



CLASSIFICATION OF BONES AND JOINTS

DR. DAVID | 08/03/2026

OUTLINE

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| II. Classification of Bones based on Development | B. Amphiarthrosis |
| A. Intramembranous bones | C. Diarthrosis |
| B. Cartilaginous bones | VII. Classification of Joints based on Structure |
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LEGENDS

Must know	Lecturer	Book	Presentation	Old Trans
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LEARNING OBJECTIVES

- At the end of the lecture, the student should be able to:
- ✓ Discuss the functional parts of the skeletal system
 - ✓ Give the parts of the skeleton
 - ✓ Differentiate the two types of bones namely the compact and spongy bones
 - ✓ Enumerate the classification of bones
 - ✓ Discuss the bone development
 - ✓ List down the different bone formations and markings
 - ✓ Identify the vasculature and innervation of the bone
 - ✓ Classify joints by connecting media and degree of movement.
 - ✓ Identify examples of synarthroses, amphiarthroses, and diarthroses.
 - ✓ Describe the structure and function of synovial joints.

SKELETAL SYSTEM

- A framework made of bones, cartilage, tendons, and ligaments that supports the body, protects organs, and makes blood cells
- Adults have 206 bones while babies are born with about 300 bones that fuse together as they grow

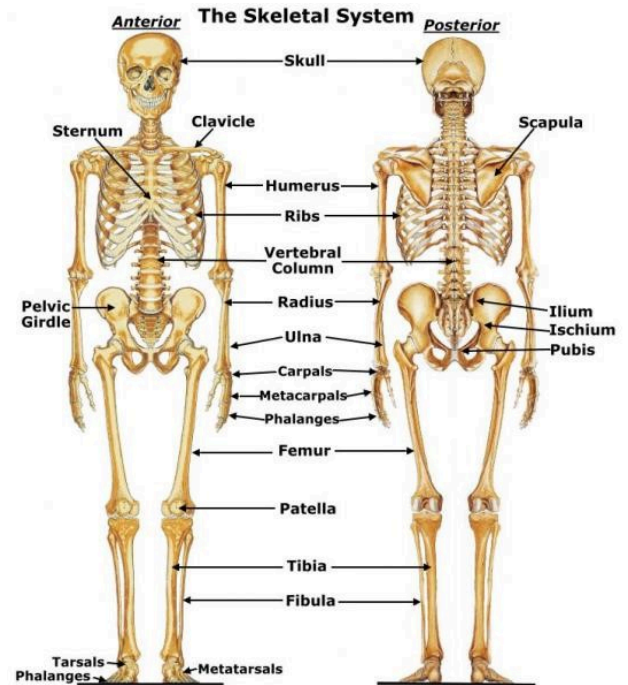


Figure 1. The Skeletal System

A. PRIMARY FUNCTION

1. Support and Structure

- Functional Description
 - Provides a rigid framework that supports the entire body and cradles soft organs
- Primary Anatomical Examples
 - Vertebral column, pelvic girdle, and long bones of the lower extremities.

2. Protection

- Functional Description
 - Shields delicate, vital internal organs from physical trauma and mechanical injury.
- Primary Anatomical Examples
 - Skull: Protects the brain
 - Rib cage: Protects the heart and lungs
 - Pelvis: Protects reproductive organs

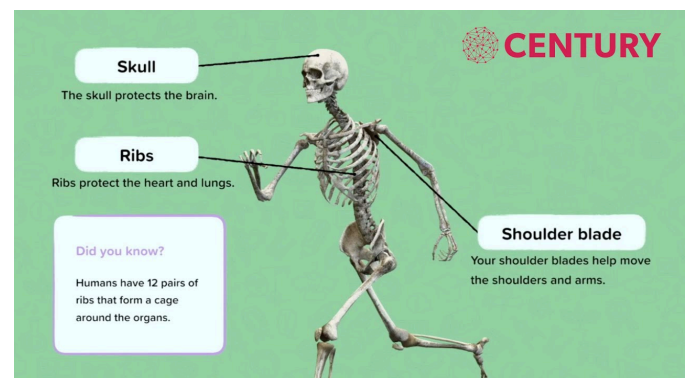


Figure 2. Anatomical examples of Skeletal System that serves as protection

3. Movement

- Functional Description
 - Bones serve as levers that skeletal muscles pull on to produce gross and fine movement
- Primary Anatomical Examples
 - Long bones such as the femur, humerus, tibia, and radius

