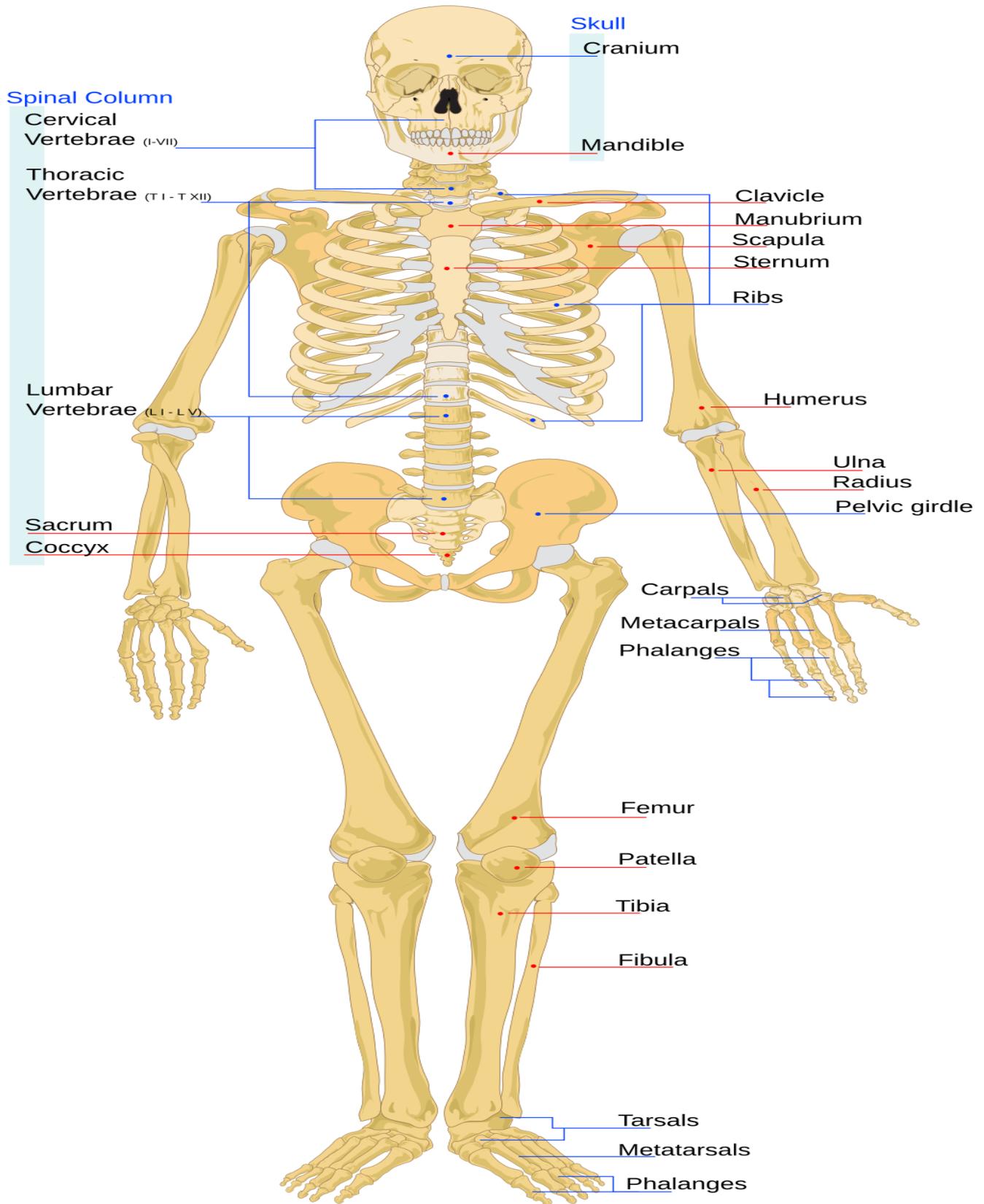




Lec.3

The Skeletal System





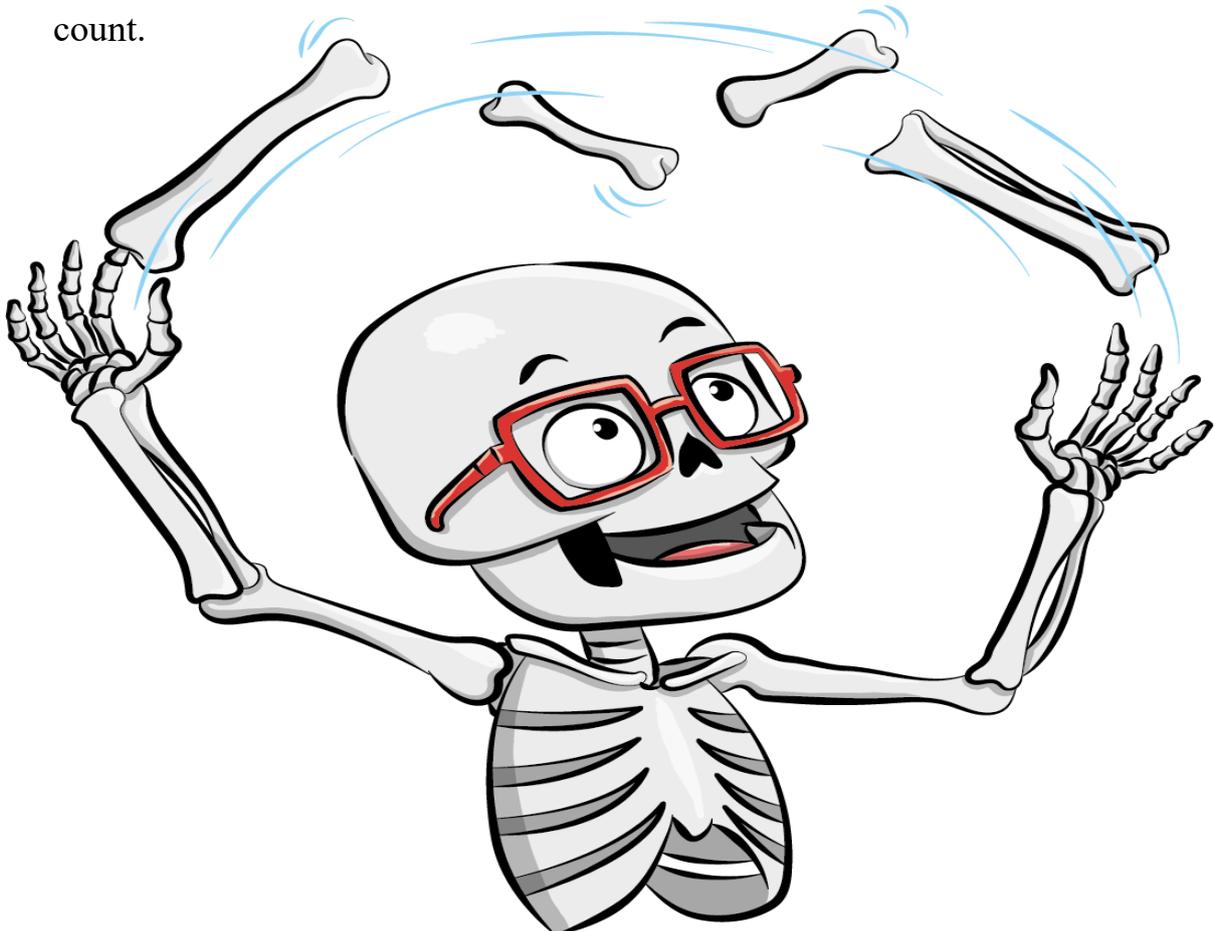
Anatomy and Physiology



The **skeletal system** consists of the bones of the skeleton along with the **cartilages, ligaments**, and other **connective tissues** that stabilize, support, and connect these bones.

Each bone is considered a living organ that plays a vital role in the overall function of the skeletal system.

- ☞ An adult human skeleton consists of approximately **206 bones**. However, the exact number of bones may vary from one individual to another due to **age-related changes** and **genetic variations**.
- ☞ At birth, a newborn possesses about **270 bones**. As growth and development occur, many of these bones undergo a process known as **ossification**, *during which bones harden and separate skeletal elements gradually fuse together*.
- ☞ During childhood and adolescence, the total number of bones **decreases** as a result of this **gradual fusion process**, ultimately reaching the typical adult count.





Functions of the Skeletal System

The skeletal system performs several essential functions, including:

1. **Structural support:**

It provides a rigid framework that supports the entire body and allows soft tissues and organs to maintain their shape and position.

