Skeletal System-1

Introduction to Anatomy and Embryology

Dr. Heba Kalbouneh
DDS, MSc, DMD/PhD
Professor of Anatomy, Histology and Embryology

The Muscoskeletal system includes: Bones (skeleton), Joints, Muscles, Cartilages & Ligaments

Dr. Heba Kalbouneh

Skeleton:

Adult Human contains 206 Bones, 2 parts:

Axial skeleton (axis):

Skull

Vertebral column

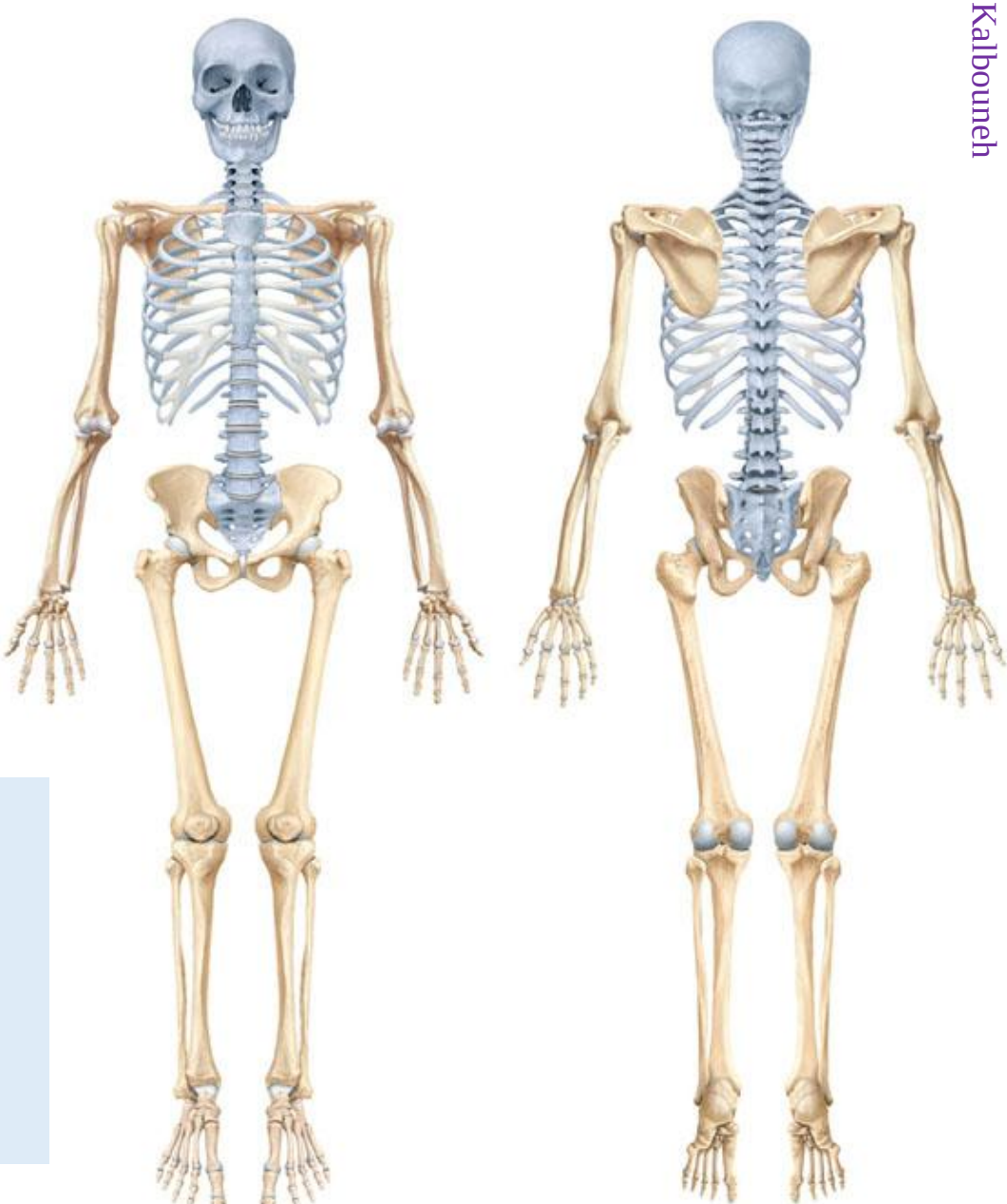
Ribs and sternum

Hyoid bone

Appendicular skeleton:

Bones of upper limb

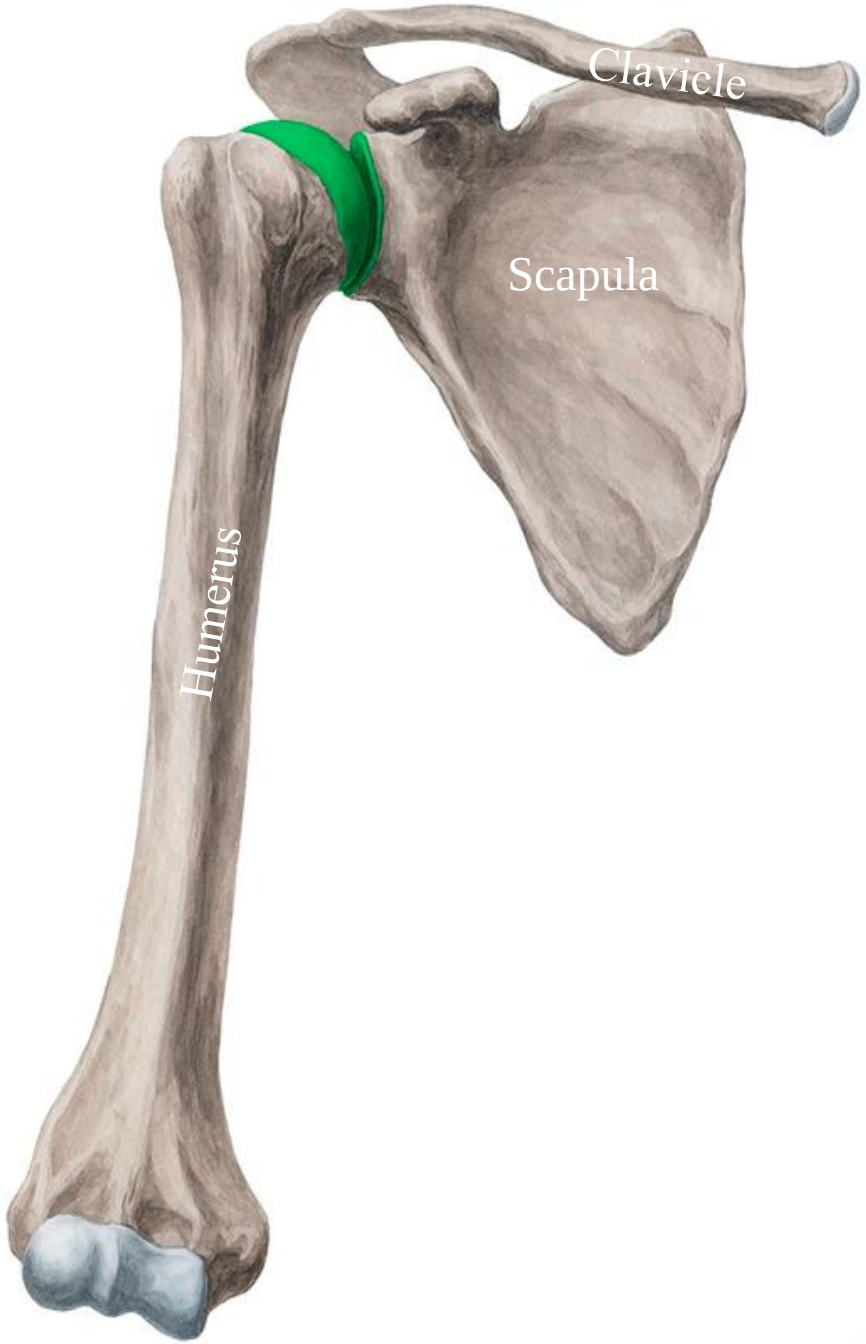
Bones of lower limb



Functions of bones:

- ✓ Support
- ✓ Protection (protect internal organs)
- ✓ Movement (provide leverage system for skeletal muscles, tendons, ligaments and joints)
- ✓ Mineral homeostasis (bones act as reserves of minerals important for the body like calcium or phosphorus)
- ✓ Hematopoiesis: blood cell formation
- ✓ Storage of adipose tissue: yellow marrow

Joints



A joint is where two or more bones meet. Also known as an **articulation**

Joints can be classified either by:
The tissue that holds the bones together or the degree of movement they provide

Synovial joints → Permits free movement

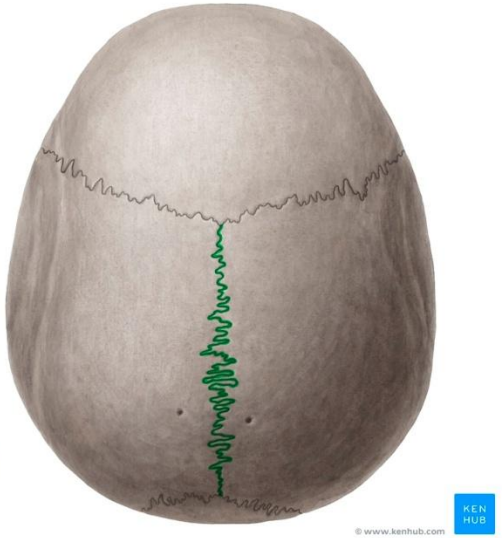
Fibrous joints
Cartilaginous joints
→ Limited or no movement

Fibrous joints are connected by dense connective tissue and have no joint cavity.
Cartilaginous joints are connected by cartilage and have no joint cavity.
Synovial joints have a synovial, fluid-filled cavity that surrounds the articulating bones.

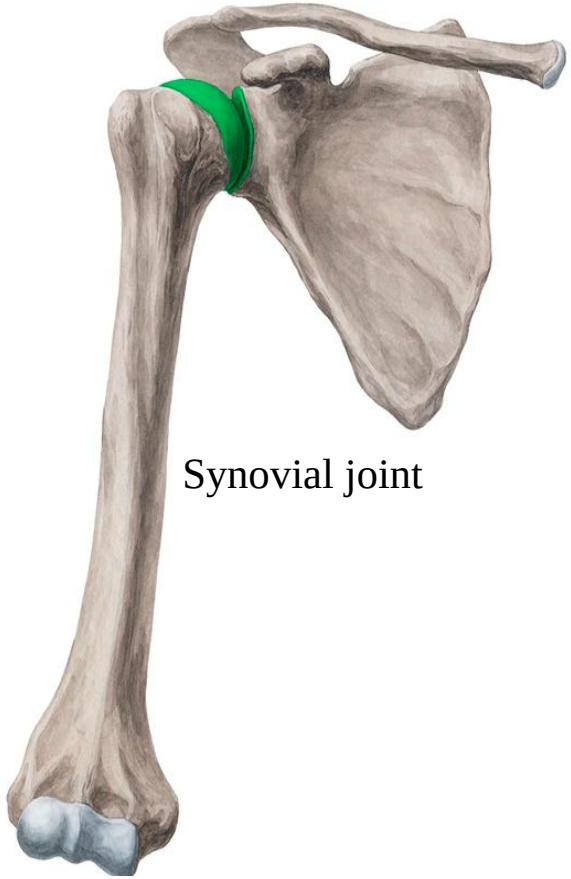
The tissue that holds the bones together

Synarthrosis: Joints that do not provide any movement.
Amphiarthrosis: Joints that only provide a small degree of movement.
Diarthrosis: Joints that allow free movement