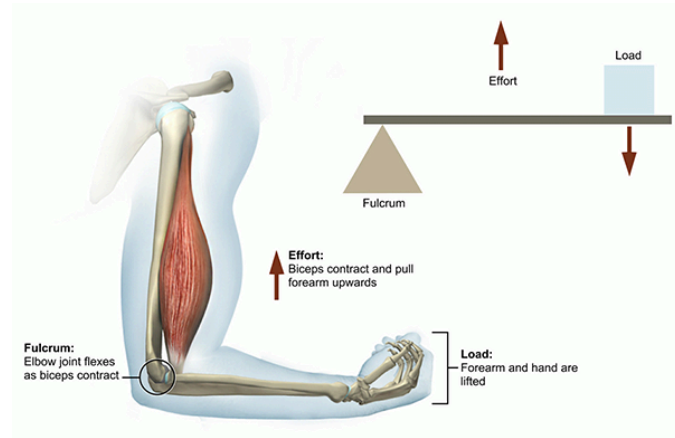


Figure 3. Biomechanics Anatomical Levers

4. Mineral Storage

- Mineral Reservoir
 - Storage: Bone tissue serves as a dynamic storehouse for essential minerals
 - Key Elements: It specifically stores and preserves calcium and phosphorus
- Homeostatic Release
 - Regulation: Minerals are dynamically released into the bloodstream as needed
 - Systemic Balance: This release actively maintains systemic acid-base and electrolytic balance across the all bone tissue

5. Blood Cell Production

- Functional Process
 - Also known as hematopoiesis; the formation of red blood cells, white blood cells, and platelets
- Primary Anatomical Site
 - Occurs within red bone marrow located inside spongy (cancellous) bone cavities

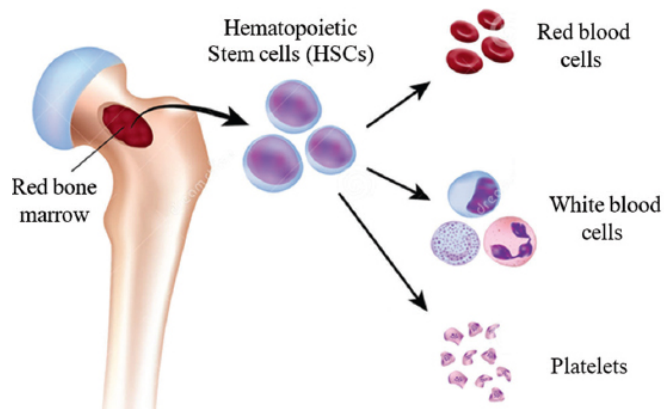


Figure 4. Bones as Blood Cell Producers

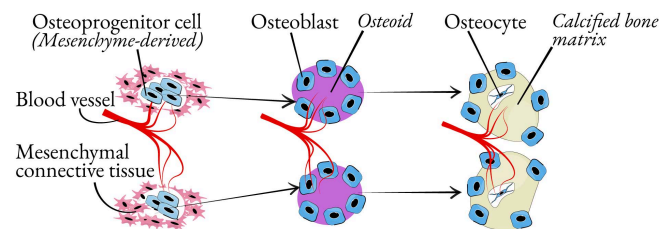
Table 1. Summarized Function of Bones		
Functional Category	Description	Examples
Support & Structure	Provides a hard framework supporting body & cradling soft organs	Vertebral column, pelvis
Protection	Shields vital internal organs from injury	Skull (brain), rib cage (heart/lungs)
Movement	Bones act as levers muscles pull on to produce movement	Long bones (femur, humerus)
Mineral Storage	Reservoir for calcium and phosphorus released as needed	All bone tissue
Blood Cell Production	Hematopoiesis occurring within marrow cavities	Spongy (cancellous) bone

BASED ON DEVELOPMENT

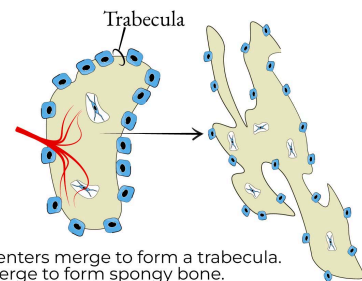
- Most bones take many years to grow and mature.
- The humerus (arm bone), for example, begins to ossify at the end of the embryonic period (8 weeks); however, ossification is not complete until 20.
- All bones **derive from mesenchyme** (embryonic connective tissue) by two different processes: **intramembranous ossification** (directly from mesenchyme) and **endochondral ossification** (from cartilage derived from mesenchyme).

A. INTRAMEMBRANOUS BONES

Intramembranous Ossification



Intramembranous ossification begins during ~ week 6.



Ossification centers merge to form a trabecula. Trabeculae merge to form spongy bone.

Figure 5. Intramembranous Ossification process

- Ossification Process
 - Intramembranous Ossification** - intra = within, membranous = membrane, ossification = formation of bone. Bone formation within mesenchymal membrane.
- Developmental Mechanism
 - Osteoblasts directly differentiate within sheets of fibrous mesenchymal connective tissue.

