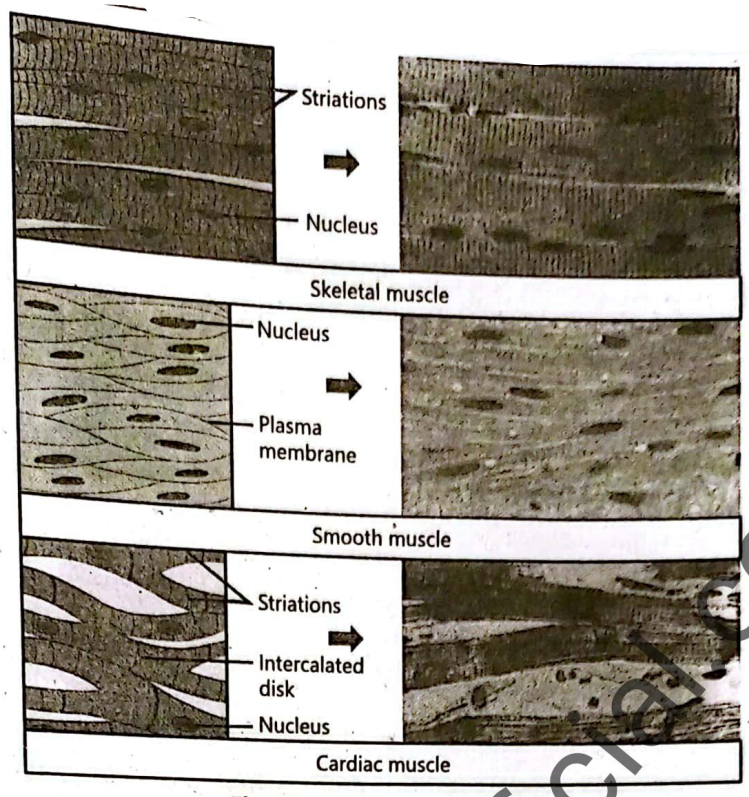


Fig. 12.19 - Types of muscles

Comparison of three types of muscle tissues

Property	Skeletal Muscle	Smooth Muscle	Cardiac Muscle
Appearance	Regularly striped (striated)	Unstriped (non-striated)	Irregularly striped (striated)
Cell Shape	Cylindrical	Spindle-shaped	Branched
Number of Nuclei	Many nuclei per cell	One nucleus per cell	One nucleus per cell
Voluntary Control	Under voluntary control	Not under voluntary control	Usually not under voluntary control
Function	Moves the skeleton	Moves substances through hollow organs	Pumps blood throughout 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.

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.

MCQs

1. **Which type of muscle is responsible for moving parts of the body such as the limbs and trunk?**
   A) Cardiac muscle
   B) Smooth muscle
   C) Skeletal muscle ✓
   D) Involuntary muscle
2. **What is the shape of smooth muscle fibres?**
   A) Cylindrical
   B) Elongated with striations
   C) Branched
   D) Spindle-shaped ✓
3. **Which muscle type is voluntary?**
   A) Cardiac muscle
   B) Smooth muscle
   C) Skeletal muscle ✓
   D) Involuntary muscle
4. **Where are cardiac muscles found?**
   A) In limbs
   B) In the walls of internal organs
   C) In the face muscles
   D) In the walls of the heart ✓
5. **Which characteristic is common between skeletal and cardiac muscles?**
   A) Both are involuntary
   B) Both have spindle-shaped fibres
   C) Both lack striations
   D) Both have striated muscle fibres ✓

SQ

1. How many types of muscle tissues are found in the human body?

Ans. The human body has three types of muscle tissues: skeletal, smooth, and cardiac.

2. What are skeletal muscles and what are their characteristics?

Ans. 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. Because their contractions are usually consciously controlled, skeletal muscles are called as voluntary muscles.

3. Where are smooth muscles found and what are their features?

Ans. Smooth muscles are present in the walls of the stomach, intestines, blood vessels, and other internal organs. 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.

4. What are cardiac muscles and where are they located?

Ans. Cardiac muscles are found only in the walls of the heart. 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.

5. What is the major difference between voluntary and involuntary muscles?

Ans. Skeletal muscles are voluntary muscles because their contractions are usually consciously controlled. In contrast, smooth muscles are involuntary muscles because most of their movements cannot be consciously controlled.

Q 10. Describe the structure of skeletal muscles in detail?

Ans. 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 (Fig. 12.20).** 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.

Myofibrils and Filament Composition

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
- Thin filaments composed of actin

The thick filaments create **dark bands** called **A-bands**, while the thin filaments create **light bands** called **I-bands**. These alternating dark and light bands give skeletal muscle its striped (**striated**) appearance.

Structure of Sarcomere

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-band**, where no overlap occurs **(Fig. 12.20).**

Mechanism of Muscle Contraction

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.

