# NEET Revision Notes
# Biology
# Locomotion and Movement

## Introduction

- **Movement** is a feature shared by all living organisms. It constitutes the various key aspects of living organisms, ranging from protoplasmic motion in a cell or unicellular organisms to organ movement in complex organisms.
- **Locomotion** refers to the movement that results in a location change.

## Types of Movements:

- There seem to be three types of movement in a cell and organ. They are as follows:
    1. **Amoeboid movement:** Similar to pseudopodia in amoeba, ameboid movement can be seen in macrophages, leukocytes, and even cytoskeletal microfilaments.
    2. **Ciliary and flagellar movement:** Ciliary motion in the tracheal epithelial lining, reproductive tract, and so on. Flagellar movement is seen in sperm.
    3. **Muscular movement:** Muscles account for the majority of movement in a complex organism. Breathing, heart function, digestion, appendage movement, and locomotion are all carried out by various **muscles** of our body. The synchronised movement of the skeletal, neural, and muscular systems is referred to as **locomotion**.

## Muscle

- Muscles develop from the germinal layer of the **mesoderm**.
- Muscular tissues have distinct characteristics including contraction, excitation, extension, elasticity, and so on.
- We are all aware that there are **three types of muscles**:
    1. **Cardiac muscles** are **striated** and **involuntary** muscles found in the heart.
    2. **Visceral muscles** are **nonstriated** and **smooth**. They are involuntary too and support different internal organs as well as participate in functions including digestion and reproduction.

3. **Skeletal muscle**s are **striated** and **voluntary** muscles that control locomotion and appendage movement.

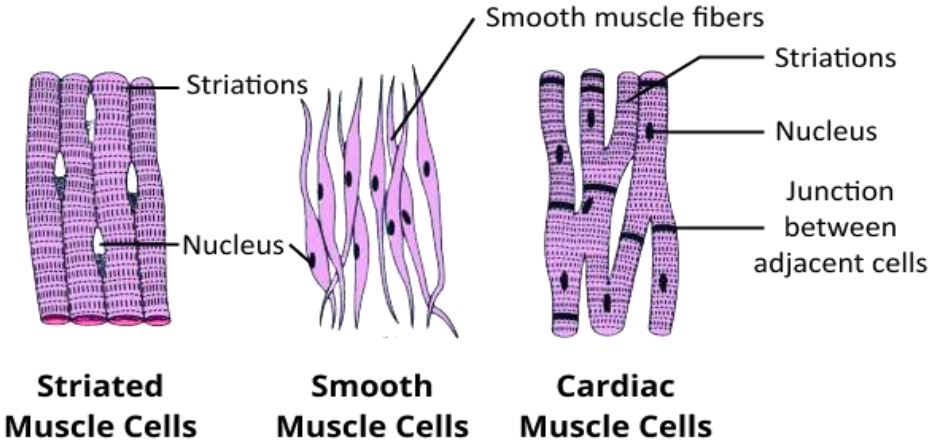


*Image: Types of Muscles*

**Muscle Fibre and Sarcomere Anatomy**

- Skeletal muscles are present in the animal's body most abundant.
- They are composed of bundles of muscle fibres surrounded by connective tissue.

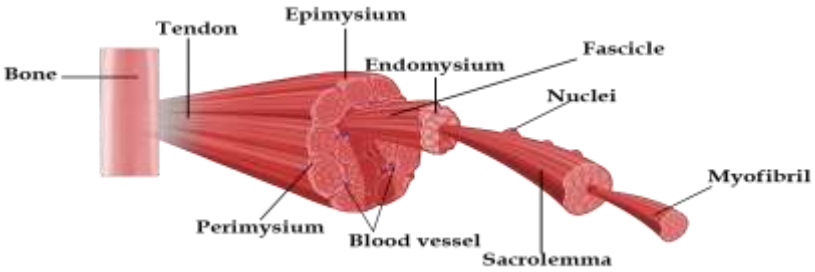


*Image: Structure of a skeletal muscle fibre*

- **Fascicles (Muscle Bundles):** A muscle, such as a biceps, is made up of numerous muscle bundles (fascicles) that are held together by fascia, a connective tissue layer. Several muscle fibres are found in each fascicle.
- **Muscle Fibres:** Muscle fibres are long cells. They are grouped into fascicles. Muscle fibres have the following characteristics:
  - ➢ Skeletal muscle fibres are all long, cylindrical, and striated.
  - ➢ It is syncytium, which means it has many nuclei.
  - ➢ The plasma membrane of the muscle fibre is known as the **sarcolemma**.
  - ➢ **Sarcoplasm** is the muscle fibre's cytoplasm.
  - ➢ The **sarcoplasmic reticulum** is the muscle fibre's endoplasmic reticulum. It is the $Ca^{2+}$ storage facility.