2. **Protection of vital organs:**

The skull protects the brain, the rib cage protects the heart and lungs, and the vertebral column protects the spinal cord.

3. **Movement:**

Bones act as levers and joints serve as pivot points for muscles to produce movement.

4. **Mineral storage:**

Bones store essential minerals, particularly calcium and phosphorus, which are released into the bloodstream as needed.

5. **Blood cell formation (Hematopoiesis):**

Red bone marrow produces red blood cells, white blood cells, and platelets.

6. **Energy storage:**

Yellow bone marrow stores fat, serving as an energy reserve.

Major Divisions of the Skeletal System

1. Axial Skeleton: The axial skeleton forms the central axis of the body and includes: **(Skull / Vertebral column / Ribs / Sternum)** Supports and protects the organs of the head, neck, and trunk.

Total bones: 80

- ✓ Head: 29 bones
- ✓ Thorax: 51 bones



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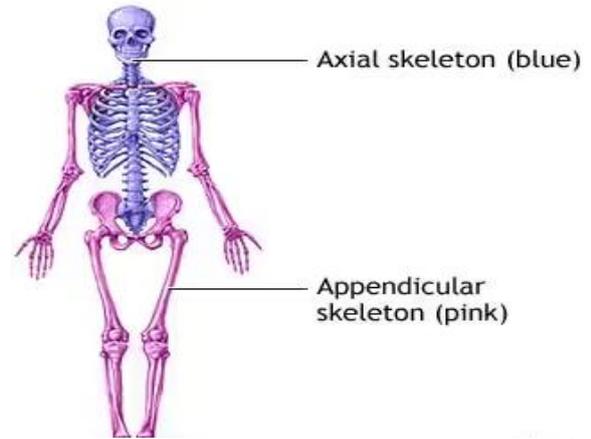


Bones may be singular, paired, or multiple.

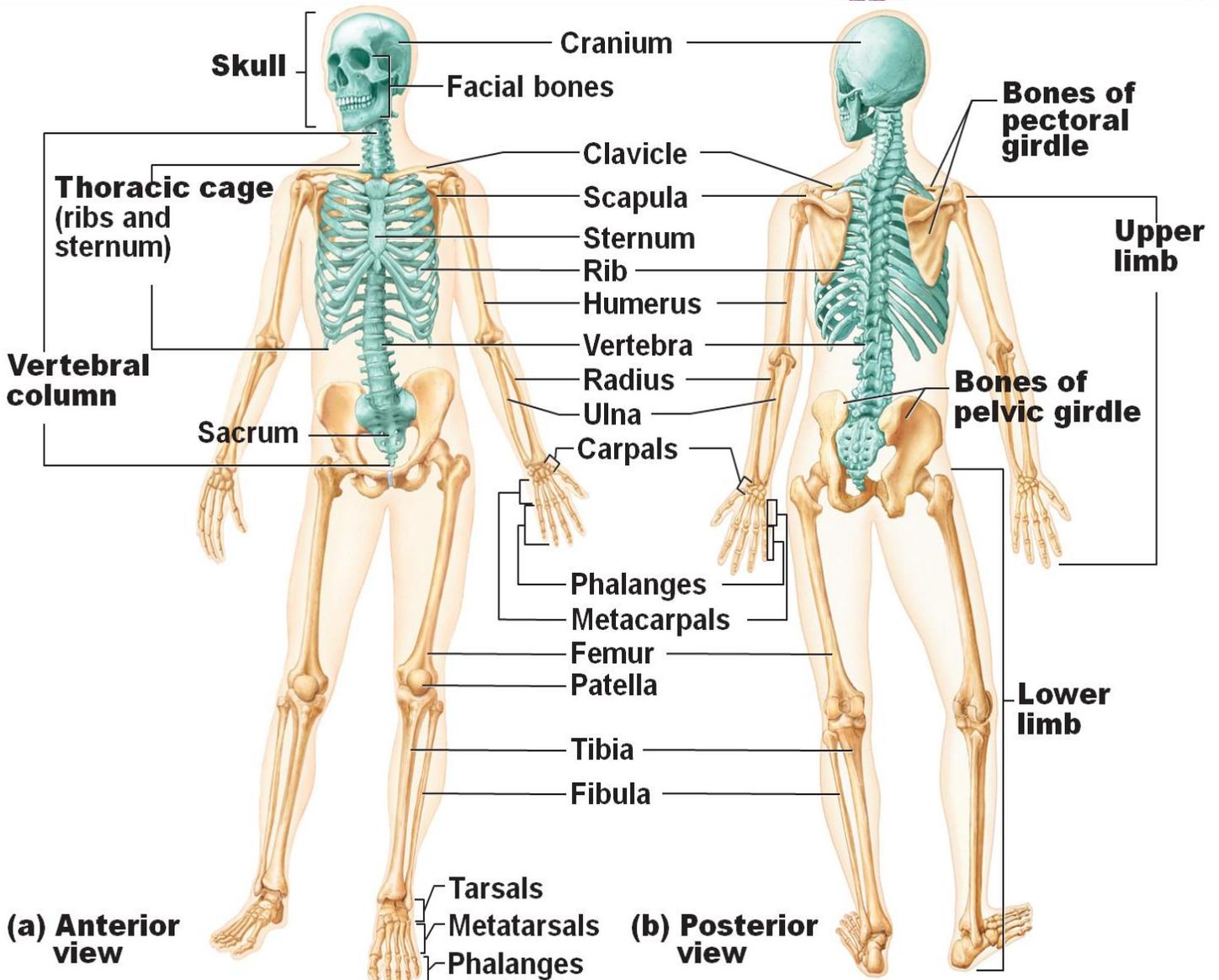
2. Appendicular Skeleton :The appendicular skeleton includes the appendages and the structures that attach them to the axial skeleton: **(Upper limbs / Lower limbs / Pectoral (shoulder) girdle / Pelvic girdle)**