Biochemistry of Myofilaments

Myofilaments are the contractile structures found within the myofibrils of muscle fibres. They are broadly classified into **thick** and **thin myofilaments**, both of which are composed of specific proteins essential for muscle contraction.

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 (Fig. 12.21).**

Thin Myofilaments

Thin myofilaments, **7-8 nm in diameter**, are made of **three proteins**:

1. Actin (Core Protein)
2. The core is made of two twisted strands of actin.
3. Tropomyosin
4. Two strands of tropomyosin wrap about the actin core and stiffen it.
5. In a relaxed muscle fibre, they block myosin binding sites on actin.
6. Troponin
7. Troponin protein is present at regular intervals on thin myofilaments.
8. It is made of three polypeptides:
   - One polypeptide is inhibitory and binds to actin.
   - The second polypeptide binds to tropomyosin to keep it in place.
   - The third polypeptide binds to calcium ions.

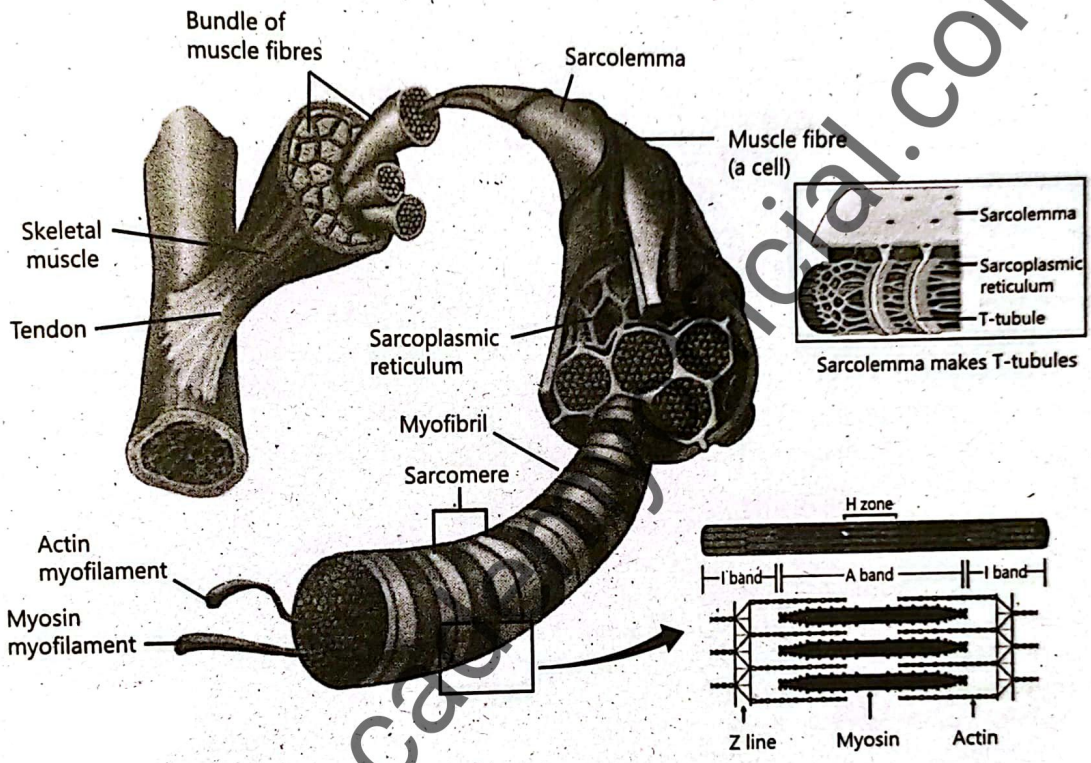


Fig. 12.20 - Ultrastructure of skeletal muscle

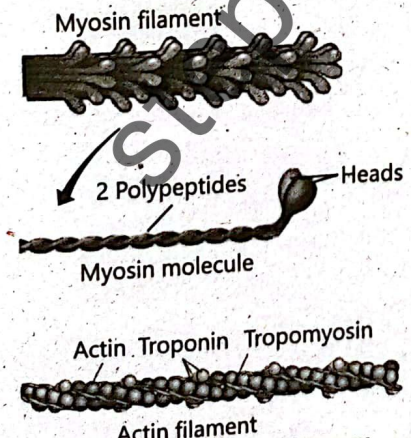


Fig. 12.21 - Structure of myofilaments

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 fiber contains bundles of myofibrils in its cytoplasm. Each myofibril is made of 2 types of myofilaments (myosin and actin).