- **Myofibrils:** Multiple myofibrils run lengthwise and adjacent to each other in the sarcoplasm of each muscle fibre. Myofibrils' alternating dark and light bands bring the muscle a striated look. Each myofibril is made up of even simplified structures known as **myofilaments**.
- **Myofilaments:** In a myofibril, there are two kinds of myofilaments. Thin filaments and others that are **thick**. Muscle contraction requires the attachment of thin and thick filaments.

1. **Actin filaments (thin myofilaments):**
   - ➢ **Thin** filaments, also known as **Actin** filaments, are composed of three types of proteins.
   - ➢ It is made up of **two** polymeric filamentous or **'F' actin filaments** that are wound around each other. They are globular or **G-actin monomer** polymers.
   - ➢ **Tropomyosin** filaments coil lengthwise around actin filaments.
   - ➢ **Troponin**, which is found at specific points on tropomyosin, protects the **active binding zones** for **myosin**.
   - ➢ Troponin and tropomyosin govern actin and myosin filament binding and thus play a significant role in muscular contractions.

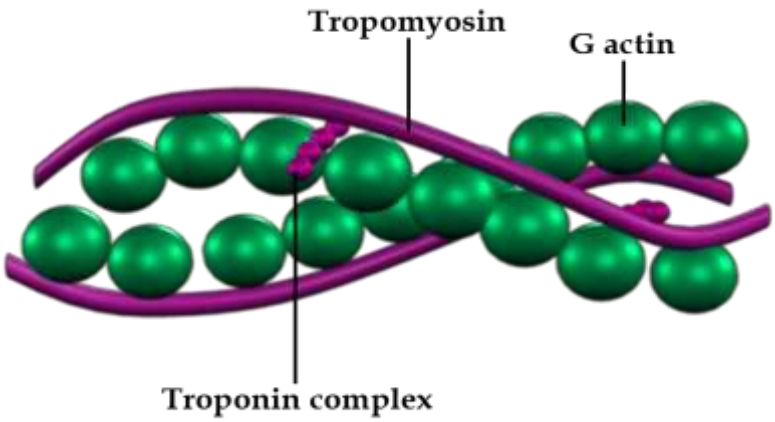


*Image: Structure of Actin (thin) filament*

2. **Myosin filament (thick myofilaments):**
   - ➢ Myosin is used to make **thick** filaments or **Myosin** filaments.
   - ➢ It is a polymeric protein made up of monomeric units of the protein **meromyosin**.
   - ➢ It is composed of **three** parts: a **tail**, a short arm or **neck**, and a **globular head**.

- ➢ At regular times, the head and cross arm extends from the filament.
- ➢ The globular head comprises ATP and actin-binding sites.
- ➢ The enzyme ATPase is activated by the head.