The degree of movement they provide



Fibrous joints



Synovial joint

Cartilaginous joints

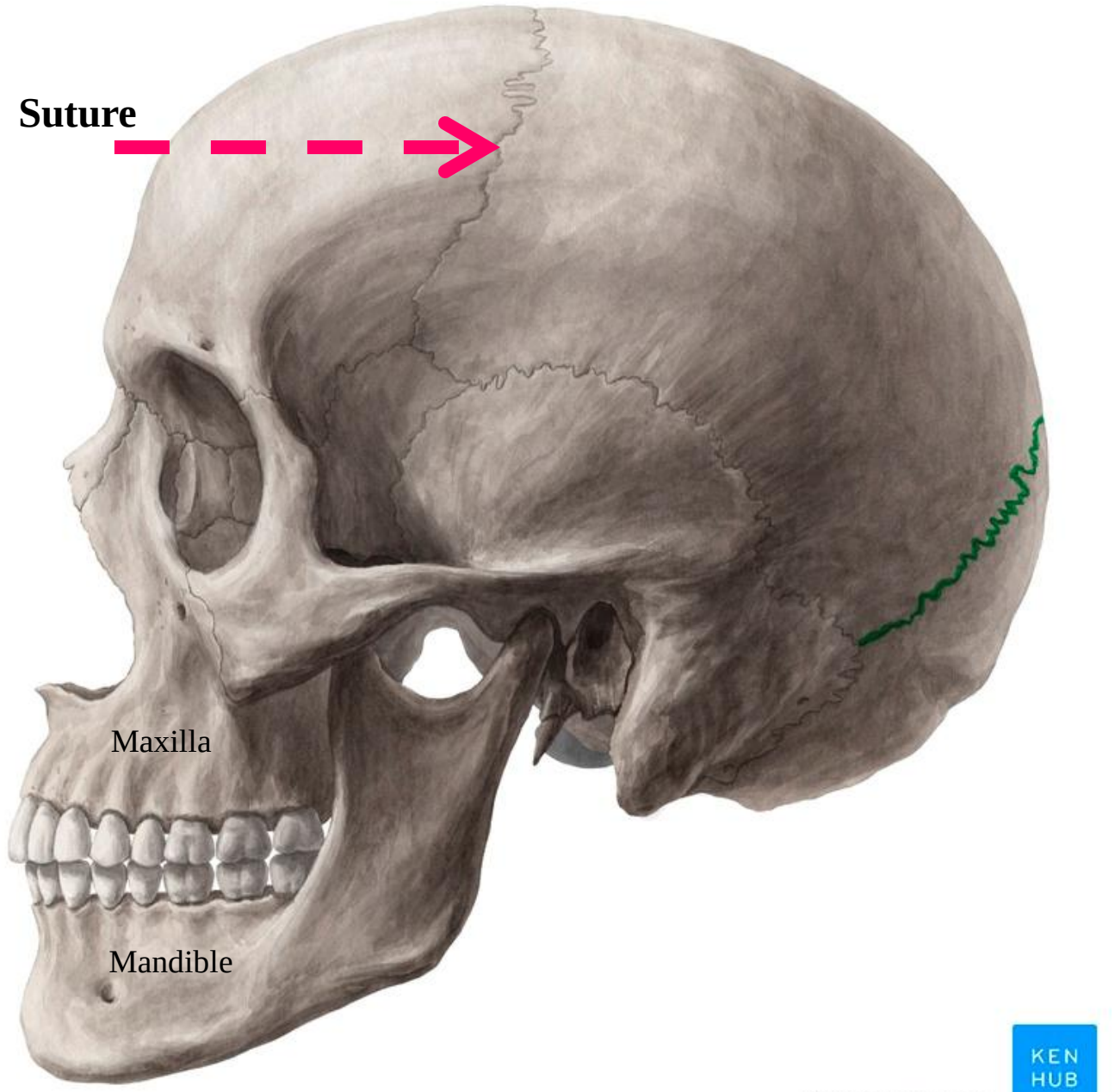
FIBROUS JOINTS

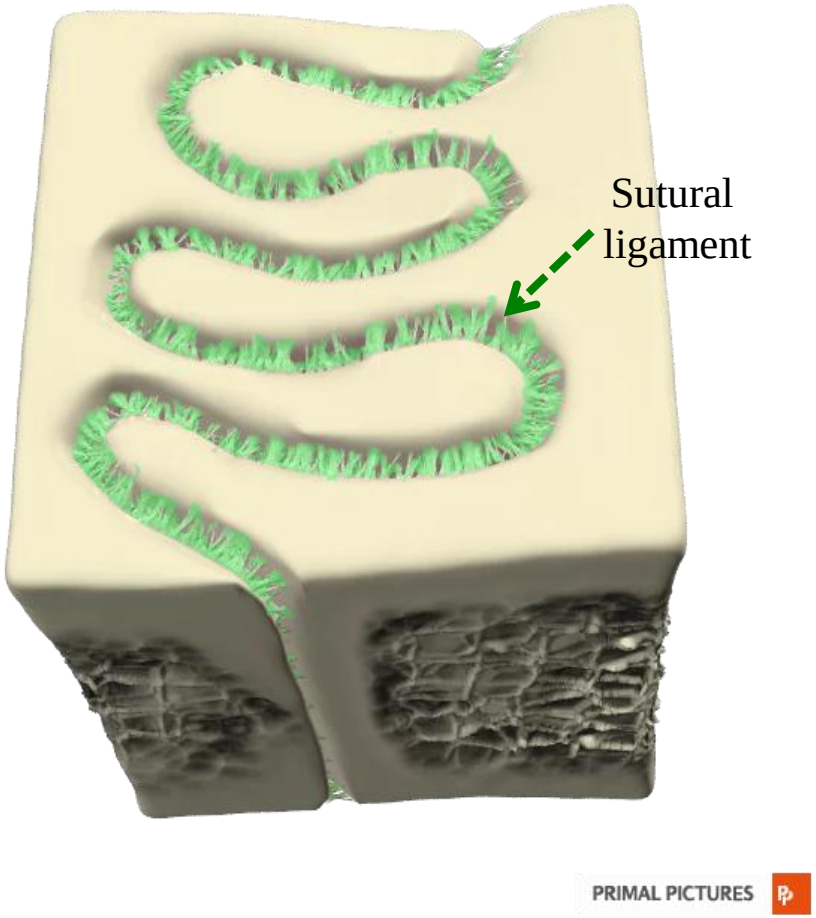
In a fibrous joint, the two bones are connected by dense fibrous connective tissue.