Total bones: 126

- ✓ Upper limbs: 32 bones (each side)
- ✓ Lower limbs: 31 bones (each side)



Bones are mostly paired and multiple.





Anatomy and Physiology



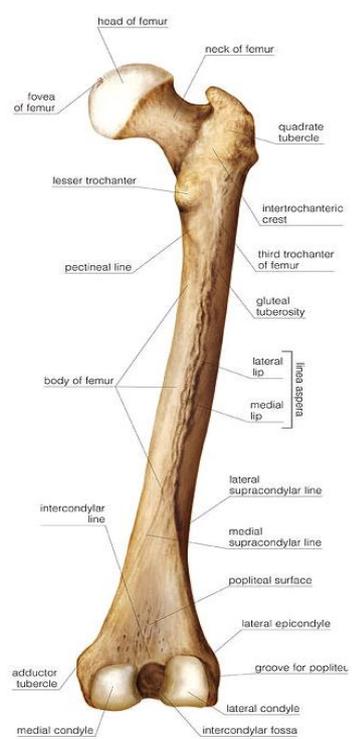
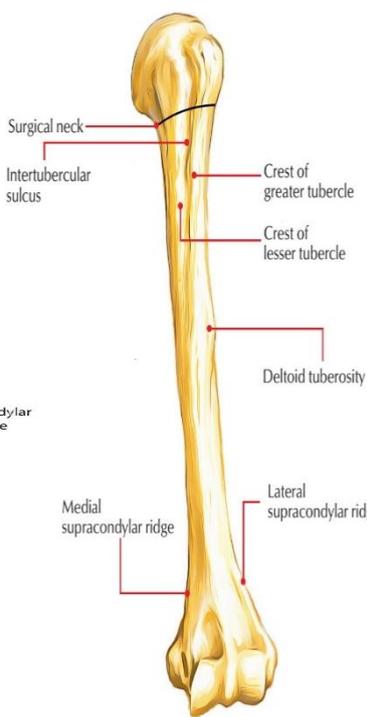
Basic Bone Shapes: *Bones are classified according to their shape into four main categories:*

1. Long Bones: (Long bones are bones that are longer than they are wide, and they play a fundamental role in support, movement, and weight bearing. They are characterized by a central shaft, known as the diaphysis, and two expanded ends called the epiphyses.

Structurally, the diaphysis consists mainly of compact bone, which provides strength and rigidity, while the epiphyses contain predominantly spongy (cancellous) bone that helps absorb shock and distribute forces at joints. The epiphyses are covered with articular (hyaline) cartilage, which reduces friction and facilitates smooth joint movement.

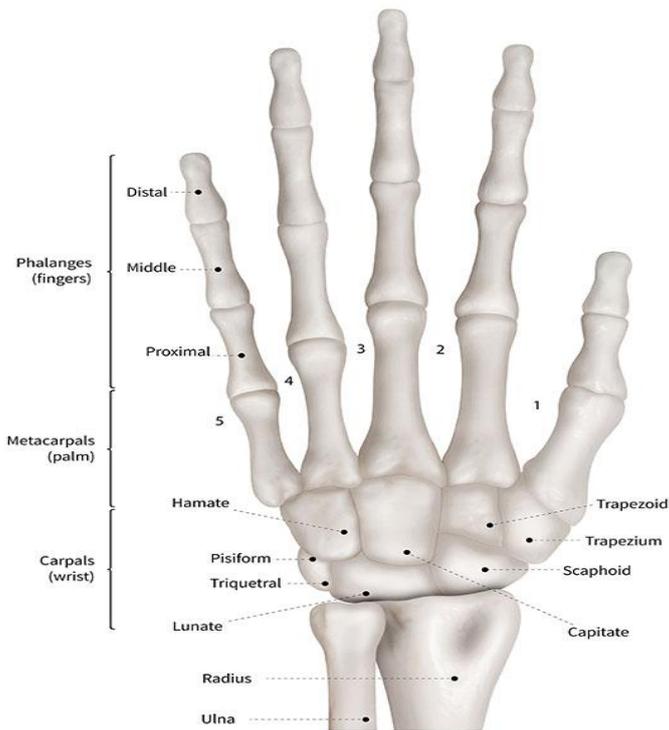
Inside the diaphysis lies the medullary cavity, which contains yellow bone marrow in adults and functions in fat storage. In children, this cavity primarily contains red bone marrow, which is responsible for blood cell formation.