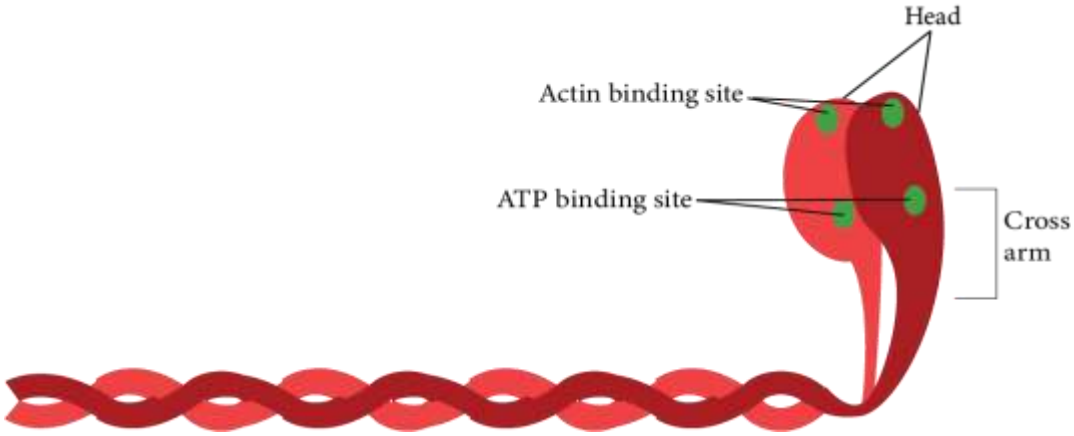


*Image: Structure of Myosin (thick) filament*

**Sarcomere:**

- A **sarcomere** is a muscle contraction functional unit.
- A myofibril is made up of hundreds of sarcomeres that are linked end to end.
- Sarcomeres are the fundamental unit of muscle contraction. It is made up of actin and myosin filament repeating units in a particular order.
- Sarcomeres are merged at the ends by filaments that interweave to form the **'Z' line**. It is a sarcomere's limiting membrane.
- At regular intervals, actin or thin filaments are linked to the Z-line.
- Between the thin filaments are thick or myosin filaments. They are kept together by a really thin fibrous membrane called the **'M' line**.
- Actin and myosin filaments span each other in a particular pattern, resulting in muscle striation. They form three kinds of bands.
- The **'I' band or isotropic band**, is the light band and is made up of actin filaments connected by two adjacent sarcomeres. Thick and thin filaments do not overlap in this case.
- The **'A' band or anisotropic band**, is the dark band, which contains both actin and myosin filaments that overlap.
- The **'H' zone** is the myosin filaments' centre portion, where actin filaments do not coincide with thick (myosin) filaments.

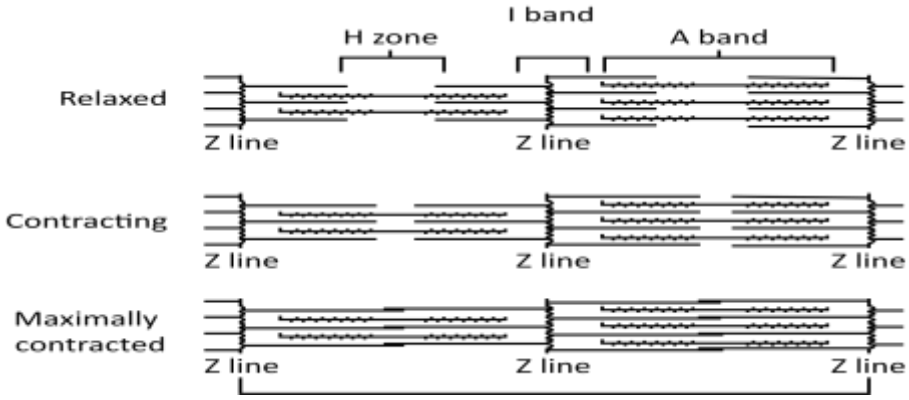


*Image: Sarcomere*

- So, a sarcomere is a basic muscle unit composed of thick and thin myofilaments. Myofibril contains hundreds of sarcomeres. A muscle fibre is made up of multiple myofibrils. Fascicles are bundles of muscle fibres. A muscle is made up of multiple muscle bundles that are encased in a fascia.

**Muscle Contraction Mechanism**

- Actin and myosin filaments slide over each other to cause muscle contraction.
- Andrew and Hugh Huxley proposed the **sliding filament model**.
- Sliding increases the overlap of thick (myosin) and thin (actin) filaments and causes the sarcomere to shorten and the muscles contract as a result of this.

