# Locomotion and Movement

## Types and Structure of Muscles

### Movement and Locomotion

- All locomotion is movement but all movement is not locomotion.
- Types of movement:

| **Amoeboid** | **Ciliary** | **Muscular** |
|---|---|---|
| Movement with the help of pseudopodia formed by cytoplasmic streaming | This movement occurs in most of our internal tubular organs lined by the ciliated epithelium. | This movement occurs because of the contractile property of muscles. |
| Examples: Movement of leucocyte, macrophages and cytoskeletal elements in our body. | Examples: Movement of cilia in trachea and movement of ova in the reproductive tract | Examples: Movement of our jaws, limbs, tongue, etc. |

- Flagellar movement is another type of movement seen commonly in human sperms. In this type of movement, propulsion of the sperm towards the ovum occurs by whip like movement of the tail and middle piece.

### Muscles

- Tissues of mesodermal origin
- Contribute 40–50% of body weight
- Properties: Excitability, Contractility, Extensibility and Elasticity
- Classification of muscles according to location:

| **Skeletal muscles** | **Visceral muscles** | **Cardiac muscles** |
|---|---|---|
| These have striped appearance under the microscope. Therefore, they are called striated muscles. | These do not exhibit any striation. They are smooth muscles (non-striated). | These are also striated. |

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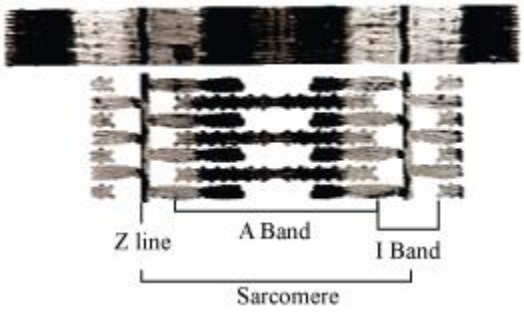
| These are associated with the skeletal components of the body. | These are associated with the inner walls of the hollow visceral organs. | These are present in the heart. |
| These are under the voluntary control of the nervous system. | These are involuntary muscles. | These are involuntary muscles. |
| Involved in locomotory actions and changes in body posture | Involved in actions such as transportation of food through the alimentary canal, etc. | Involved in the conduction of cardiac impulses |

**Structure of a Skeletal Muscle**

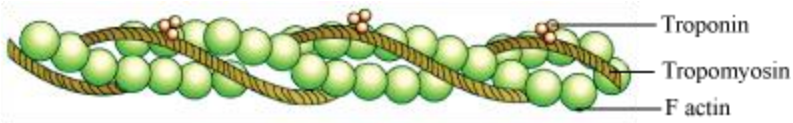
- Each skeletal muscle in the body is made of muscle bundles or fascicles. Each fascicle is held together by fascia (collagenous connective tissue layer).
- Muscle bundle: A collection of many muscle fibres
- Muscle fibre: Has sarcoplasm lined by sarcolemma (plasma member). It has the sarcoplasmic reticulum (endoplasmic reticulum) which is a storehouse for calcium ions.
- Myofibrils or myofilaments (parallel arrangement of filaments) are present inside the sarcoplasm of muscle fibre.
- Structure of Myofibril:
- Each myofibril has alternate light and dark bands on it (striated appearance).
- Light band: Contains the protein actin and is called the I band (Isotropic band)
- Dark band: Contains the protein myosin and is called the A band (anisotropic band)
- Actin: Thin filament; Myosin: Thick filament
- Actin and myosin are arranged parallel to each other as rod-like structures.
- Z line: An elastic fibre which bisects the I band. Portion between two Z lines represents a functional sarcomere.
- In resting state, the edges of thin filaments on either side of the thick filaments partially overlaps the free ends of the thick filaments.
- H zone: The zone where the central part of the thick filaments are not overlapped by the free ends of the thin filament

- M line: Holds the dark band at the centre; thus, it bisects the H zone.




**Contractile Proteins**

- **Actin**
- Actin filament has two F actins (filamentous actins) helically wound around each other.
- Two filaments of tropomyosin also run close to F actins throughout its length.
- Troponin is distributed at regular intervals on tropomyosin.
- Significance of troponin: It masks the binding sites for myosin on actin in resting state.