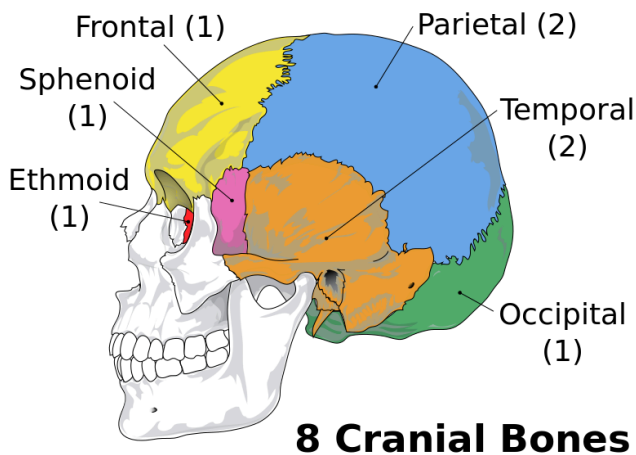


Figure 6. Example of Intramembranous Ossification

- Anatomical Examples:
 - Flat bones of the skull
 - Much of the mandible
 - Clavicle

B. CARTILAGINOUS BONES

- Ossification Process
 - Endochondral Ossification** - Endo = within, chondral = cartilage, ossification = formation of bone. Bone formation within cartilage
- Development Mechanism
 - Develops through progressive replacement of an initial hyaline cartilage model by bone tissue.

Endochondral Ossification

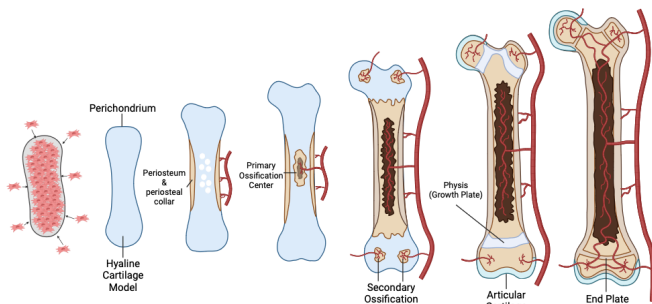


Figure 7. Endochondral Ossification

- Anatomical Examples:
 - Femur
 - Tibia
 - Humerus
 - Most axial/Appendicular elements

Table 2. Summarized Developmental Classification

Bone Category	Ossification Type	Precursor / Mechanism	Key Examples
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Membranous Bones	Intramembranous	Direct replacement of mesenchymal membranes	Skull bones, Clavicle
Cartilaginous Bones	Endochondral	Replacement of pre-existing hyaline cartilage	Femur, Tibia, Humerus

BASED ON STRUCTURE

A. FIBROUS JOINT

- Fibrous joints are connected by dense regular connective tissue rich in collagen fibers. These joints lack a joint cavity and generally provide little to no movement, functioning primarily to provide stability and protection.
 - Sutures:** Immovable joints found exclusively in the skull. The adjacent bones are tightly bound by very short fibrous connective tissue fibers.
 - Syndesmosis:** Bones are united by longer bands of fibrous tissue, such as interosseous ligaments or membranes. They permit slight movement depending on the length of the connecting fibers (e.g., radioulnar and tibiofibular joints).
 - Gomphosis:** A specialized "peg-and-socket" fibrous joint. The only examples in the human body are the articulations of teeth anchored into their alveolar sockets in the jawbones via periodontal ligaments.

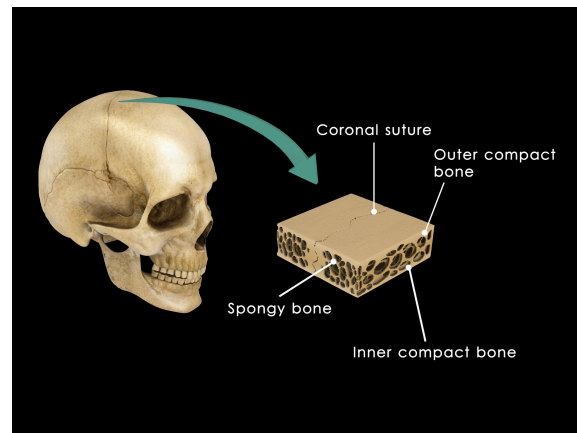


Figure 8. Fibrous Joint

B. CARTILAGINOUS JOINTS

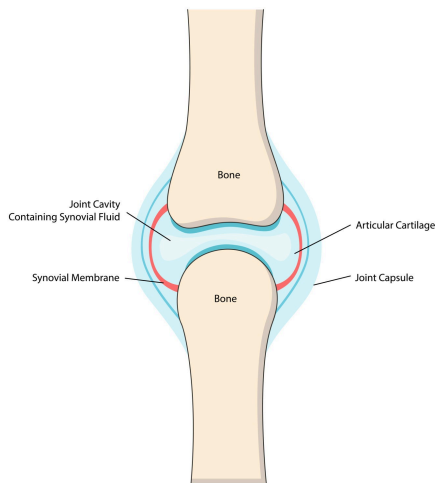
- In cartilaginous joints, the articulating bones are united entirely by cartilage. Like fibrous joints, they lack a joint cavity. However, they typically allow for more movement than fibrous joints while still maintaining significant structural stability.
 - Primary (Synchondrosis):** Bones are joined by a bar or plate of hyaline cartilage. These are typically temporary joints present during bone growth and are essentially immovable (e.g., the epiphyseal growth plate)

in long bones, and the joint between the first rib and the sternum).