These joints can be either synarthrotic or amphiarthrotic.

There are three different types of fibrous joints:

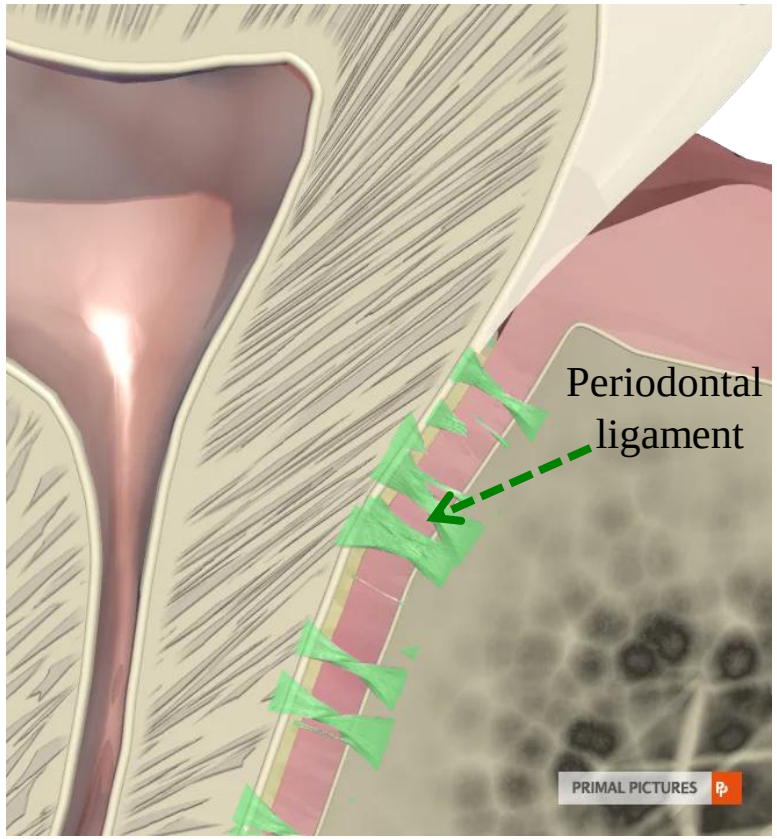
1. **Suture:** between the flat bones of the skull
2. **Gomphosis:** The roots of a tooth and the bony sockets in the maxilla or mandible
3. **Syndesmosis:** Interosseous membrane