- **Myosin**
- Myosin is a polymerised protein, i.e., polymer of meromyosins
- Meromyosin has two parts:
  Globular head with a short arm (Heavy meromyosin; HMM) and a tail (Light meromyosin; LMM)
- The head and the arm project outwards at a regular distance and angle from each other at the surface of the polymerised myosin and are together called the cross arm.
- Globular head has ATPase activity.
- Classification of muscles based on oxygen content:

| **Red muscle fibres** | **White muscle fibres** |
|---|---|

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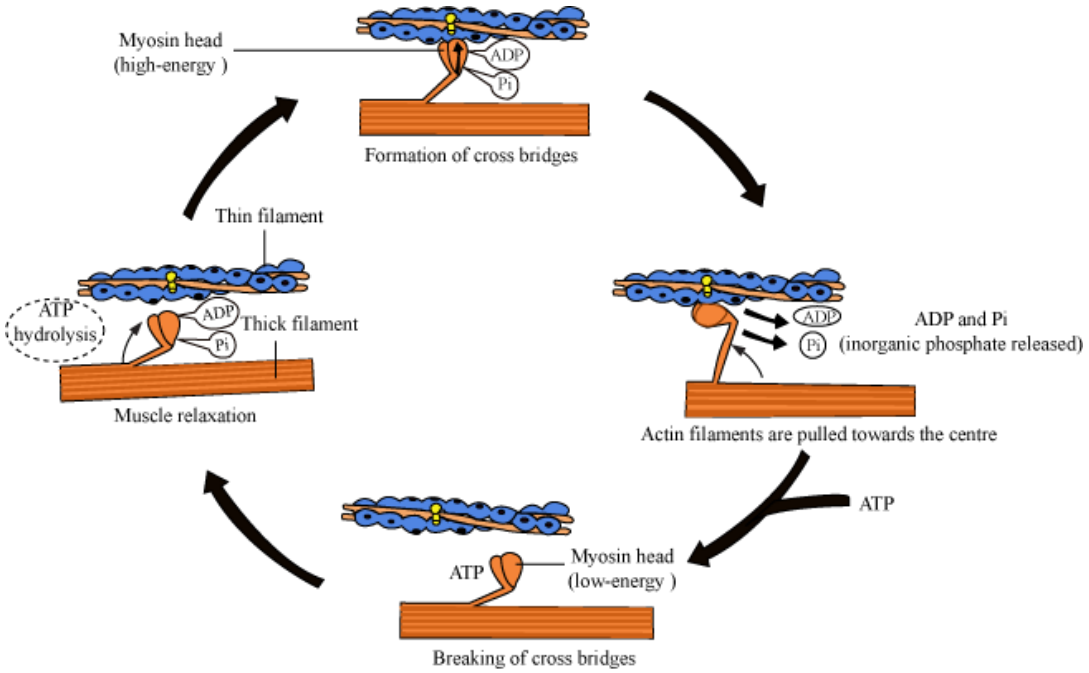
| Myoglobin content is higher in them, making them red in colour. | Lesser myoglobin content makes them white in colour. |
| They contain plenty of mitochondria | They contain fewer mitochondria. |
| They are aerobic muscles since large amount of oxygen is stored in them. | They are anaerobic muscles. |