- **Secondary (Symphysis):** The articulating surfaces of the bones are covered with hyaline cartilage, which is then fused to an intervening pad or broad disc of fibrocartilage. This structure acts as a strong shock absorber and permits limited movement (e.g., intervertebral discs and the pubic symphysis).

C. SYNOVIAL JOINTS

- Synovial joints are the most complex and common joints in the body. Their defining structural characteristic is the presence of a fluid-filled cavity that separates the articulating bones, which allows for a substantial and free range of motion.
 - **Joint (Articular) Cavity:** A fluid-filled space between the opposing bones.
 - **Synovial Fluid:** A viscous, lubricating fluid secreted by the synovial membrane that reduces friction and nourishes the cartilage.
 - **Articular Capsule:** A two-layered enclosure comprising a tough outer fibrous capsule and an inner synovial membrane.
 - **Articular Cartilage:** A smooth layer of hyaline cartilage covering the opposing bone surfaces, absorbing compression and preventing bone-on-bone contact.



SYNOVIAL JOINT

Figure 9. Synovial Joint

Synovial Joint Subtypes

- Synovial joints are further classified into six subtypes based on the shapes of their articulating surfaces, which dictates the specific movements they allow.

TYPES OF SYNOVIAL JOINTS

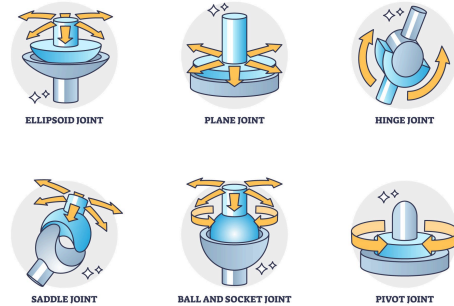


Figure 10. Types of Synovial Joint

Table 3. Types of Synovial Joint

Joint Type	Movement Permitted	Description with Examples
Hinge	Uniaxial (Bending)	The convex cylindrical surface of one bone fits into a concave trough on another. Examples: Elbow, knee, and interphalangeal joints.
Pivot	Uniaxial (Rotation)	The rounded end of one bone rotates within a "ring" formed by a bone and a ligament. Examples: Atlantoaxial joint (C1-C2 vertebrae), proximal radioulnar joint.
Condyloid (Ellipsoid)	Biaxial	An oval convex surface fits into a complementary oval concave depression. Examples: Radiocarpal (wrist) joint, metacarpophalangeal (knuckle) joints.
Saddle	Biaxial (Wide range)	Both articulating surfaces have alternating convex and concave areas, resembling a saddle. Example: Carpometacarpal joint of the thumb.

Ball and Socket	Multiaxial	The spherical head of one bone articulates with the cup-like socket of another, offering the greatest freedom of movement. Examples: Shoulder and hip joints.
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Appendicular Skeleton	Bones of limbs and anchoring girdles	Bones of the Upper and Lower Limbs, Shoulder Girdle, Pelvic Girdle
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BASED ON LOCATION

A. AXIAL

- The axial skeleton consists of the bones of the head (cranium or skull), neck (hyoid bone and cervical vertebrae), and trunk (ribs, sternum, vertebrae, and sacrum)
- Bones forming the vertical central axis of the human body
- Composed of the Skull, Vertebral Column, and Thoracic cage (Ribs & Sternum)
- Includes the laryngeal skeleton (e.g. hyoid bone and auditory ossicles)

B. APPENDICULAR

- Bones of the appendages and girdles linking limbs to the central axis
- Bones of the Upper Limbs (Arms/Hands) and Lower Limbs (Legs/Feet)
- It also includes the Shoulder Girdle (Scapula & Clavicle) and Pelvic Girdle (Hip bones)