**Steps of Muscle Contraction:**

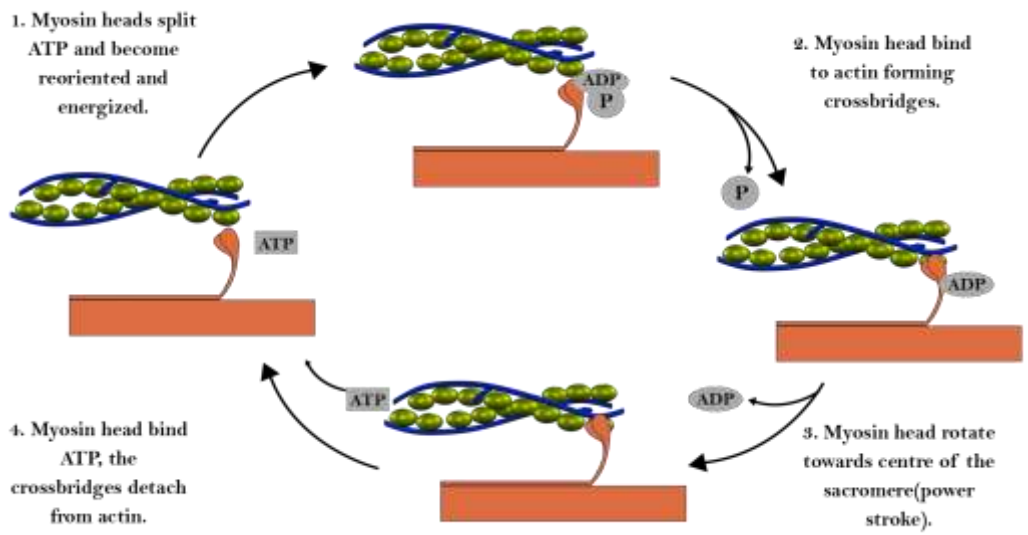


*Image: Steps of Muscle contraction*

- The brain or spinal cord (CNS) sends a signal to motor neurons to initiate muscle contraction.
- The neural signal induces the neurotransmitter **acetylcholine** to be released at the neuromuscular junction's synaptic cleft. Acetylcholine binds to receptors on muscle fibres, causing **sarcolemma depolarization**.
- The generated action potential propagates through the muscle fibre. The sarcoplasmic reticulum **releases $Ca^{2+}$ ions** into the sarcoplasm. Another protein, **dystrophin**, regulates $Ca^{2+}$ release. (NOTE: The dystrophin coding gene is the human body's longest gene.)
- $Ca^{2+}$ ions interact with **troponin** and alter its conformation. Myosin-binding areas on actin filaments become visible.
- The myosin head also has an ATP binding site, where ATP binds. The myosin head's ATPase activity catalyses ATP hydrolysis. The cocked (energised) myosin head binds to actin's active binding sites, creating a cross bridge.
- Following the attachment, the myosin head releases phosphate, resulting in the **'power stroke.'** Myosin filaments deform and pull actin filaments towards the sarcomere's centre, causing the sarcomere and muscle to shorten. During the process, ADP is released.
- ATP is also responsible for myosin head detachment.
- The process is repeated in the existence of sufficient $Ca^{2+}$ ions.

**Muscle Relaxation**

- When the neural signal stops, **Acetylcholinesterase** is a protein that **deactivates acetylcholine** in the synaptic cleft. Muscle fibres enter a state of rest.
- $Ca^{2+}$ ions are returned to the sarcoplasmic reticulum.
- In the complete lack of $Ca^{2+}$ ions, the troponin-tropomyosin complex re-covers the actin filaments' myosin-binding sites.
- Sarcomere Z-line comes back to its original position, and muscles relax.

**Muscle Fatigue**

- ATP drives muscle contraction.
- ATP is obtained by muscle fibres from the backup of creatine phosphate and glycogen. Under normal conditions, glycogen is turned into glucose, which is then used to produce ATP during cellular respiration.

- Muscles require a lot of energy when doing strenuous exercise. The body could not substitute the oxygen demand and glucose is degraded anaerobically.
- As a result, lactic acid builds up, causing muscle fatigue.
- **Rigour Mortis**, or short-term muscle stiffening after death, is caused by ATP depletion as cellular respiration terminates. ATP is necessary for the dissociation of the myosin head; in the absence of ATP, the cross-bridges in the muscles that were contracting remain intact. It aids in calculating the death time.
- **Muscle fibres** are classified into **two types** based on the quantity of oxygen-binding pigment which is myoglobin, present in them.
    1. **Red fibres**, also known as aerobic muscles, are reddish and contain too much myoglobin and mitochondria.
    2. **White fibres** (anaerobic muscles) are pale or white and have less myoglobin and mitochondria, but much more sarcoplasmic reticulum.