MCQs

1. **The cells of skeletal muscles are enclosed by?**
   A) Myelin sheath B) Cartilage
   C) Collagen fibres and connective tissue ✓
   D) Ligaments
2. **The tendons at the ends of skeletal muscles are formed by?**
   A) Bone marrow B) Sarcomeres
   C) Collagen and connective tissue ✓
   D) Z-lines
3. **The plasma membrane of a skeletal muscle fibre is called?**
   A) Sarcomere B) Sarcoplasm
   C) Sarcolemma ✓ D) Myolemma
4. **The cytoplasm of a skeletal muscle fibre is known as?**
   A) Sarcolemma B) Sarcoplasm ✓
   C) Sarcotubule D) Sarcomere
5. **The transverse tubules (T-tubules) are?**
   A) Part of the nucleus
   B) Elongated tubes from the sarcoplasm
   C) Hollow tubes from the sarcolemma ✓
   D) Extensions of myosin filaments
6. **Myofibrils are composed of?**
   A) Actin and collagen B) Myosin and actin ✓
   C) Myosin and troponin D) Actin and elastin
7. **The dark bands in skeletal muscles are?**
   A) I-bands B) H-bands
   C) Z-lines D) A-bands ✓
8. **The light bands in skeletal muscles are formed by?**
   A) Myosin filaments B) Actin filaments ✓
   C) Collagen fibres D) T-tubules
9. **A sarcomere is the section between?**
   A) Two M-lines B) Two H-zones
   C) Two Z-lines ✓ D) Two A-bands
10. **During muscle contraction, the A-bands?**
    A) Narrow B) Disappear
    C) Widen
    D) Are pulled closer together ✓

SQ

1. How are skeletal muscle fibres arranged and connected to bones?

Ans. 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.

2. What is the ultrastructure of a skeletal muscle fibre?

Ans. 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 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.

3. What are myofibrils and what filaments are they composed of?

Ans. 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 I-bands. These alternating dark and light bands give skeletal muscle its striped (striated) appearance.

4. What is a sarcomere and what is its structure?

Ans. 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-band, where no overlap occurs.

5. How does muscle contraction occur in skeletal muscle?

Ans. 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.

Q

11. Explain the mechanism of muscle contraction using the sliding filament model?

Ans. Introduction

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:

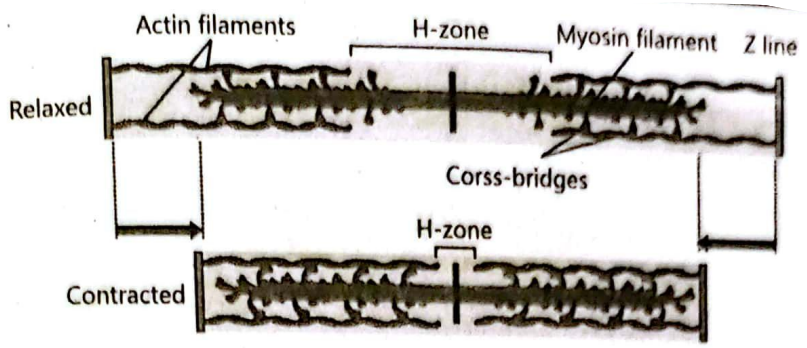


Fig. 12.22 - Sliding filament model of muscle contraction

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.

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.

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 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.

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.

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 fiber to the T tubules.

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.