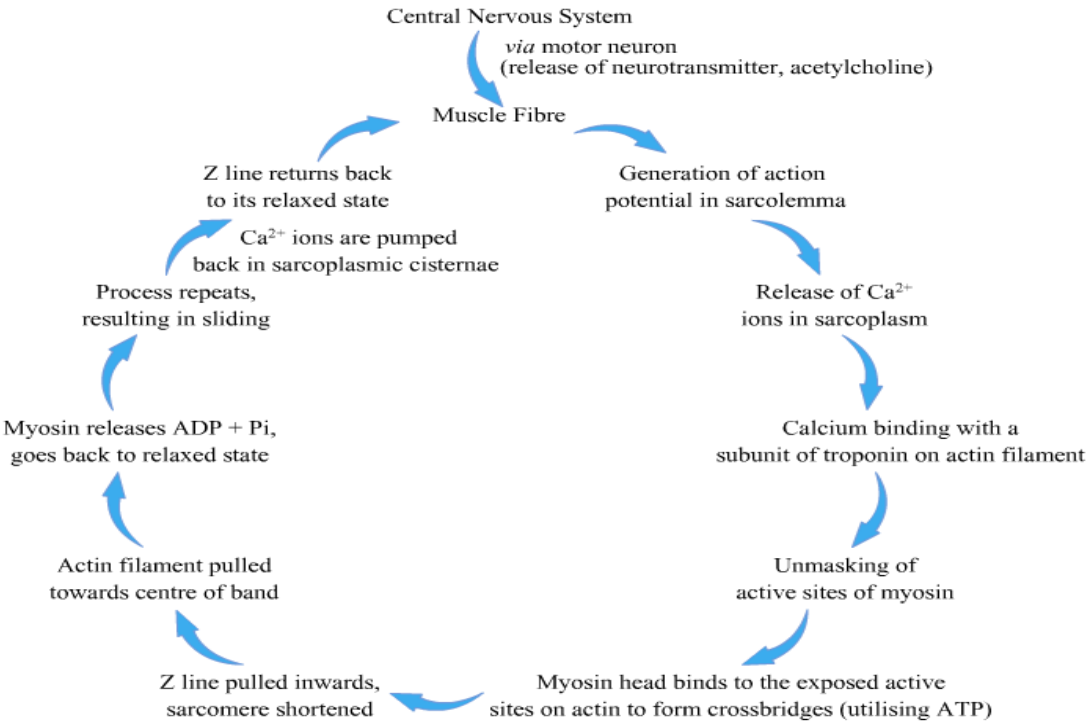
**Mechanism of Muscle Contraction: Sliding Filament Theory**

**Mechanism of Muscle Contraction – Sliding Filament Theory**

- Muscle contraction is initiated by the signal sent by the CNS.
- Neural signal, on reaching the neuromuscular junction, releases a neurotransmitter (acetylcholine) that generates action potential in the sarcolemma.
- Action potential spreads through the muscle fibre and causes release of calcium ions in the sarcoplasm.
- These calcium ions bind with troponin subunits. Hence, the masking of the active sites of myosin is removed.
- Exposed active sites on actin now binds with the myosin head to form a cross bridge.
- Cross bridge formation pulls the attached actin filament towards the centre of A band. The Z line attached to the actin is also pulled in, leading to muscle contraction.
- Myosin releases ADP + Pi, and relaxes. A new ATP binds and the cross bridge is broken. ATP is again hydrolysed by the myosin head, and cycle of cross bridge formation and breakage is repeated, causing further sliding.
- Process continues till calcium ions are pumped back and actin filaments are masked again. The Z lines return to their original position and the muscle relaxes.




The mechanism for muscle contraction can be summarised as:




**Skeletal System**

**Skeletal System**

- Bony framework of our body

**Functions of Skeletal System**

- Provides framework to all the body parts, thus giving our body a definite shape
- Maintains erect posture
- Helps in locomotion
- Protects internal soft organs
- Plays a major role in formation of blood cells
- Acts as storehouse of calcium and phosphorus for the body

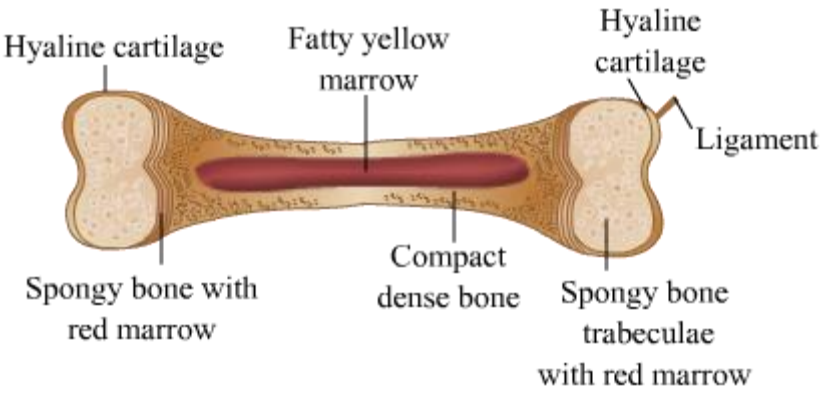
**Skeletal system = 206 bones + A few cartilages**

- Bones are connective tissues, which are hard due to calcium salts

- Cartilages are connective tissues. They have a pliable matrix due to chondroitin salts.