- Femur
- Humerus
- Tibia and fibula
- Radius and ulna
- Metacarpals and metatarsals

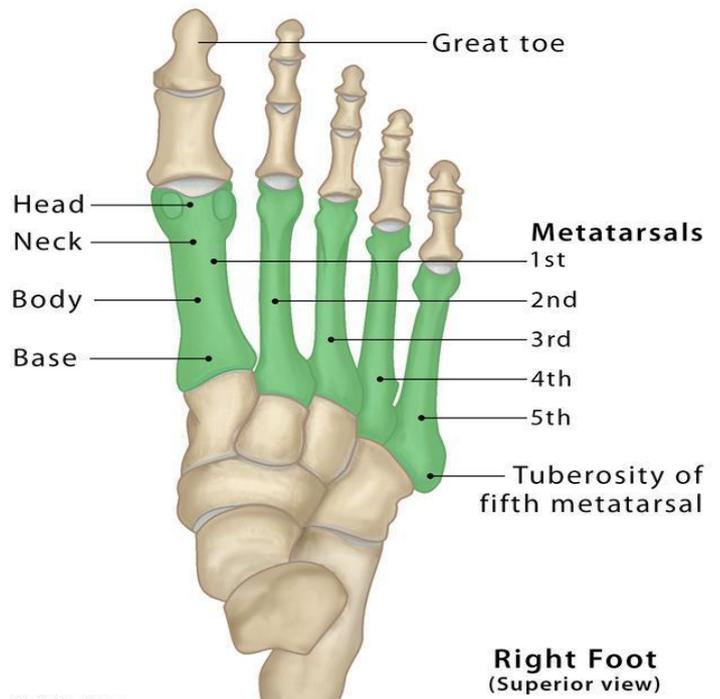




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Metatarsal Bones

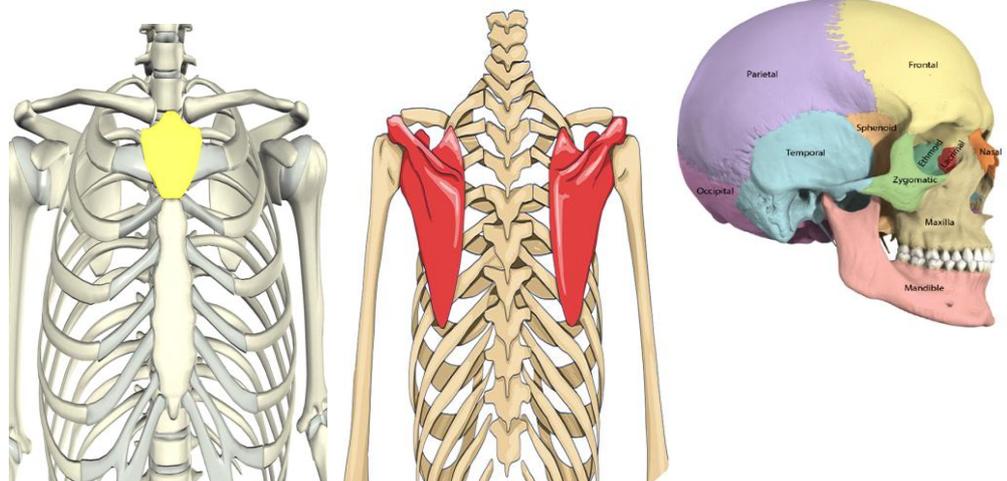


2. Short Bones: (cube-shaped and are characterized by having nearly equal length, width, and thickness. They are composed primarily of spongy (cancellous) bone)

- ✓ **Carpal bones** of the wrist
- ✓ **Tarsal bones** of the ankle

3. Flat Bones : (Flat bones are thin, flattened, and often curved bones that provide extensive surface areas for muscle attachment and protection of vital organs)

- ✓ **Bones of the skull**
- ✓ **Sternum**
- ✓ **Ribs**
- ✓ **Scapulae**



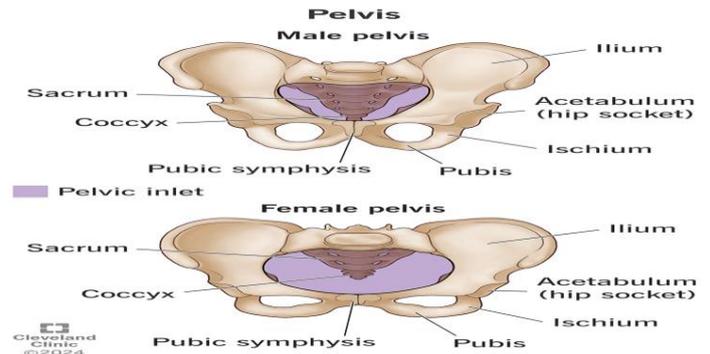


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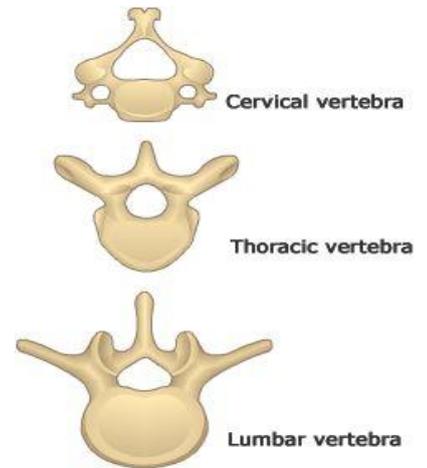
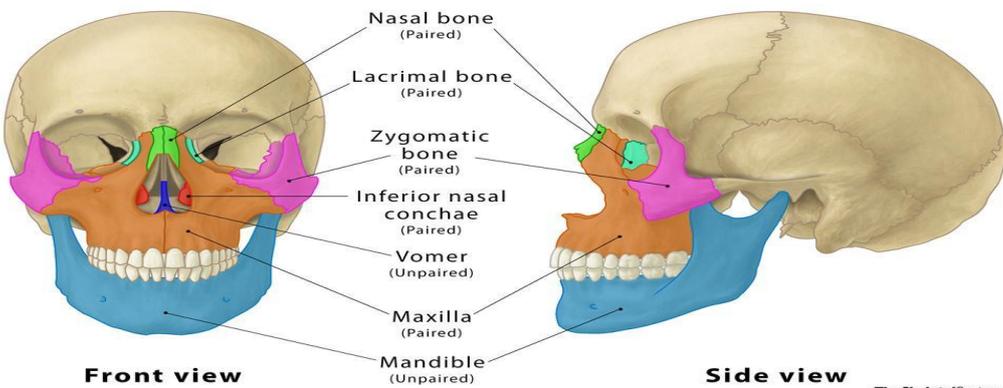


4. Irregular Bones : (Irregular bones are bones with **complex and unusual shapes** that do not fit into the categories of long, short, or flat bones.