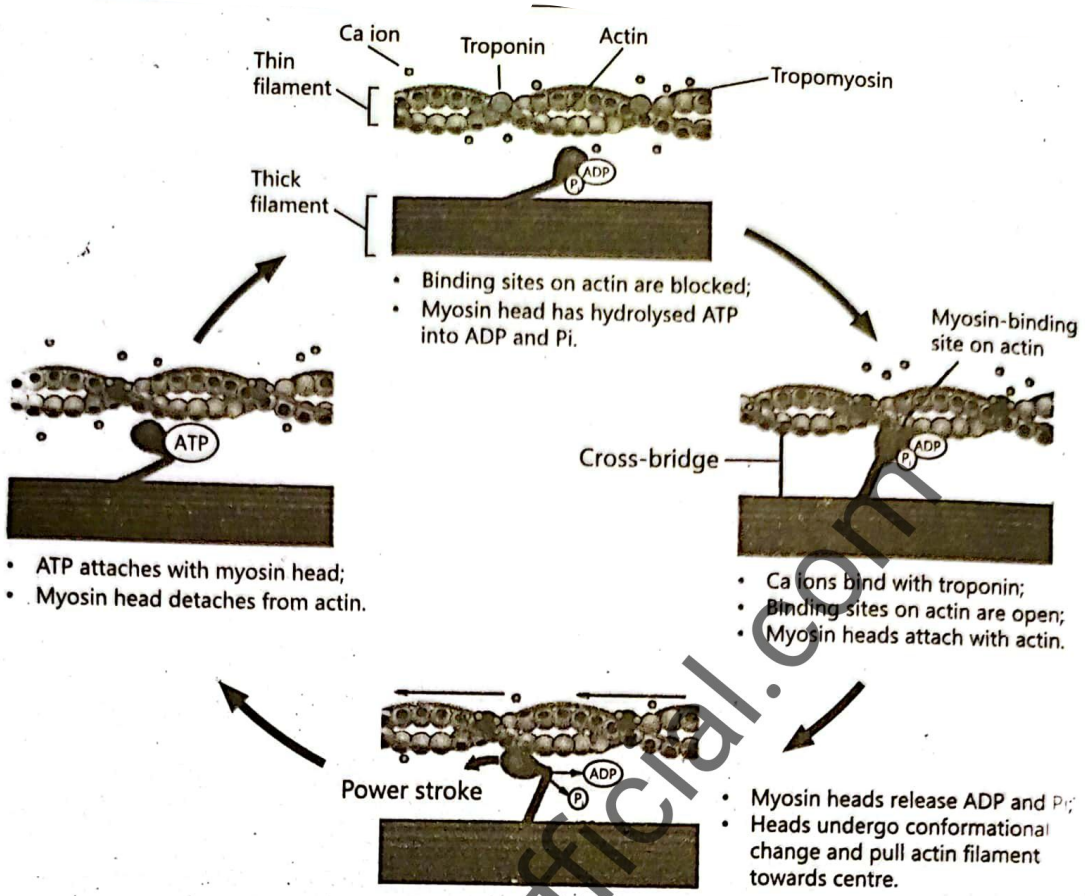


Fig. 12.23 - Steps of a power-stroke (cross bridge cycle)

MCQs

1. **According to the sliding filament model, muscle contraction occurs when:**
   A) Myosin filaments break down
   B) Thin filaments slide past thick filaments ✓
   C) Sarcomeres expand
   D) Z-lines disappear
2. **What prevents myosin from binding to actin in a relaxed muscle?**
   A) Calcium ions
   B) ADP and Pi
   C) Tropomyosin ✓
   D) ATP molecules
3. **What is the state of myosin heads in a relaxed muscle fibre?**
   A) They are bound to actin
   B) They are unhydrolyzed
   C) They have hydrolysed ATP into ADP and Pi ✓
   D) They are detached and inactive
4. **Where does the nerve impulse travel after reaching the muscle fibre?**
   A) Directly to the sarcomere
   B) To the Z-lines
   C) Along sarcolemma to T-tubules and SR ✓
   D) To the myosin heads
5. **What role does troponin play during muscle contraction?**
   A) Blocks myosin-binding sites
   B) Binds calcium ions and shifts tropomyosin ✓
   C) Breaks ATP
   D) Binds myosin to actin
6. **What initiates the formation of cross-bridges in muscle fibres?**
   A) Hydrolysis of ATP
   B) Disappearance of the H-zone
   C) Exposure of binding sites on actin ✓
   D) Relaxation of sarcomere
7. **What happens during the power stroke?**
   A) Tropomyosin blocks actin
   B) Myosin heads bend, pulling actin filaments ✓
   C) Sarcomere returns to relaxed state
   D) ATP is synthesized
8. **What disappears during sarcomere shortening?**
   A) I-band
   B) A-band
   C) Z-line
   D) H-zone ✓
9. **What causes myosin to detach from actin after a power stroke?**
   A) Troponin release
   B) Binding of new ATP molecule ✓
   C) SR absorbing calcium
   D) Relaxation of muscle fibre
10. **What happens after ATP is split into ADP and Pi?**
    A) Myosin detaches permanently
    B) Sarcomere disintegrates
    C) Myosin head returns to original conformation ✓
    D) Troponin rebinds calcium

1. What happens to sarcomeres in a relaxed muscle?

Ans. 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.

2. What is the role of a nerve impulse in muscle contraction?

Ans. 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. How are cross-bridges formed and what is a power stroke?

Ans. 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.

4. What causes the detachment of myosin heads from actin?

Ans. 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.

5. What is the sliding filament model of muscle contraction?

Ans. 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: relaxed state of sarcomeres, arrival of nerve impulse, formation of cross-bridges and power stroke, and separation of myosin heads from actin.

Q 12. Describe the arrangement of skeletal muscles at moveable joints and explain the mechanism of movement at the knee joint.

Ans. Arrangement of Skeletal Muscles at 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**.
- 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 an arrangement, when one muscle, called **flexor**, contracts, it **bends the bone** at the joint. When the opposing muscle, called **extensor**, contracts, it **straightens the bone** at joints.
- During such antagonistic action, when a muscle (e.g., flexor) contracts, the other muscle (i.e., extensor) is **relaxed** and **vice versa**.

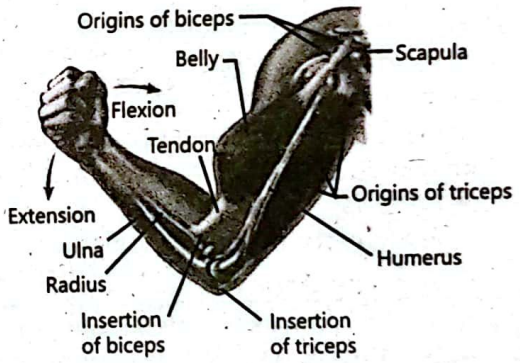


Fig. 12.24 - Arrangement of skeletal muscles at elbow joint

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.
- 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.