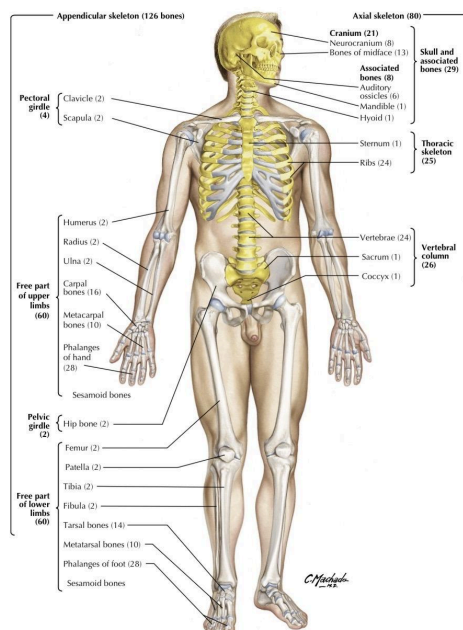


Figure 10. Overview of the Classification of Bones based on Location

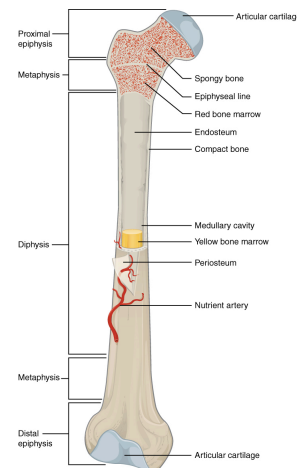
Table 4. Summarized Location Classification

Anatomical Division	Description	Key Components
Axial Skeleton	Forms the central axis; protects internal organs	Skull, Vertebral column, Thoracic cage, Laryngeal Skeleton

BASED ON SHAPE

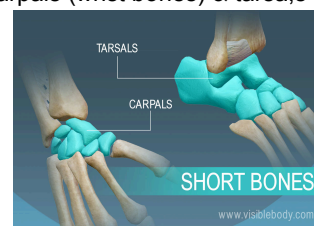
A. LONG BONES

- Longer than they are wide; consists of a central shaft (diaphysis) and two ends
- Function: Supports body weight and acts as levers to facilitate movement
- e.g. femur, tibia, humerus, & radius



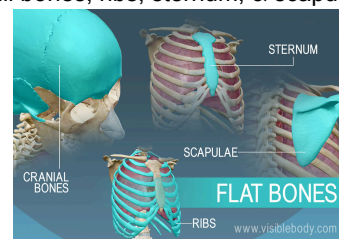
B. SHORT BONES

- Cube-shaped; nearly equal in length and width with a thin cortex of compact bone
- Function: Provides structural stability and support with limited, precise movement
- e.g. carpals (wrist bones) & tarsals (ankle bones)



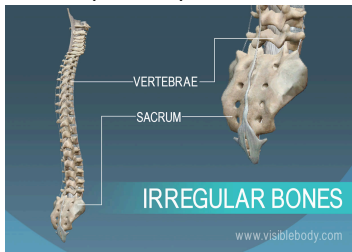
C. FLAT BONES

- Thin, flattened, and often gently curved with broad parallel surfaces
- Function: Protects vital internal organs and serves as expansive attachment points for muscles
- e.g. skull bones, ribs, sternum, & scapula



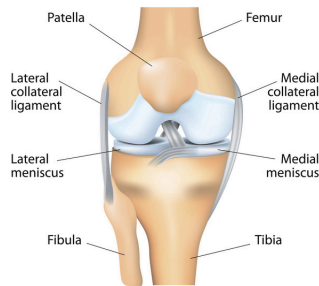
D. IRREGULAR BONES

- Possess complex, specialized shapes that do not fit into any other category
- Function: Protects complex internal organs and provides specialized skeletal support
- e.g. vertebrae, pelvis, sphenoid, & ethmoid



E. SESAMOID BONES

- Small, round nodular bones embedded directly within tendons
- Function: Reduces friction and protects delicate tendons from excessive mechanical wear
- e.g. patella (kneecap) & small tendon bones in hands and feet



F. ACCESSORY BONES

- Extra bones that result from variations in normal ossification during development
- e.g. Os trigonum in the ankle & Os acromiale in the shoulder gird
- Clinical note: Important in radiologic evaluation to distinguish normal variants from fractures

Table 5. Summarized Shape Classification

Bone Category	Description	Primary functions	Key Examples
Long Bones	Longer than they are wide	Supports weight & facilitates movement	Femur, Tibia, Humerus, Radius
Short Bones	Cube-shaped; equal length & width	Provide stability with limited movement	Carpals (wrist) & Tarsals(ankle)
Flat Bones	Thin, flattened. & often curved	Protect internal organs; muscle attachment	Skull, Ribs, Sternum, scapula
Irregular Bones	Complex shapes; non-standard	Protects organs & support structure	Vertebrae, Pelvis, Sphenoid

Sesamoid Bones	Small, round, embedded in tendons	Reduces friction & protects tendons	Patella, Hand/foot tendon bones
Accessory Bones	Extra bones in ossification during development		Os trigonum & Os acromiale

CLASSIFICATION OF FUNCTIONAL JOINTS

A. BASED ON MOVEMENT

1. Synarthrosis (Immobile Joints)

- Description
 - Immobile or nearly immobile joints; providing protection for internal organs
- Structural Correlation
 - Most synarthroses are structurally classified as fibrous joints.
- Anatomical Examples
 - Sutures (skull) gomphosis (teeth in jaw), and manubriosternal joint