**Skeletal System**

- The skeletal system serves as our body's structural framework and aids in movement as well as locomotion.
- It shields the internal organs from harm. Our skeletal system is made up of different types of connective tissues, such as bones and cartilage.
- A human being has 206 bones. Because of the presence of Calcium salts in the matrix, bones are hard, whereas cartilage consists of chondroitin salts.
- The human skeleton is divided into two sections: the axial skeleton (80 bones) and the appendicular skeleton (126 bones).
- The axial skeleton (80 bones) includes the skull, vertebral column, ribs, and sternum.
- The appendicular skeleton has 126 bones consisting of the pectoral and pelvic girdles, as well as the limbs.

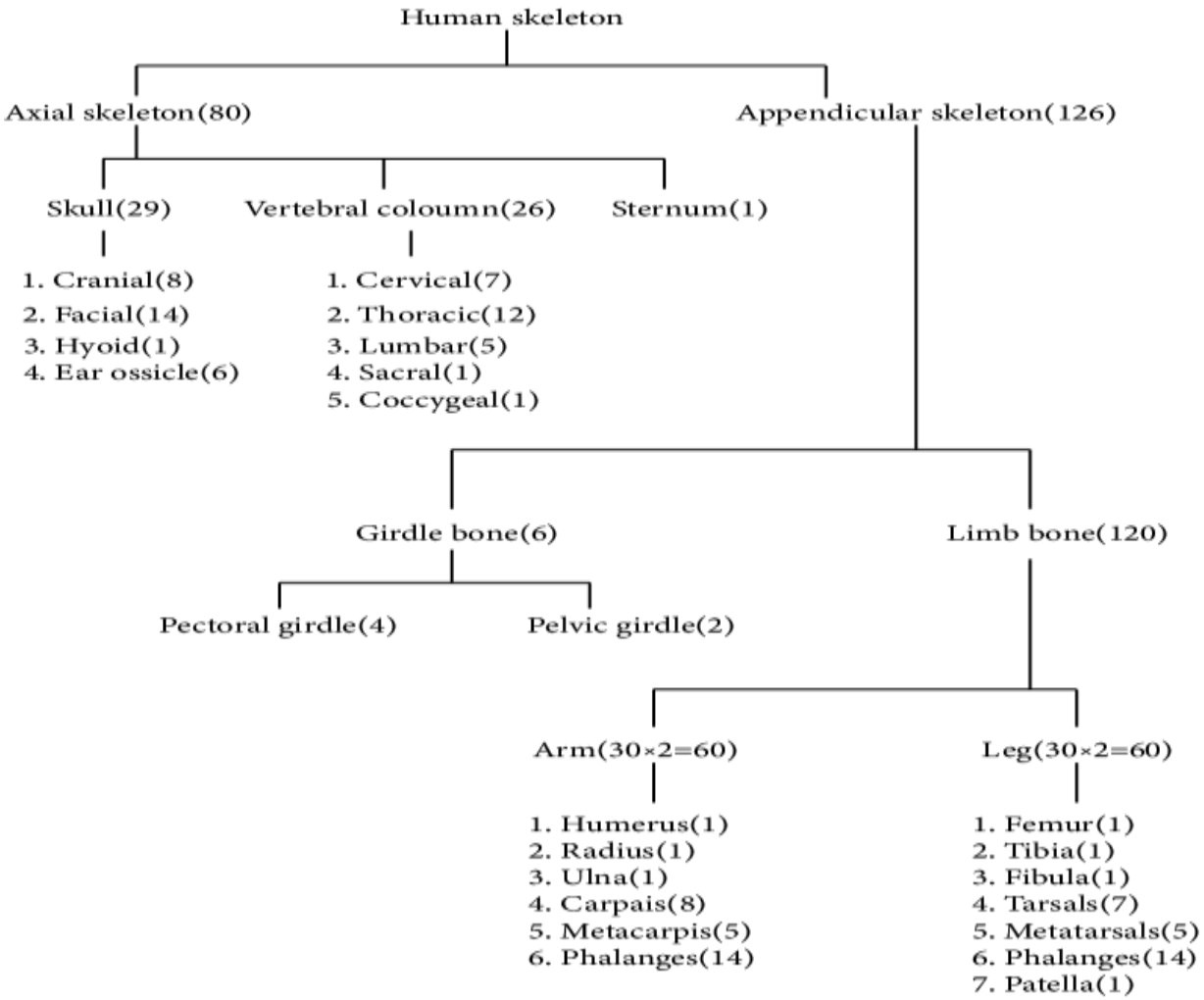


*Image: Flow chart of all bones present in the human body*