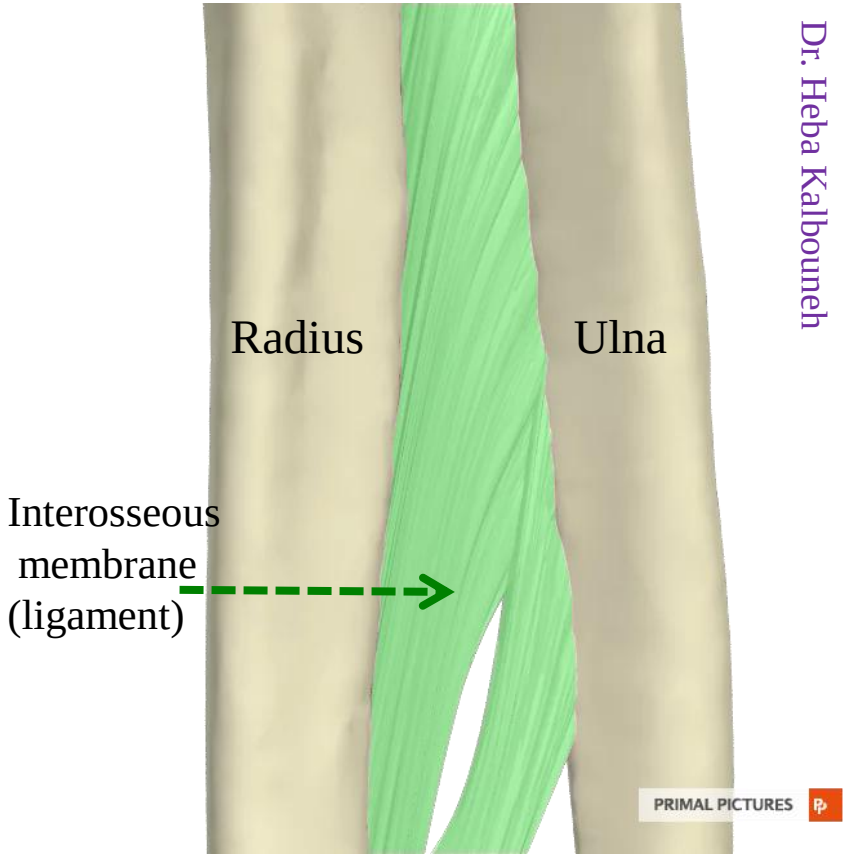
Sutures
Occur between the flat bones of the skull.

These joints are synarthrotic



Gomphoses
Occur only between the teeth and surrounding bone.
In these joints, short collagen tissue fibers in the periodontal ligament run between the root of the tooth and the bony socket.

These joints are synarthrotic ??



Syndesmoses
Occur between the bones linked by ligaments/a strong membrane
Ex. Radius/ ulna and tibia/ fibula/

These joints are amphiarthrotic

CARTILAGINOUS JOINTS

In a cartilaginous joint, the two bones are connected by a cartilage.

These joints can be either synarthrotic or amphiarthrotic.