- ✓ **Vertebrae**
- ✓ **Pelvic bones**
- ✓ **Certain bones of the facial skeleton**



Facial Bones



Composition of Bone : *Bone mass is composed of:*

- ✓ **Two-thirds (2/3) inorganic mineral salts** (mainly calcium phosphate)
- ✓ **One-third (1/3) organic collagen fibers**
- ✓ **Bone cells** (approximately **2%**) (**Osteoprogenitor (Osteogenic) Cells** – **Osteoblasts – Osteocytes – Osteoclasts**)

Types of Bone Tissue

- 1. Compact bone:** Homogeneous, relatively solid & protective outer layer
- 2. Spongy (Cancellous) bone:** Open network of small needle like pieces of bone.



Bone Marrow

- **Red bone marrow:** site of blood cell production
- **Yellow bone marrow:** contains fat cells; functions in energy storage

Bone Cells

Bone tissue contains **four main types of cells**, each playing a specific and essential role in bone growth, maintenance, and remodeling:

1. Osteocytes

Osteocytes are **mature bone cells** responsible for **maintaining the bone matrix**. They play an important role in **recycling calcium salts** within the bony matrix surrounding them, thereby contributing to the regulation of mineral balance and bone integrity.

2. Osteoclasts

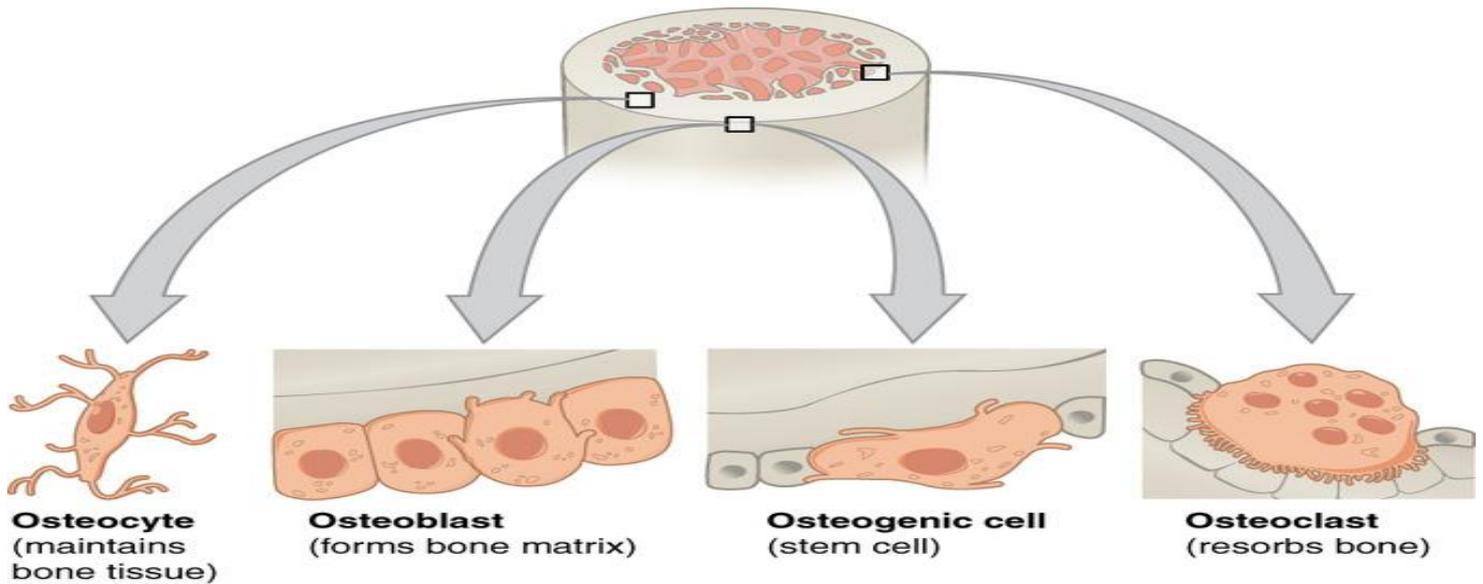
Osteoclasts are **large, multinucleated cells** that secrete **acids and proteolytic enzymes** capable of dissolving the bony matrix. Through a process known as **osteolysis or bone resorption**, osteoclasts break down bone tissue and release **stored minerals**, particularly calcium and phosphorus, into the bloodstream.

3. Osteoblasts

Osteoblasts are the cells responsible for the **formation of new bone**, a process called **osteogenesis**. They synthesize and secrete the organic components of the bone matrix and initiate its mineralization during bone growth and repair.

4. Osteoprogenitor (Osteogenic) Cells

Osteoprogenitor cells are **bone stem cells** found mainly in the **deep layers of the periosteum and within the bone marrow**. These are the **only bone cells capable of division** and they differentiate into **osteoblasts**, particularly during growth, remodeling, and fracture healing.



Joints

Joints, also known as **articulations**, are the points at which two or more bones meet. They permit body movement and provide stability to the skeleton. Joints are held together and strengthened by **fibrous connective tissues called ligaments**, which connect bone to bone.

Joints vary in their degree of movement:

1. Immovable joints

Some joints, such as those found in the **skull**, allow **no movement**. These joints provide strong protection for vital organs like the brain.

2. Slightly movable joints

Other joints permit **limited movement**, allowing flexibility while maintaining stability. For example, the **joints of the vertebral column** allow movement in several directions but within a restricted range.

3. Freely movable joints

Movable joints are continuously **lubricated by synovial fluid**, which reduces friction between the articulating bone surfaces. These joints have a **wide and variable range of movement** and are known as **synovial joints**.



Classification of Joints

Joints can be classified based on **two main criteria: Structure and Function.**

A- (Structural Classification)

The structural classification of joints is based on the anatomy of the joint and the type of connective tissue that binds the bones together. According to this classification, joints are divided into three main types:

1. Fibrous joints

Bones are joined by dense fibrous connective tissue.

2. Cartilaginous joints

Bones are connected by cartilage.

3. Synovial joints

Bones are separated by a joint cavity and enclosed within a joint capsule.

The fibrous and cartilaginous joints reflect the type of connective tissue binding the bones together, whereas synovial joints have a distinct joint cavity.

B- (Functional Classification)

The functional classification of joints is based on the degree of movement they allow:

1. Synarthrosis

An immovable joint that permits no movement.

2. Amphiarthrosis

A slightly movable joint that allows limited movement.