2. Amphiarthrosis (Slightly Movable)

- Description
 - Slightly movable joints with limited mobility
- Structural Correlation
 - Typically cartilaginous joints (like symphyses) or certain fibrous joints (like syndesmoses)
- Anatomical Examples
 - Intervertebral discs, pubic symphysis, and interosseous membranes

3. Diarthrosis (Freely Movable)

- Description
 - Freely movable joints providing a wide range of motion
- Structural Correlation
 - Includes all synovial joints possessing a fluid-filled joint cavity
- Anatomical Examples
 - Shoulder, hip, elbow, and knee joints

Table 6. Functional Classification Summary Table

Category	Description	Structural correlation	Examples
Synarthrosis	Immobile or nearly immobile joints; providing protection for internal organs	Most are fibrous joints	Sutures (skull), gomphosis (teeth in jaw), manubriosternal joint
Amphiarthrosis	Slightly movable joints with limited mobility	Typically cartilaginous joints (symphyses) or fibrous (syndesmoses)	Intervertebral discs, pubic symphysis, interosseous membrane

Diarthrosis	Freely movable joints providing a wide range of motion	Includes all synovial joints	Shoulder, hip, elbow, and knee joints
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B. BASED ON STRUCTURE

1. Fibrous Joints

- Sutures
 - Bones joined by dense connective tissue; immovable in adults (e.g., skull sutures).
- Syndesmosis
 - Parallel bones united by interosseous ligaments (e.g., radioulnar & tibiofibular joints),
- Gomphosis
 - *Peg-and-socket" joint anchoring teeth into jawbones via periodontal ligaments.

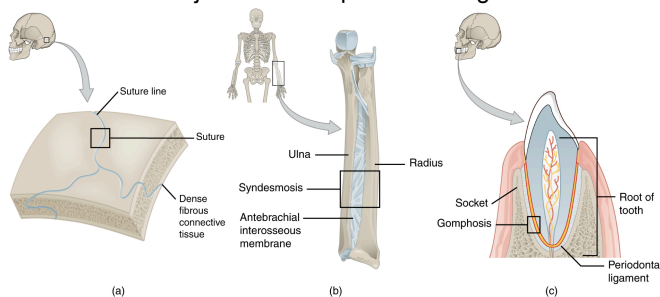


Figure 11. Fibrous Joints

2. Cartilaginous Joints

- Primary (Synchondrosis)
 - Joined by hyaline cartilage; immovable (e.g., 1st rib & sternum, epiphyseal growth plate).
- Secondary (Symphysis)
 - Connected by a broad fibrocartilage disc (e.g., intervertebral discs, pubic symphysis).

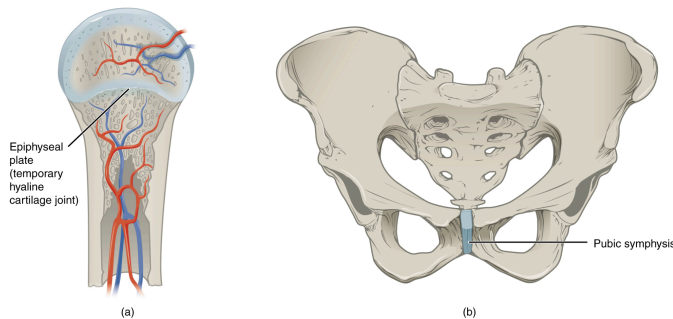


Figure 12. Cartilaginous Joints

3. Key Characteristics of Synovial Joints

- Joint Cavity & Fluid
 - Fluid-filled space containing viscous synovial fluid for surface lubrication and cartilage nutrition.
- Capsule & Cartilage
 - Two-layered articular capsule (fibrous & synovial) with hyaline articular cartilage covering bone ends.

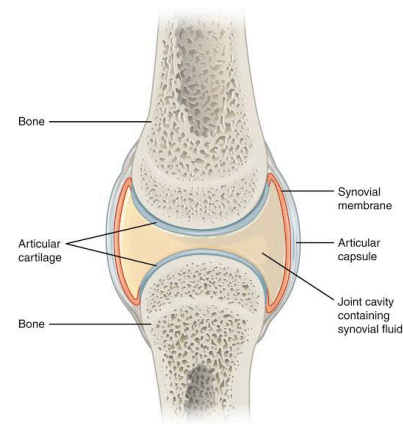


Figure 13. Synovial Joint

Synovial Joint Subtypes

- Plane (Gliding)
 - Flat surfaces permitting sliding movements (e.g., intercarpal & intertarsal joints).
- Hinge
 - Convex-concave articulation allowing uniaxial bending (e.g. elbow, knee, ankle).
- Pivot
 - Rounded bone rotating within a ring (e.g., atlantoaxial C1-C2 & proximal radioulnar joints).
- Saddle Joint
 - Concavo-convex surfaces allowing wide motion (e.g., carpometacarpal joint of thumb).
- Condylloid (Ellipsoid)
 - Oval convex into concavo surface; biaxial movement (e.g., radiocarpal wrist, knuckles).
- Ball and Socket
 - Spherical head into cup cavity; multiaxial freedom (e.g., shoulder and hip joints).