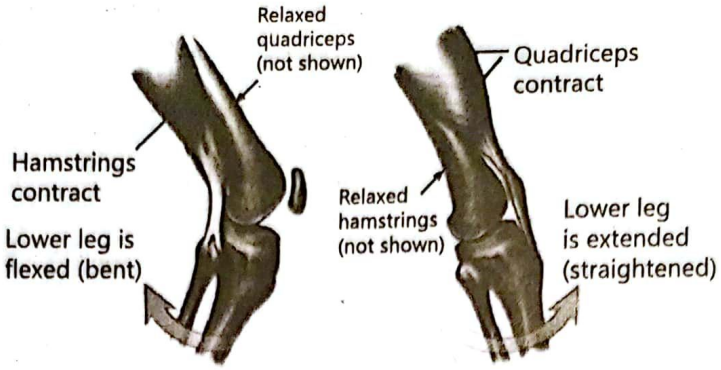


Fig. 12.25 - Movement at knee joint

MCQs

1. **What are skeletal muscles attached to bones by?**
   A. Ligaments B. Cartilage
   C. Tendons✓ D. Joints
2. **What is the end of the muscle called that is attached to the stationary bone during contraction?**
   A. Insertion B. Origin✓
   C. Belly D. Extension
3. **Which part of the muscle is referred to as the belly?**
   A. End attached to stationary bone
   B. End attached to the moving bone
   C. Middle part of the muscle✓
   D. Outer sheath of the muscle
4. **How do skeletal muscles work to move bones at joints in two directions?**
   A. Individually
   B. By contracting randomly
   C. By working in pairs✓
   D. By stretching the bone
5. **What is the arrangement of muscles called when they produce opposing actions?**
   A. Cooperative arrangement
   B. Antagonistic arrangement✓
   C. Symbiotic arrangement
   D. Linear arrangement
6. **What is the name of the muscle that bends the bone at a joint?**
   A. Extensor B. Rotator
   C. Flexor✓ D. Contractor
7. **What happens to the extensor muscle when the flexor contracts?**
   A. It contracts simultaneously
   B. It bends the bone
   C. It rotates the joint
   D. It relaxes✓
8. **Between which bones is the knee joint located?**
   A. Radius and ulna B. Femur and humerus
   C. Femur and tibia and fibula✓
   D. Tibia and scapula
9. **What group of muscles performs flexion of the lower leg at the knee joint?**
   A. Quadriceps B. Gluteals
   C. Calf muscles D. Hamstrings✓
10. **What happens when the quadriceps contract?**
    A. The lower leg bends and hamstrings relax
    B. The lower leg straightens and hamstrings relax✓
    C. The thigh rotates and hamstrings contract
    D. The foot lifts and hamstrings stiffen

SQ

1. **How are skeletal muscles attached to bones and what are their typical attachment points?**

Ans. 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.

2. **How do muscles work to move bones at a joint in two directions?**

Ans. For the movement of bones at a joint in two directions, muscles work in pairs. They produce opposing actions when they contract. Such an arrangement of muscles is called an antagonistic arrangement. In this arrangement, when one muscle, called the flexor, contracts, it bends the bone at the joint. When the opposing muscle, called the extensor, contracts, it straightens the bone at joints.

3. What happens to the opposing muscle during an antagonistic muscle action?

Ans. During such antagonistic action, when one muscle contracts, the opposing muscle is relaxed. For example, when a muscle such as the flexor contracts, the extensor is relaxed, and vice versa. This coordination allows smooth and controlled movement at joints.

4. What bones form the knee joint and what is the function of the hamstrings in this joint?

Ans. 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, which 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.

5. What is the role of quadriceps in the movement at the knee joint?

Ans. Extension, or straightening, of the lower leg is done by the quadriceps, 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 quadriceps contract, the lower leg straightens and the hamstrings relax.

13. Describe Ssome common muscle disorders in detail.

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

Causes

- 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.

Treatment

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:

Causes

- Dehydration
- An imbalance of salts
- Overuse or injury of the muscle
- Certain medications (like diuretics)
- Medical conditions such as diabetes, liver disease, and 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. The most common cause of tetany is **hypocalcaemia** (low level of calcium in blood), which may be due to:

- Vitamin D deficiency
- Renal failure
- Thyroid disorders
- Tetany may also be due to other salt imbalances, such as a low level of magnesium in blood.

Treatment

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

Muscles pull but do not push. 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.

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.