**Bones**

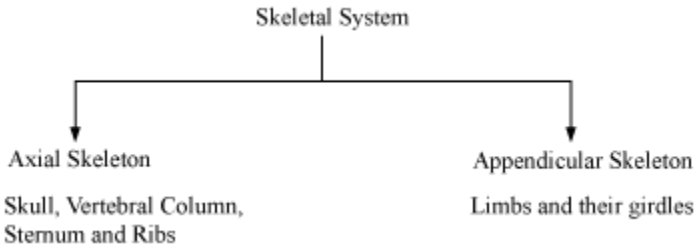
- Bones are the chief constituents of the skeletal system.
- They consist of organic and inorganic parts (compounds of calcium and phosphorus).
- As we grow old, the organic part gets on reducing, making bones fragile.
- On the basis of shape, bones can be classified as:
- **Long bones:** Have a thick-walled shaft with a knob at each end. Examples, bones of arms, legs and chest
- **Short bones:** Box-like, spongy bones that show little movement. Examples, ankle, wrist, etc
- **Flat bones:** Made up of two or more parallel plates of compact bones. Examples, shoulder blade, skull, etc
- **Irregular bones:** Have complex shape. Examples, vertebral bones




**Structure of a long bone**

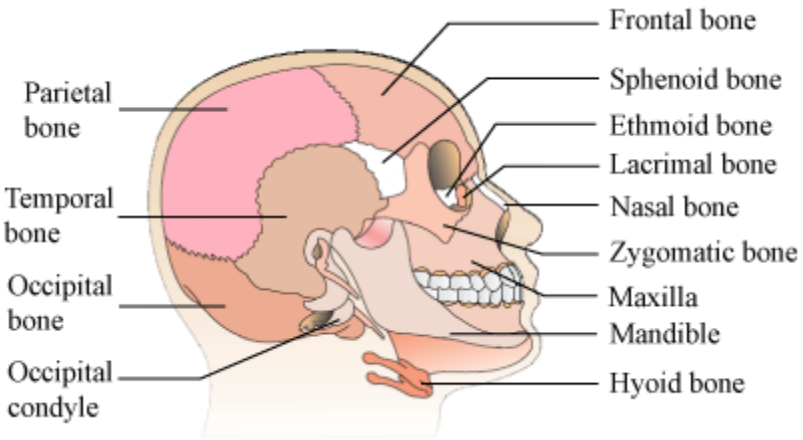
A typical bone consists of osteocytes or bone cells that are embedded in a ground matrix made up of collagen fibres and calcium and phosphorus salts. The external surface of the bone is covered by a membrane called periosteum. Its outer layer is fibrous while inner layer is cellular. The hollow cavity in the middle of the bone is filled with bone marrow. The yellow marrow is made up of adipose tissue (fat storing cells) and gives rise to white blood cells. The red marrow, which is present at the ends gives rise to red blood cells.

**Major divisions of the skeletal system**



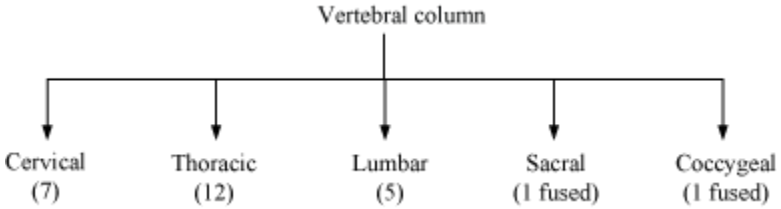

**Axial Skeleton (80 bones)**

- Skull – 22 bones
- Has two sets of bones – Cranial (8) and Facial (14)
- Skull also includes a U-shaped bone called *hyoid,* present at the base of the buccal cavity
- Ear Bones (ear ossicles) – Malleus, Incus, Stapes
- Skull articulates with the vertebral column via two occipital condyles.

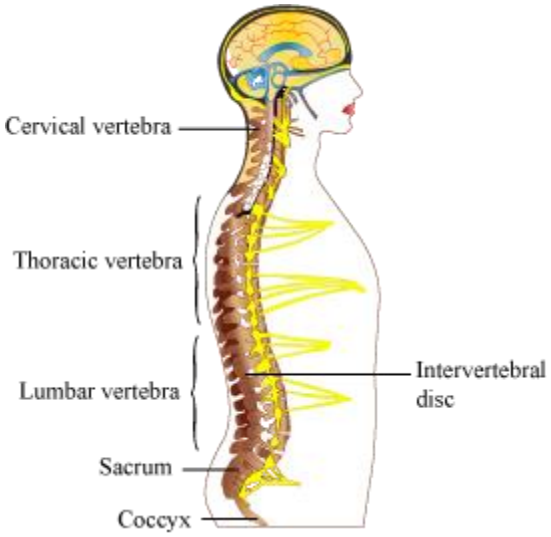



- Vertebral Column – 26 vertebra
- Each vertebra has a central hollow portion through which the spinal cord passes. This hollow portion is called the neural canal.