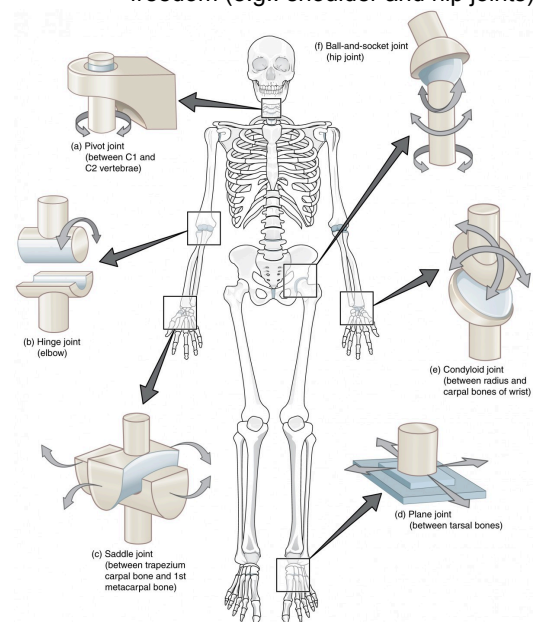


Figure 14. Synovial Joints subtype

ANATOMICAL TERMS BASED ON MARKINGS

A. PROJECTIONS FOR MUSCLE & LIGAMENT ATTACHMENT

- **Tuberosity**
 - Large, rounded, often roughened elevation or process
 - E.g., Deltoid tuberosity of humerus, Tibial tuberosity
- **Tubercle**
 - Small, rounded nodular projection or process
 - E.g., Greater and Lesser tubercles of the humerus
- **Trochanter**
 - Very large, blunt, irregularly shaped process exclusive to the femur
 - E.g., greater or lesser trochanter
- **Crest & line**
 - Prominent, narrow ridge of bone (Crest, e.g., iliac crest) or a subtle, elongated ridge (line, e.g., Linea aspera)

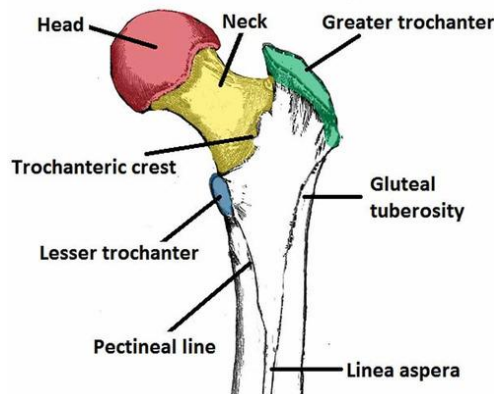


Figure 16. Examples of projections for muscle and ligament attachment.

B. ADDITIONAL ATTACHMENT FEATURES

- **Epicondyle**
 - A prominent raised area positioned directly upon or superior to a condyle
 - E.g., medial and lateral epicondyles of humerus and femur
- **Spine**
 - Sharp, slender, and often pointed bony projection serving as a precise connective tissue anchor
 - E.g., spinous process of vertebra, anterior superior iliac spine
- **Process**
 - Any prominent bony outgrowth or extension from a main bone body
 - E.g., mastoid process, styloid process of temporal bone

C. ARTICULAR PROJECTIONS (JOINT SURFACES)

- **Head**
 - Rounded, prominent bony expansion supported by a constricted neck portion
 - E.g., head of femur, head of humerus
- **Condyle**
 - Large, smooth, rounded articular prominence that forms a hinge or gliding joint
 - E.g., medial/lateral femoral condyles, occipital condyles
- **Facet**
 - Smooth, nearly flat cartilage-covered articular surface

- E.g., superior/inferior articular facets of vertebrae
- **Ramus**
 - Arm-like bar or extension of a bone extending at an angle
 - E.g., ramus of the mandible, pubic ramus

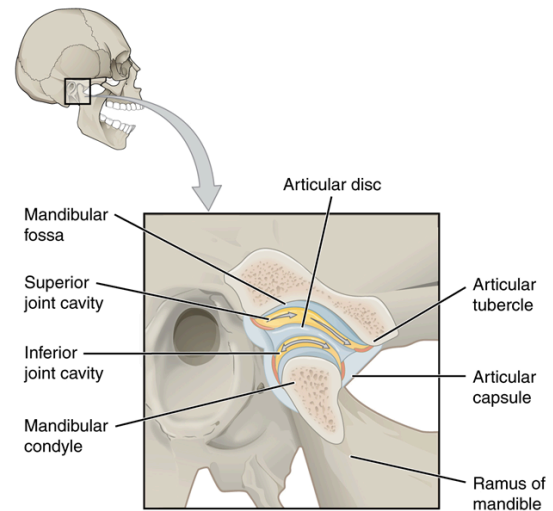


Figure 17. Examples of articular projections (joint surfaces)