MCQs

1. **What is muscle fatigue?**
   A) Permanent loss of muscle function
   B) A sudden contraction of muscle
   C) Decline in muscle performance after prolonged activity✓
   D) Complete breakdown of muscle tissue

2. **Which of the following is a symptom of muscle fatigue?**
   A) Hyperactivity B) Increased endurance
   C) Pain and decreased muscle strength✓
   D) Muscle enlargement

3. **Which compound is depleted during exercise, leading to muscle fatigue?**
   A) Glucose B) Oxygen
   C) ATPs✓ D) Calcium

4. **How do metabolic wastes contribute to muscle fatigue?**
   A) By stimulating muscle growth
   B) By enhancing oxygen uptake
   C) By impairing muscle contraction✓
   D) By increasing energy reserves

5. **What happens to calcium ion handling in muscle fibres during repeated activation?**
   A) It improves with time
   B) It becomes more efficient
   C) It becomes ineffective and impairs muscle function✓
   D) It leads to bone contraction

6. **Which group of disorders includes sudden, involuntary contractions of muscles?**
   A) Muscle fatigue B) Muscle cramps✓
   C) Bone fractures D) Tetany

7. **Which of the following is a common cause of muscle cramps?**
   A) Excess sleep B) High blood sugar
   C) Dehydration and imbalance of salts✓
   D) Hyperventilation

8. **What is tetany?**
   A) Permanent muscle relaxation
   B) A condition with involuntary muscle spasms✓
   C) Muscle regeneration process
   D) Muscle thickening condition

9. **What is the most common cause of tetany?**
   A) Excess sodium B) Hyperglycemia
   C) Hypocalcaemia✓
   D) High levels of potassium

10. **How is tetany treated when caused by salt imbalances?**
    A) By surgery B) By applying ice
    C) By calcium or magnesium supplements and intravenous fluids✓
    D) By massage only

SQ

1. **What is muscle fatigue?**

Ans. 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.

2. **What factors contribute to muscle fatigue?**

Ans. The following factors contribute to muscle fatigue:

- 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.

3. **What are the symptoms of muscle fatigue?**

Ans. The symptoms of muscle fatigue include pain, decreased muscle strength, and reduced endurance.

4. **How does depletion of ATPs cause muscle fatigue?**

Ans. During exercise, the muscles use ATPs to contract. When the supply of ATPs is depleted, the muscle is no longer able to contract.

5. **How do metabolic wastes contribute to muscle fatigue?**

Ans. As muscles work, they produce metabolic wastes e.g., lactate, hydrogen ions, and reactive oxygen. These wastes contribute to muscle fatigue.

6. **How does repeated activation of muscle fibres affect muscle function?**

Ans. When muscle fibres are repeatedly activated, they are not able to effectively handle calcium ions, which can impair muscle function.

7. **What happens to muscle fibres during prolonged or intense exercise?**

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

8. **How is muscle fatigue treated?**

Ans. Muscle fatigue typically improves with rest. If it is severe, it requires medical attention.

9. **What are muscle cramps?**

Ans. 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.

10. **What are some common causes of muscle cramps?**

Ans. Common causes of muscle cramps 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.

14. What is the difference between Tetany and Tetanus?

Ans. **Tetany and tetanus** are different conditions often confused due to their similar names. However, they are distinct in cause, symptoms, and severity. The following points highlight their differences:

1. **Cause and Nature**
   - **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. **Affected Body Parts**
   - **Tetany** can affect various body parts like the hands, feet, face, or larynx.
   - **Tetanus** mainly affects the jaw and neck muscles.
3. **Underlying Causes**
   - **Tetany** can result from issues like electrolyte imbalances or nerve problems.
   - **Tetanus** is caused by a specific bacterial infection.
4. **Severity**
   - **Tetanus** is more serious and potentially life-threatening compared to **tetany**.

MCQs

1. **What causes tetany?**
   A) Bacterial infection by *Clostridium tetani*
   B) Increased muscle tone and overactive nerves causing involuntary muscle contractions ✓
   C) Viral infection affecting muscles
   D) Lack of oxygen in muscles
2. **Which body parts are mainly affected by tetanus?**
   A) Hands and feet B) Face and larynx
   C) Jaw and neck muscles ✓
   D) Lower back muscles
3. **What is the cause of tetanus?**
   A) Electrolyte imbalance B) Nerve problems
   C) Bacterial infection producing a toxin ✓
   D) Muscle fatigue
4. **What is a key difference in severity between tetany and tetanus?**
   A) Tetany is more serious than tetanus
   B) Both have equal severity
   C) Tetanus is more serious and potentially life-threatening ✓
   D) Neither condition is serious
5. **Why are tetany and tetanus often confused?**
   A) Because both are caused by bacteria
   B) Because both affect the jaw muscles
   C) Because they have similar names but are different conditions ✓
   D) Because both result from electrolyte imbalance

SQ

1. **What is the main difference between tetany and tetanus in terms of their causes and nature?**
Ans. Tetany involves increased muscle tone and overactive nerves, causing involuntary muscle contractions or spasms. On the other hand, 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. **Which body parts are affected by tetany and tetanus respectively?**
Ans. Tetany can affect various body parts such as the hands, feet, face, or larynx. In contrast, tetanus mainly affects the jaw and neck muscles.
3. **What are the underlying causes of tetany and tetanus?**
Ans. Tetany can result from issues like electrolyte imbalances or nerve problems. Whereas tetanus is caused by a specific bacterial infection by *Clostridium tetani*.
4. **How does the severity of tetany compare to tetanus?**
Ans. Tetanus is more serious and potentially life-threatening compared to tetany.
5. **Why are tetany and tetanus often confused with each other?**
Ans. Tetany and tetanus are often confused because of their similar names, even though they are different conditions with distinct causes, symptoms, and levels of severity.