3. Diarthrosis

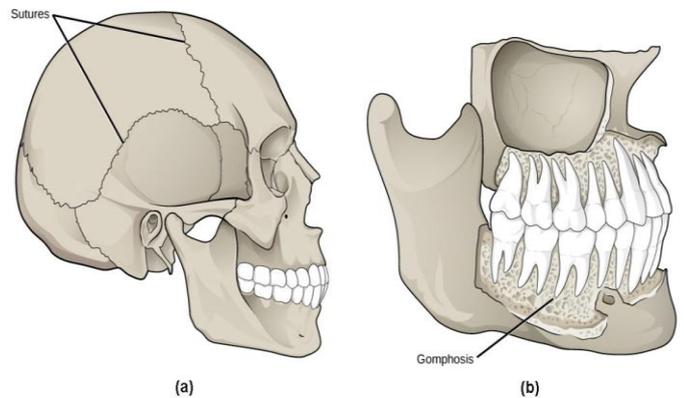
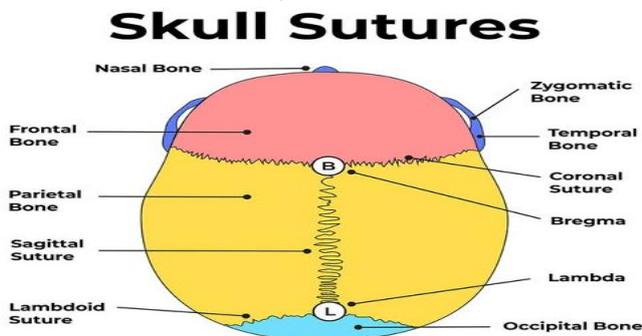
A freely movable joint with a wide range of motion.



1. Synarthroses (Immovable Joints)

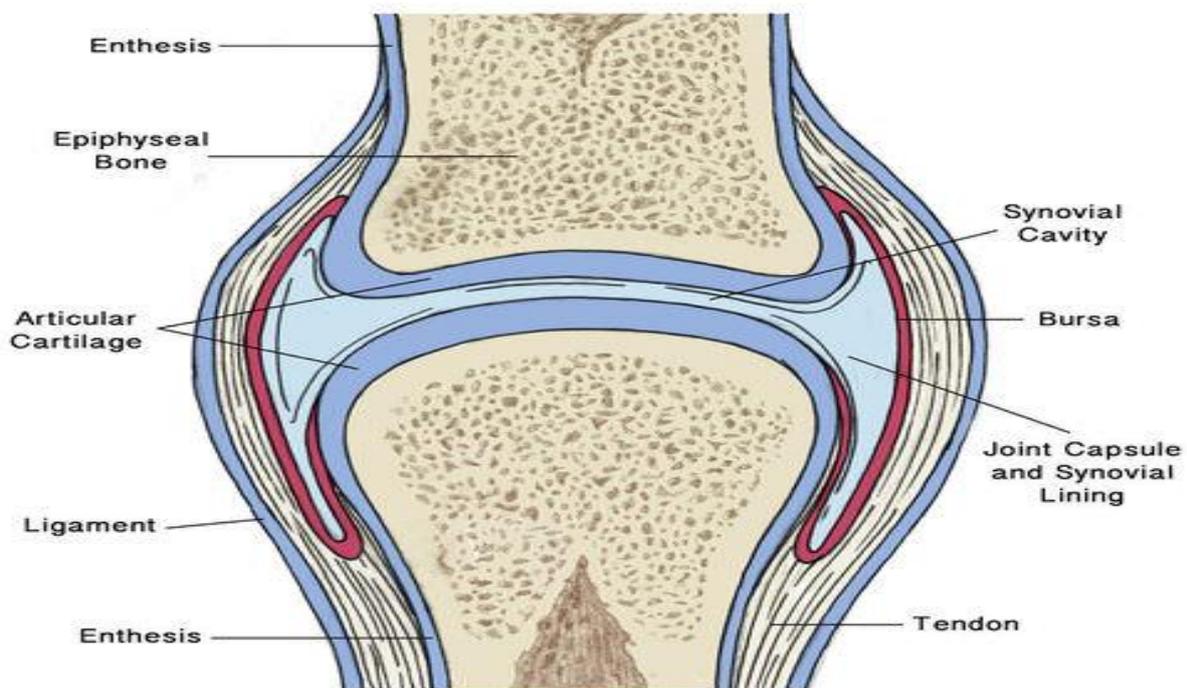
A synarthrosis is an immovable joint and may be either fibrous or cartilaginous in structure. These joints provide strength and protection, particularly in areas that safeguard vital organs. Two common examples are found in the skull:

- ✓ **Sutures:** In sutures, the bones of the skull are interlocked and bound together by dense fibrous connective tissue, allowing no movement.
- ✓ **Gomphoses:** In a gomphosis, a ligament secures each tooth within its bony socket in the jaw.



2. Amphiarthroses (Slightly Movable Joints)

Amphiarthroses are joints that permit very limited movement. They provide both stability and flexibility. (The joint between the tibia and fibula in the leg).

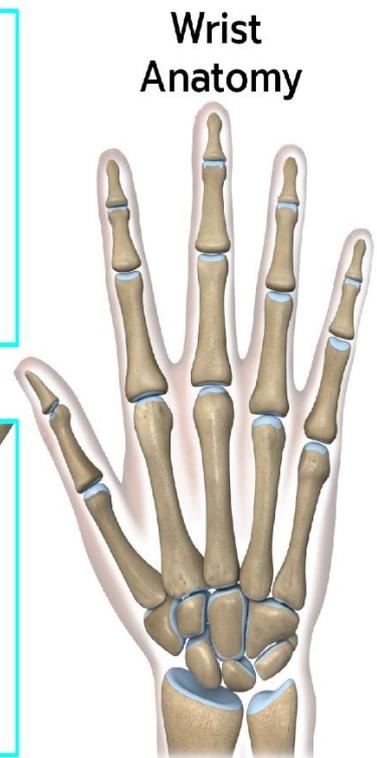
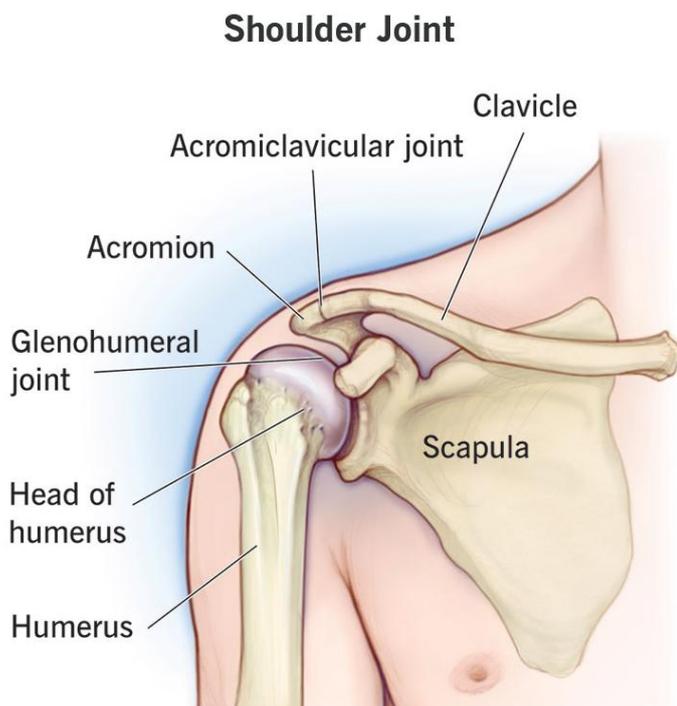




3. Diarthroses (Freely Movable Joints)

Diarthroses are joints that allow a wide range of free movement. Most joints in the human body fall into this category, such as those in the **shoulder** and **wrist**.