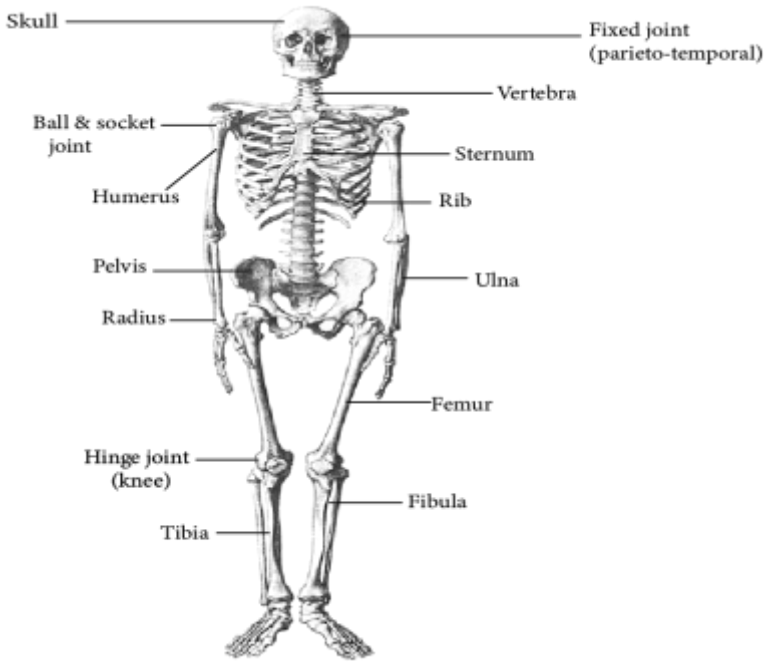


*Image: Human Skeleton*

**Joints**

- Joints exist between bones as well as between a bone and cartilage. Joints facilitate movement and locomotion.
- Joints are classified into three types:
    1. **Fibrous joints** are immobile joints found in the cranium.
    2. **Cartilaginous joints** have limited movement, for example, vertebrae in the spine have an intervertebral disc between two vertebrae.
    3. **Synovial joints** are mobile joints. They have a joint cavity filled with liquid between two bones that allows for significant movement. The following are the main synovial joints:
        - ➢ Pivot joint (between 1st and 2nd cervical vertebrae Atlas and Axis)
        - ➢ Socket and ball joint (shoulder)
        - ➢ Hinge joint (knee, elbow)
        - ➢ Gliding joint (carpals)
        - ➢ Saddle joint (between carpal and metacarpal)