SOLVED EXERCISE

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct answer.

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 myofiber 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 push while other pulls
(c) It allows muscles to produce opposing movements (d) It doubles the strength of contraction

SHORT ANSWER QUESTIONS

1. **Name three types of cells associated with bone and write their functions?**
- **Osteoblasts**: Bone-forming cells that synthesize and secrete bone matrix.
- **Osteocytes**: Mature bone cells that maintain bone tissue and regulate mineral homeostasis.
- **Osteoclasts**: Bone-resorbing cells that break down bone tissue for remodelling and calcium release.

2. **Name the bones of cranium?**
- Frontal bone
- Parietal bones (2)
- Temporal bones (2)
- Occipital bone
- Sphenoid bone
- Ethmoid bone

3. **Enlist the bones in the five groups of vertebrae?**
- **Cervical vertebrae (7)** – Neck region
- **Thoracic vertebrae (12)** – Attach to ribs
- **Lumbar vertebrae (5)** – Lower back
- **Sacrum (5 fused)** – Pelvic region
- **Coccyx (4 fused)** – Tailbone

4. **What bones make the rib cage?**
- **Sternum** (breastbone)
- **12 pairs of ribs** (attached to thoracic vertebrae)
- **Costal cartilages** (connect ribs to sternum)

5. **Name the bones of pectoral girdle and pelvic girdle?**
- **Pectoral girdle**: Scapula (shoulder blade) and clavicle (collarbone)
- **Pelvic girdle**: Two hip bones (each made of ilium, ischium, and pubis)

6. **Name the bones of forelimbs and hindlimbs?**
- **Forelimbs**: Humerus, radius, ulna, carpals (wrist), metacarpals (palm), phalanges (fingers)
- **Hindlimbs**: Femur, patella, tibia, fibula, tarsals (ankle), metatarsals (foot), phalanges (toes)

7. **What is fibrous joint? Give examples?**
- **Definition**: Immovable joints held together by dense connective tissue.
- **Examples**: Sutures in the skull, teeth sockets (gomphosis), and interosseous membrane between radius and ulna.

8. **Name the steps involved in bone repair?**
1. **Hematoma formation** (blood clot at fracture site).
2. **Fibrocartilaginous callus formation** (soft callus of collagen and cartilage).
3. **Bony callus formation** (hard callus of spongy bone).
4. **Bone remodelling** (osteoclasts and osteoblasts reshape bone).

9. **What skeletal structures are affected from the osteoarthritis?**
   - **Articular cartilage** (wears down)
   - **Subchondral bone** (thickens)
   - **Synovial membrane** (inflamed)
   - **Joint capsule** (stiffens)
10. **List the major parts of skeletal muscle fibre?**
   - **Sarcolemma** (cell membrane)
   - **Sarcoplasm** (cytoplasm)
   - **Myofibrils** (contractile proteins)
   - **Sarcoplasmic reticulum** (stores Ca^{2+})
   - **T-tubules** (conduct impulses)
11. **What do you mean by I-band, A-band and H-zone?**
   - **I-band**: Light band (only actin filaments).
   - **A-band**: Dark band (overlapping actin and myosin).
   - **H-zone**: Central region of A-band (only myosin).
12. **Describe the antagonistic arrangement of skeletal muscles?**
   - Muscles work in pairs (agonist and antagonist) for opposite movements.
   - Example: **Biceps** (flexor) and **triceps** (extensor) in the arm.
13. **Ligaments are elastic while tendons are hard. Justify?**
   - **Ligaments** (bone-to-bone) contain more elastin for flexibility.
   - **Tendons** (muscle-to-bone) have more collagen for strength.
14. **Draw a diagram of sarcomere and label its parts?**

Ans. *(Visual answer: Z-lines, I-band, A-band, H-zone, M-line, actin, myosin)*

15. **Differentiate between?**

Comparison	Item 1	Item 2	Item 3 (if applicable)
Bone Type	Compact Bone: Dense, solid, outer layer, strength/support	Spongy Bone: Porous trabeculae, inner layer, shock absorption	—
Skeleton Division	Axial Skeleton: Skull, vertebrae, ribs, sternum	Appendicular Skeleton: Limbs, shoulder and hip girdles	—
Rib Types	True Ribs (1–7): Directly attached to sternum	False Ribs (8–10): Indirectly via cartilage	Floating Ribs (11–12): No sternal attachment
Arthritis Type	Rheumatoid Arthritis: Autoimmune, synovial inflammation	Osteoarthritis: Wear-and-tear, cartilage degeneration	—
Joint Types	Fibrous: Immovable (e.g., skull sutures)	Cartilaginous: Slightly movable (e.g., discs)	Synovial: Freely movable, fluid-filled cavity
Bone Cells	Osteoblasts: Build bone matrix	Osteocytes: Maintain bone tissue	—
Muscle Proteins	Tropomyosin: Blocks actin binding sites	Troponin: Binds Ca^{2+}, exposes actin	—
Connective Tissues	Ligament: Bone-to-bone, elastic	Tendon: Muscle-to-bone, tough	—
Muscle Disorders	Tetany: Muscle spasms (low Ca^{2+})	Tetanus: Sustained contraction (high-frequency stimulation)	—

LONG QUESTIONS

Q1. Explain the structure of bone?