- ✓ The ends of the bones are covered with articular (hyaline) cartilage, which reduces friction and absorbs shock.
- ✓ A joint cavity is present between the articulating bones, allowing freedom of movement.
- ✓ Ligaments bind the bones together, preventing dislocation and limiting excessive movement.



Types of Synovial (Diarthrodial) Joints

Synovial joints, also known as diarthrodial joints, are freely movable joints characterized by the presence of a joint cavity, articular cartilage, and synovial fluid. Based on the shape of the articulating surfaces and the type of movement they permit, synovial joints are classified into several types:

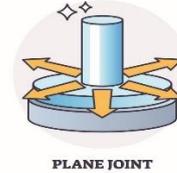


1. Ball-and-Socket Joint

- ✓ Allows movement in all directions, including rotation
- ✓ *Examples:* Shoulder joint, Hip joint

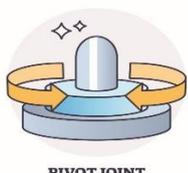
2. Hinge Joint

- ✓ Permits movement mainly in **one direction**, similar to the opening and closing of a door
- ✓ Allows **flexion and extension**
- ✓ *Examples:* Elbow joint, knee joint



3. Pivot Joint

- ✓ Allows **rotational movement**
- ✓ *Examples:* Atlanto-axial joint (neck), Proximal radioulnar joint

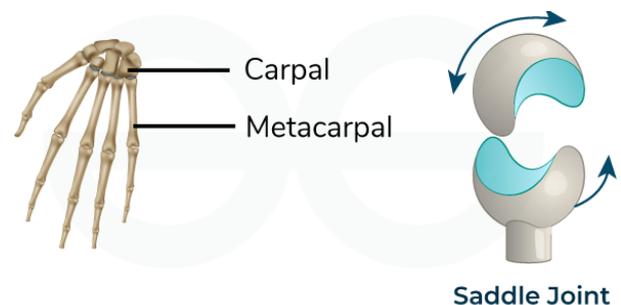


4. Gliding (Plane) Joint

- ✓ Allow **limited movement in multiple directions**
- ✓ *Examples:* intercarpal joints (wrist), intertarsal joints (ankle), facet joints of the spine

5. Saddle Joint

- ✓ Allows movement in **two planes**
- ✓ *Example:* carpometacarpal joint of the thumb



6. Condyloid (Ellipsoid) Joint

- ✓ Allows movement in **two planes**, but no rotation
- ✓ *Examples:* wrist joint, metacarpophalangeal joints



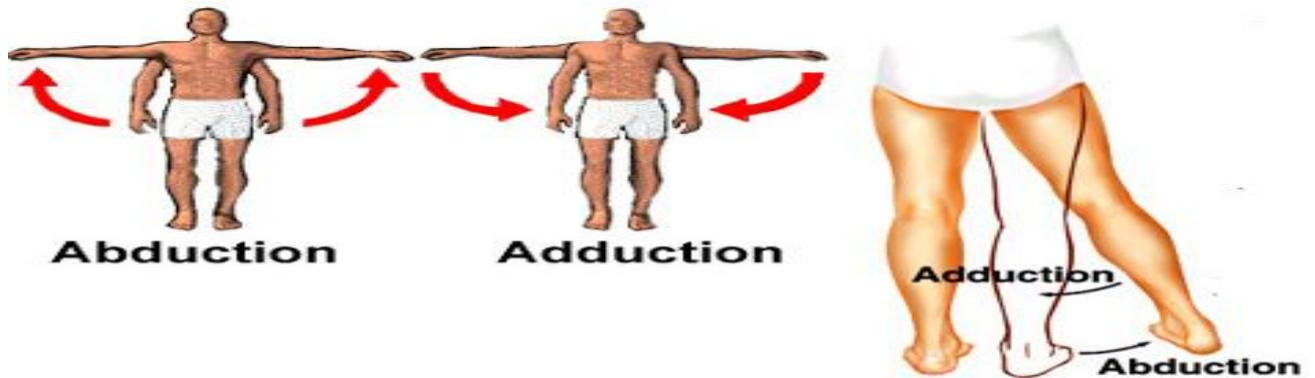
Types of Movement

Movement at joints occurs as a result of muscle contraction acting on bones.

The main types of movement include:

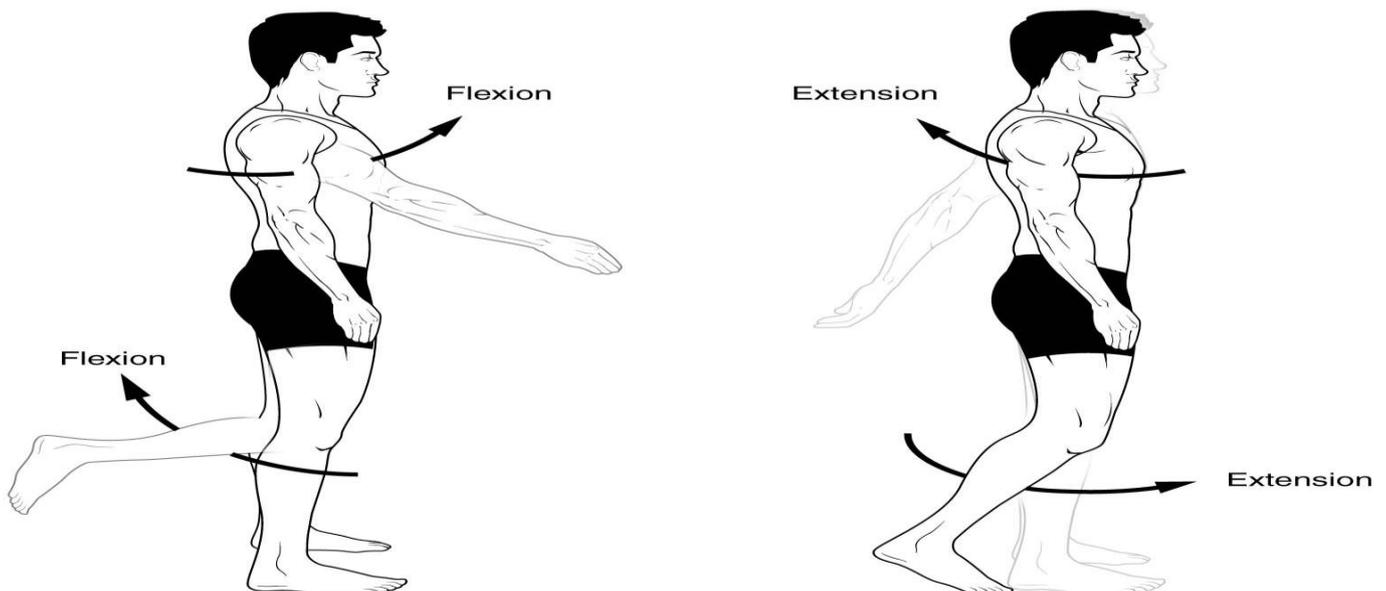
1. **Abduction** : (Is the movement of a body part **away from the midline** of the body).

2. **Adduction**:((Is the movement of a body part **toward the midline** of the body.



3. **Flexion**: (Is the bending movement at a joint, which **reduces the angle between two bones**).

4. **Extension**; (Is the **straightening movement** at a joint, which **increases the angle** between two bones, such as increasing an angle from 90° to 180°).





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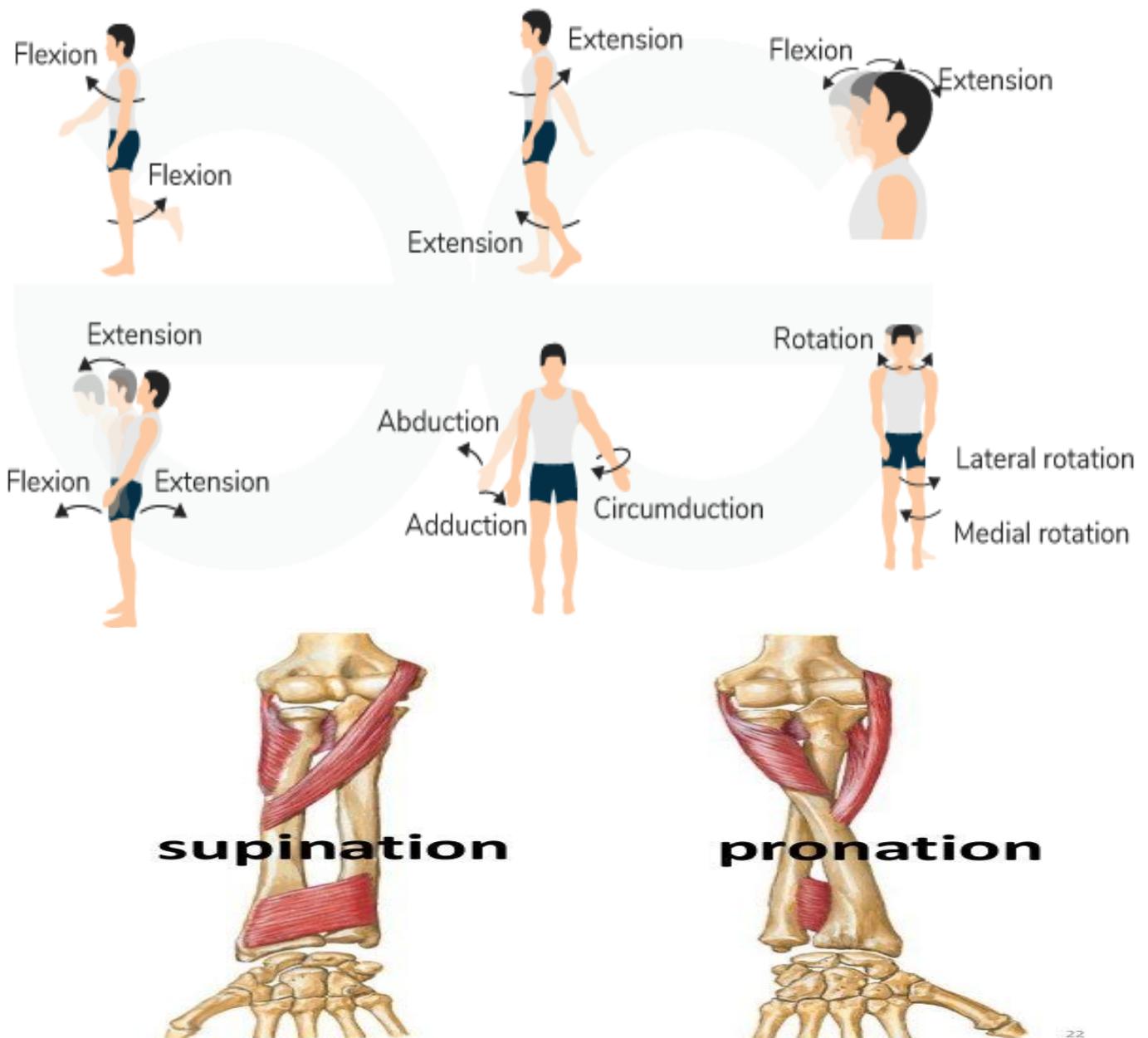


5. **Medial Rotation;** (refers to the **inward rotation** of a limb around its longitudinal axis).

6. **Lateral Rotation;** (refers to the **outward rotation** of a limb around its longitudinal axis).

7. **Supination;** (Is the rotation of the **forearm** so that the **palm faces forward** (in the anatomical position) or upward.

8. **Pronation;** (Is the rotation of the **forearm** so that the **palm faces backward** (in the anatomical position) or downward.





The Connectors of the Body

The skeletal system is supported and stabilized by specialized connective structures that link bones and muscles:

1. **Ligaments** (Connect bone to bone and provide joint stability and limit excessive movement).
2. **Tendons** (Attach muscles to bones and transmit the force of muscle contraction to produce movement).
3. **Cartilage** (Acts as a cushion between bones at joints and Reduces friction and protects bones from wear and tear).