- Functions: Protects the spinal cord; supports the head; serves as the point of attachment of the ribs and the musculature of the back
- First vertebra: Atlas – it articulates with the occipital condyles

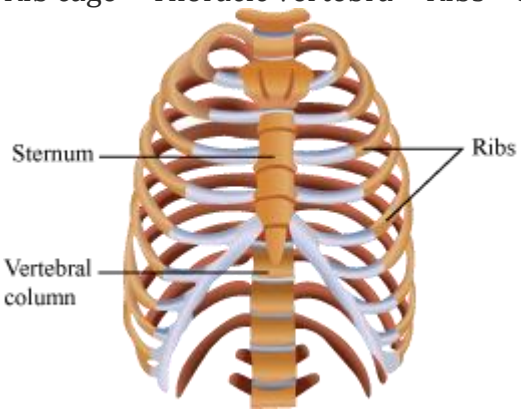



- Formula for vertebral column in man is $C_7\ T_{12}\ L_5\ S_1\ Co_1$



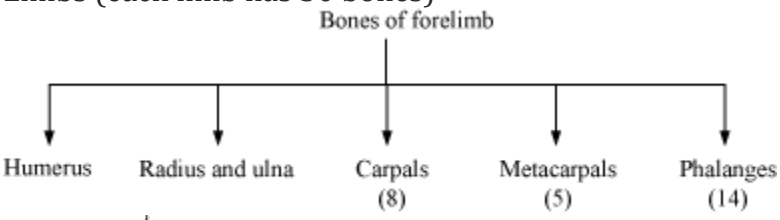

- Sternum – 1
- Flat bone on the ventral midline of the thorax, to which the ribs are attached ventrally
- Ribs – 12 pairs
- Connects dorsally to the vertebral column
  Connects ventrally to the sternum
- True Ribs: First 7 pairs; they connect both dorsally and ventrally to the vertebrae and the sternum respectively via the hyaline cartilage
- False (vertebrochondral) Ribs: $8^{th}$, $9^{th}$ and $10^{th}$ pairs; do not connect to the sternum directly, but connect indirectly through the seventh rib
- Floating Ribs: $11^{th}$ and $12^{th}$ pairs; do not connect ventrally

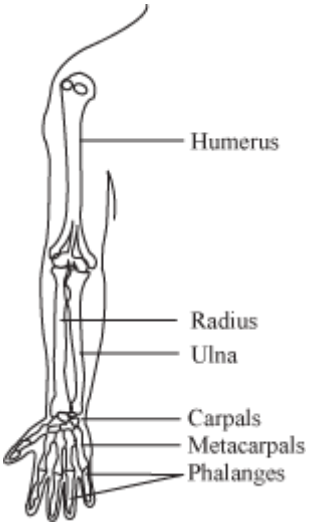
- Rib cage = Thoracic vertebra + Ribs + Sternum