Ans. See Long Question No. 01

Q2. Describe the structure of three types of cartilage?

Ans. See Long Question No. 04

Q3. Write the cause and symptoms of joint dislocation, spondylosis, and sciatica?

Ans. See Long Question No. 07

Ans. See Long Question No. 09

Q6. Explain the ultrastructure of skeletal muscle?

Ans. See Long Question No. 10

Q7. Write a detailed note on the sliding filament model of muscle contraction?

Ans. See Long Question No. 11

Q8. Explain the action of antagonistic muscles in the movement of knee joint?

Ans. See Long Question No. 12

Q9. Draw a diagram of sarcomere and label its parts?

Ans. See Long Question No. 13

Q10. Describe causes and symptoms of muscle fatigue, cramps and tetany?

Ans. See Long Question No. 14

Q11. Justify how the main functions of the skeleton are to act as a system of rods and levers?

Ans. See Long Question No. 13

Q12. Justify why do the muscles pull but do not push?

Ans. See Long Question No. 14

INQUISITIVE QUESTIONS

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

Ans. Calcium provides hardness and strength to bones by forming calcium phosphate crystals. In muscle contraction, calcium ions bind to troponin, exposing actin binding sites for myosin, enabling contraction.

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

Ans. Rigid bones provide support and protection, while flexible joints allow movement. A single solid structure would restrict motion and adaptability in different physical activities.

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

Ans. Muscles can only pull, not push. Antagonistic pairs (like biceps and triceps) allow movement in opposite directions—one contracts while the other relaxes—enabling controlled motion.

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

Ans. Lack of mechanical stress reduces stimulation of muscles and bones. Muscles shrink (atrophy) and bones lose density (osteopenia/osteoporosis) due to reduced calcium deposition and protein synthesis.

Self-Assessment Unit 12

Max. Marks: 28 **Time allowed 60 Mins**

Q1. Each of the following question has four options. Select the correct answer. (10x1=10)

1. **Which of the following bones belongs to the appendicular skeleton?**
   (a) Ethmoid bone (b) Floating ribs (c) Lumbar vertebrae (d) Humerus
2. **The term "muscle fibre" or "myofibre" specifically refers to:**
   (a) A muscle organ (b) A type of tissue (c) An individual muscle cell (d) A cellular component
3. **What structure runs the full length of a muscle fibre?**
   (a) Sarcomere (b) Myofibril (c) Myosin filament (d) Actin filament
4. **Actin filaments are composed of the following proteins:**
   (a) Myosin and troponin (b) Actin and troponin
   (c) Actin and myosin (d) Actin, tropomyosin, and troponin
5. **In skeletal muscle, the Z-line serves as the point of attachment for:**
   (a) Actin filaments (b) Myosin filaments (c) Both actin and myosin (d) The sarcomere unit
6. **A sarcomere is the structural unit located between:**
   (a) Two H-zones (b) Two A-bands (c) Two Z-lines (d) Two I-bands
7. **Which structure in a muscle fibre stores and releases calcium for contraction?**
   (a) Sarcolemma (b) Sarcoplasm (c) T-tubules (d) Sarcoplasmic reticulum
8. **What best explains the sliding filament theory of muscle contraction?**
   (a) Myosin filaments contract to shorten actin filaments
   (b) Myosin pulls actin filaments, shortening the sarcomere
   (c) Actin filaments move myosin filaments to shorten sarcomere
   (d) Sarcomere pulls actin and myosin toward each other
9. **When a muscle contracts, which of the following shortens?**
   (a) Actin filament (b) Myosin filament (c) Sarcomere (d) Z-disc
10. **Which of the following occurs during muscle contraction?**
    (a) Myosin heads attach to troponin (b) ATP binds directly to actin
    (c) ATP is used to release myosin from actin (d) Troponin completely covers binding sites

Q2. Write short answers to the following questions **(5x2=10)**

1. Name three types of cells associated with bone and write their functions.
2. Enlist the bones in the five groups of vertebrae.
3. Name the steps involved in bone repair.
4. What do you mean by I-band, A-band and H-zone?
5. Describe the antagonistic arrangement of skeletal muscles.

Q3. Write detailed answer to the following question **(4+4=8)**

1. Describe the structure of three types of cartilage.
2. Write a detailed note on the sliding filament model of muscle contraction.