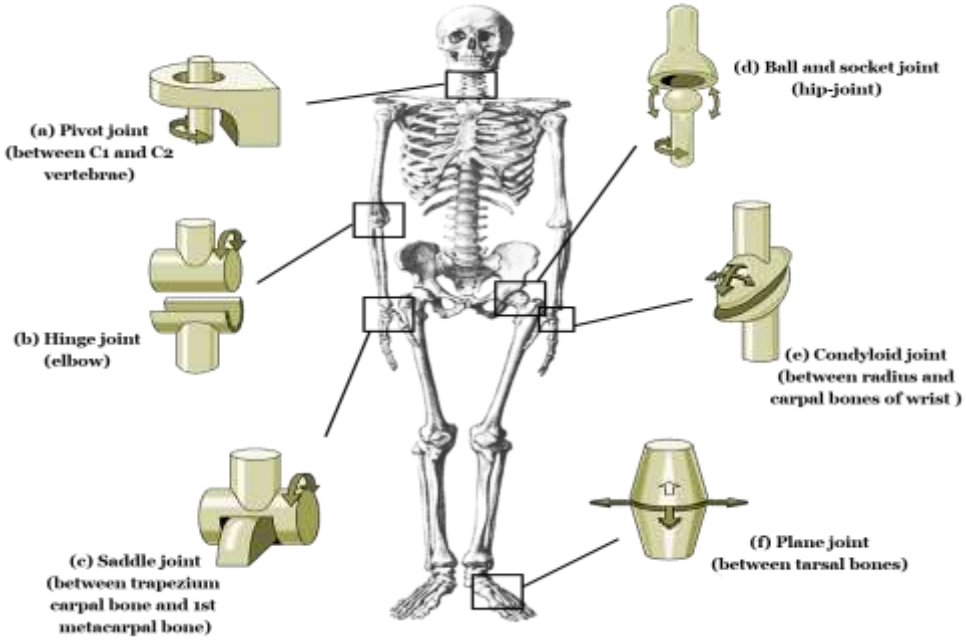


*Image: Types of joints found in the human body*

**Disorders of the Muscular and Skeletal System**

- **Tetany** is caused by a calcium deficiency. Spasms occur as a result of continued contraction of involuntary muscle as Ca ions carry back to the sarcoplasmic reticulum.

- **Tetanus** or **lockjaw** is a bacterial disease caused by *Clostridium tetani*. The bacteria's toxin mimics acetylcholine and unites the receptors on muscle fibres permanently, causing painful contractions.
- **Myasthenia Gravis** is a type of autoimmune disorder. Antibodies are made against acetylcholine, resulting in muscle weakness and paralysis.
- **Duchenne Muscular Dystrophy** is an X-linked recessive genetic disorder. The gene that codes for dystrophin protein is faulty. Muscle degeneration progresses, resulting in difficulty breathing and death. Males are disproportionately affected.
- **Osteoarthritis** develops as a result of an injury, infection, or another disease that causes joint inflammation.
- **Rheumatoid Arthritis** is an example of an autoimmune disease that affects joints and causes inflammation as a result of the body's immune system attacking the joints.
- **Gout** is a metabolic disease caused by an increase in uric acid levels. Deformities, pain, and inflammation are caused by the accumulation of uric acid crystals in the joints.
- **Osteoporosis** is an age-linked disease that is caused by demineralisation and a low oestrogen level. It causes decreased bone mass, which leads to bone weakness and frequent fractures.

**Points to Remember:**

- Movement is a requirement for all living things. Animals exhibit a variety of movements including protoplasmic movement, ciliary movements, fin, limb, and wing movements, among others.
- Locomotion is defined as a voluntary movement that causes an animal to change its location. Animals generally migrate in search of food, mate, shelter, a breeding site, a better climate, or to protect themselves.
- Human body cells move in amoeboid, ciliary, and muscular ways.
- Coordination of muscular activities is required for locomotion and several other movements.
- Our body contains three types of muscles.
- Skeletal muscles connect to skeletal elements. They have a striated appearance and are voluntary.
- Visceral muscles are nonstriated and involuntary muscles found in the interior lining of visceral organs.

- Cardiac muscles are the heart muscles. The appearance of these muscles is striated and branched. Thy are involuntary in function.
- Muscles are excitable, contractile, extensible, and elastic.
- The basic unit of muscle is the muscle fibre. Myofibrils are parallelly organised in each muscle fibre. Each myofibril contains numerous serially organised functional units called sarcomeres.
- Each sarcomere has a central 'A' band of thick myosin filaments and two half 'I' bands of thin actin filaments on each side, denoted by 'Z' lines.
- Actin and myosin are contractile polymerised proteins. A protein-troponin masks the active sites present for myosin on resting actin filament. Myosin head contains ATPase, as well as ATP binding sites and actin active sites.
- A motor neuron sends a signal to a muscle fibre, which causes an action potential to be generated in it. $Ca^{2+}$ is released from the sarcoplasmic reticulum as a result of this. $Ca^{2+}$ causes actin to bind to the myosin head, forming a cross bridge. These cross bridges cause the actin filaments to slide over the myosin filaments, allowing contraction. $Ca^{2+}$ is then returned to the sarcoplasmic reticulum, where it inactivates actin. Cross bridges are destroyed, and muscles relax.
- Muscle fatigue results from repeated stimulation. Muscles are categorised as red or white fibres based on the amount of myoglobin, a red pigment, in them.
- Our skeletal system is made up of bones and cartilages. The skeletal system is divided into two parts: axial and appendicular. The axial skeleton is made up of the skull, vertebral column, ribs, and sternum. The appendicular skeleton is made up of limb bones and girdles.
- Fibrous, cartilaginous, and synovial joints develop between bones or between bones and cartilage. Synovial joints facilitate the significant movements and thus play an important role in locomotion.