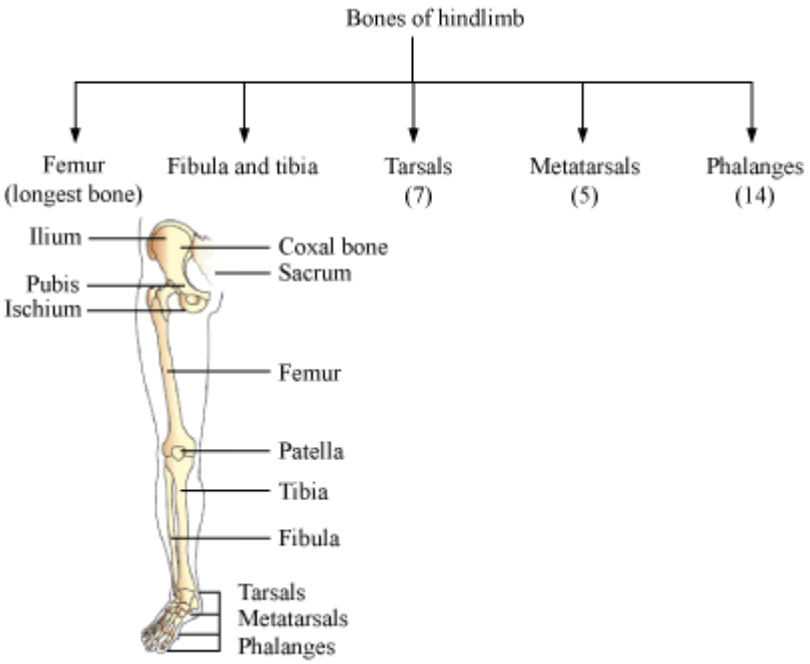



**Appendicular Skeleton**

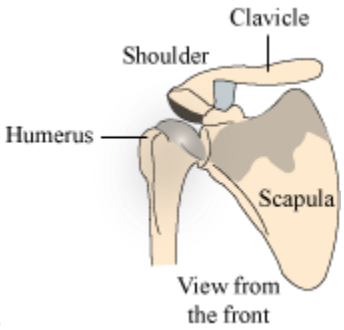
- Limbs (each limb has 30 bones)



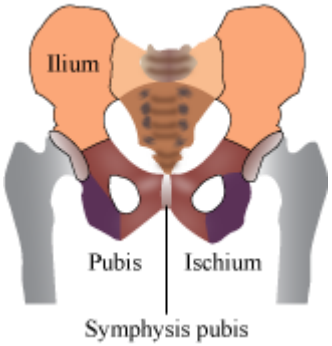



- Girdles (Pectoral and Pelvic)
- Articulates the limbs with the axial skeleton
- Each girdle is composed of two halves.
- Pectoral girdle:
- Consists of clavicle (collar bone) and scapula
- Scapula is a triangular flat bone with a slightly elevated ridge called the spine, projecting as a flat, expanded process called acromion.
- Clavicle articulates with acromion.
- Below acromion, a depression called glenoid cavity is present. Here, humerus articulates to form the shoulder joint.




- Pelvic girdle:
- Has 2 coxal bones formed by the fusion of ilium, ischium and pubis
- Acetabulum is a cavity formed at the point of fusion of these three bones where the thigh bone articulates

- Two halves of the pelvic girdle meet ventrally to form Pubic Symphysis (contains fibrous cartilage)




**Joints & Disorders of Musculo-Skeletal System**

**Joints**

- Points of contact between bones or between bones and cartilages
- Joints act as fulcrum used to carry out movement by force generated through muscles.
- Classification of joints depending upon structure:

| **Fibrous joints** | **Cartilaginous joints** | **Synovial joints** |
|---|---|---|
| Bones fuse end to end with the help of dense fibrous connective tissues. | Bones are joined together with the help of cartilages. | Bones are not joined together directly, but fluid-filled synovial cavity is present between articulating surfaces of two bones. |
| Do not allow any movement | Permit limited movement | Show maximum movement |
| Example – Skull bones fuse end to end with the help of dense fibrous connective tissues called sutures to form cranium. | Example – Joints between adjacent vertebrae | Example – Ball and socket joint |
| | | |

**Types of Synovial joints**

- Synovial joint – five types:

- Ball and socket joint
  Allows free movement
  Found between humerus and pectoral girdle, femur and acetabulum

- Hinge joint
  Allows movement in one plane
  Example: knee joint, elbow joint
- Pivot joint
  One bone rotates over other.
  Found between atlas and axis
- Gliding joint
  Allows only gliding and sliding movement
  Found between carpals and wrist
- Saddle joint
  This type of joints allows back and forth and side to side motion, but only limited rotation.
  Found between carpal and metacarpal of thumb

**Disorders of Musculo-Skeletal System**

**Disorders of Muscular and Skeletal Systems**

- **Myasthenia Gravis**

- Autoimmune disorder affecting neuromuscular junction
- Leads to fatigue, weakening, and skeletal muscle paralysis

- **Muscular Dystrophy**

- Genetic disorder leading to degeneration of skeletal muscle

- **Tetany**

- Low calcium concentration in body fluid
- Rapid spasms in muscle

- **Arthritis**

- Inflammation of joints

- **Osteoporosis**

- Age related disorder associated with decreased estrogen levels
- Decreased bone mass and increased chances of fractures

- **Gout**

- Accumulation of uric acid crystals
- Inflammation of joints