D. DEPRESSIONS FOR VESSELS & SOFT TISSUES

- **Fossa**
 - A shallow, basin-like depression on a bone surface, often accommodating an articulating bone or soft tissue
 - E.g., glenoid fossa, olecranon fossa, iliac fossa
- **Sulcus / groove**
 - An elongated furrow or ditch along a bone surface housing long blood vessels, nerves, or tendons
 - E.g., intertubercular sulcus of humerus, radial groove
- **Notch**
 - A distinct indentation at the edge or margin of a flat bone structure
 - E.g., greater sciatic notch of pelvis, supraorbital notch

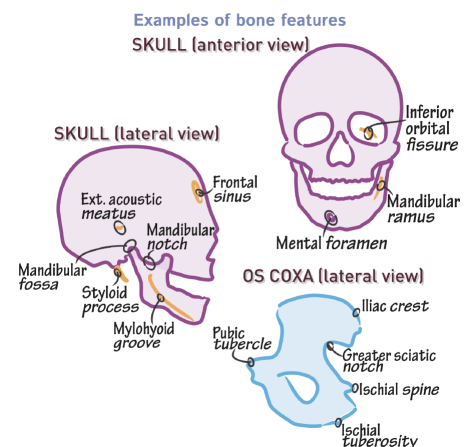


Figure 18. Examples of depressions for vessels and soft tissues

E. OPENINGS, CANALS & CAVITIES

- **Foramen**
 - A round or oval hole through a bone that permits the transit of nerves and blood vessels
 - E.g. Foramen magnum, Vertebral foramen, Mental foramen)
- **Fissure**

- narrow, slit-like cleft or groove between adjacent bone segments
- E.g Superior orbital fissure
- Meatus & Sinus
 - Meatus: Tube-like or canal passageway
 - E.g External acoustic meatus
 - Sinus: Mucous-lined, air-filled cavity within skull bones
 - E.g Frontal sinus

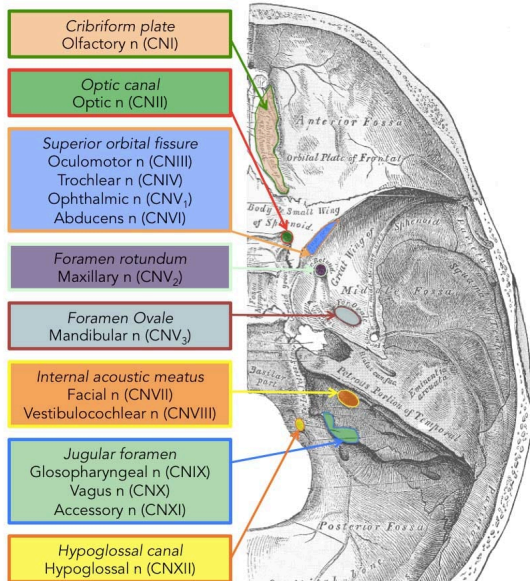


Figure 19. Examples of openings, canals, and cavities

		on a narrow neck	
Condyle/Facet	Rounded joint projection (Condyle)/Flat surface (Facet)	Femoral condyle, Vertebral facet	
Ramus	Arm-like bar or extension of bone	Ramus of the mandible, Pubic ramus	
Depressions & Openings	Fossa/Sulcus	Shallow basin (Fossa)/Elongated groove (Sulcus)	Glenoid fossa, Bicipital groove
Foramen/Fissure	Round opening (Foramen) /Slit-like opening (Fissure)	Foramen magnum, Orbital fissure	
Meatus/Sinus	Canal passageway (Meatus)/ Air cavity (Sinus)	Acoustic meatus, Paranasal sinuses	

REFERENCES

1. Moore, K. L., Dalley, A. F., II., & Agur, A. M. R. (2014). Clinically Oriented Anatomy (7th ed.). Lippincott Williams & Wilkins

Table 7. Bone Surface Terms

Category	Terms	Description and Key Features	Anatomical Examples
Projections (Attachment Sites)	Tuberosity	Large, rounded, roughened process	Deltoid & Tibial tuberosity
Tubercle	Small rounded nodular process	Greater tubercle of humerus	
Trochanter	Very large, blunt process (femur only)	Greater/ Lesser trochanter	
Crest/Line	Prominent ridge (Crest) or subtle ridge (Line)	Iliac crest, Linea aspera	
Epicondyle/Spine	Raised area on condyle (Epicondyle) /Sharp process (Spine)	Humeral epicondyles, Vertebral spine	
Articular Projections (Joints)	Head	Rounded bony expansion	Head of femur & humerus