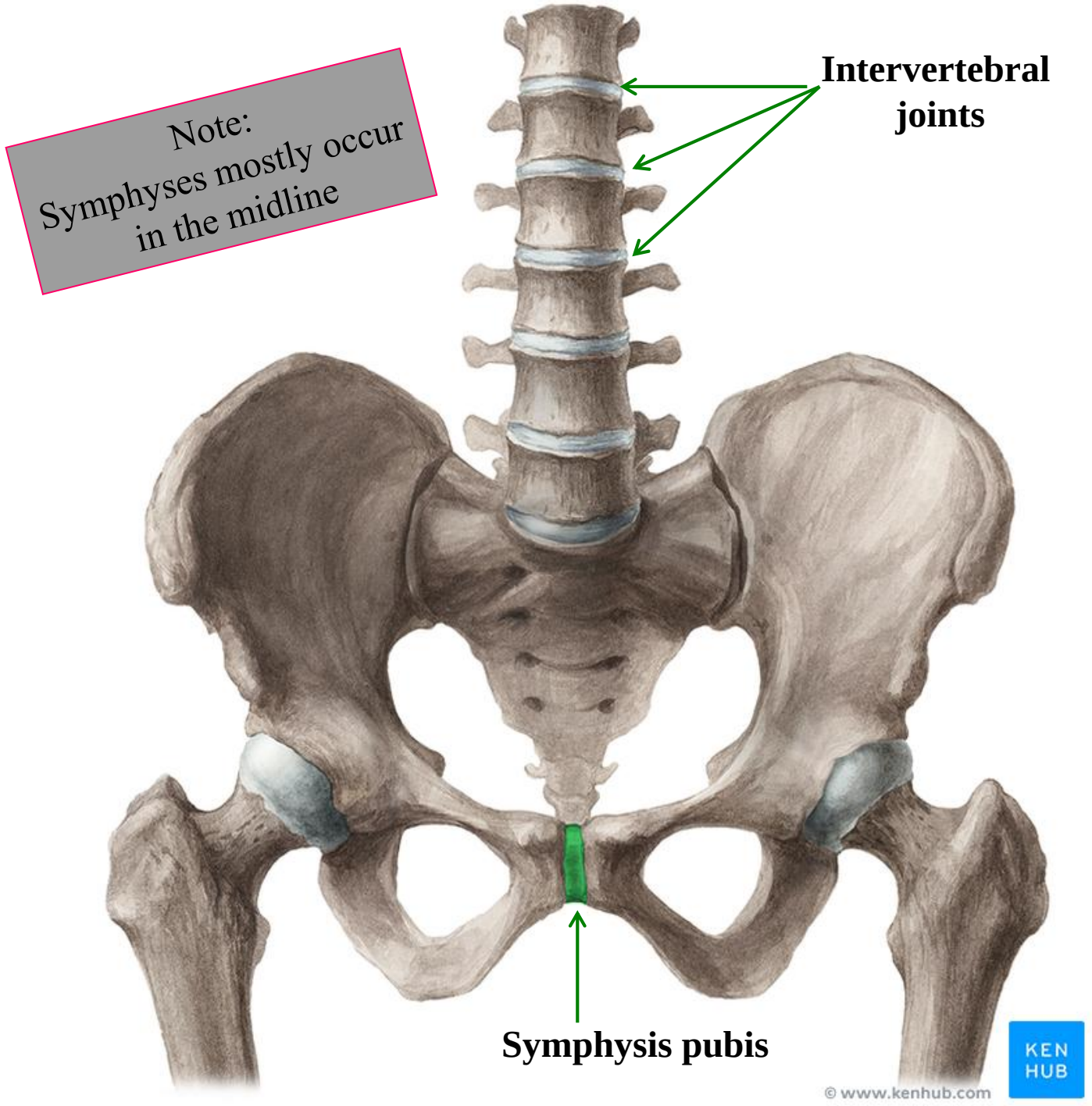
There are two types of cartilaginous joints:

Synchondroses: growth plate

Hyaline cartilage

Symphyses: intervertebral joints, symphysis pubis

Fibrocartilage

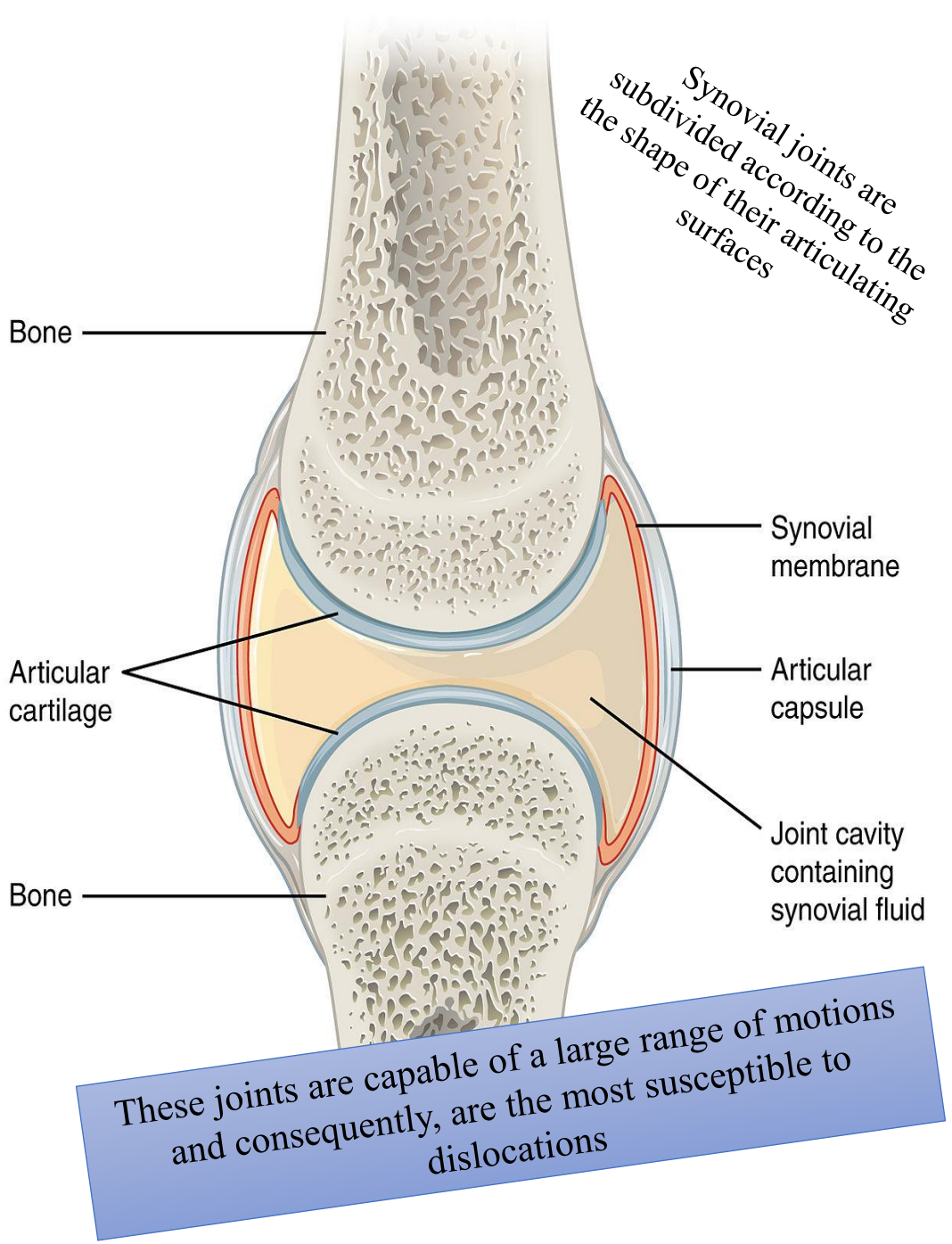


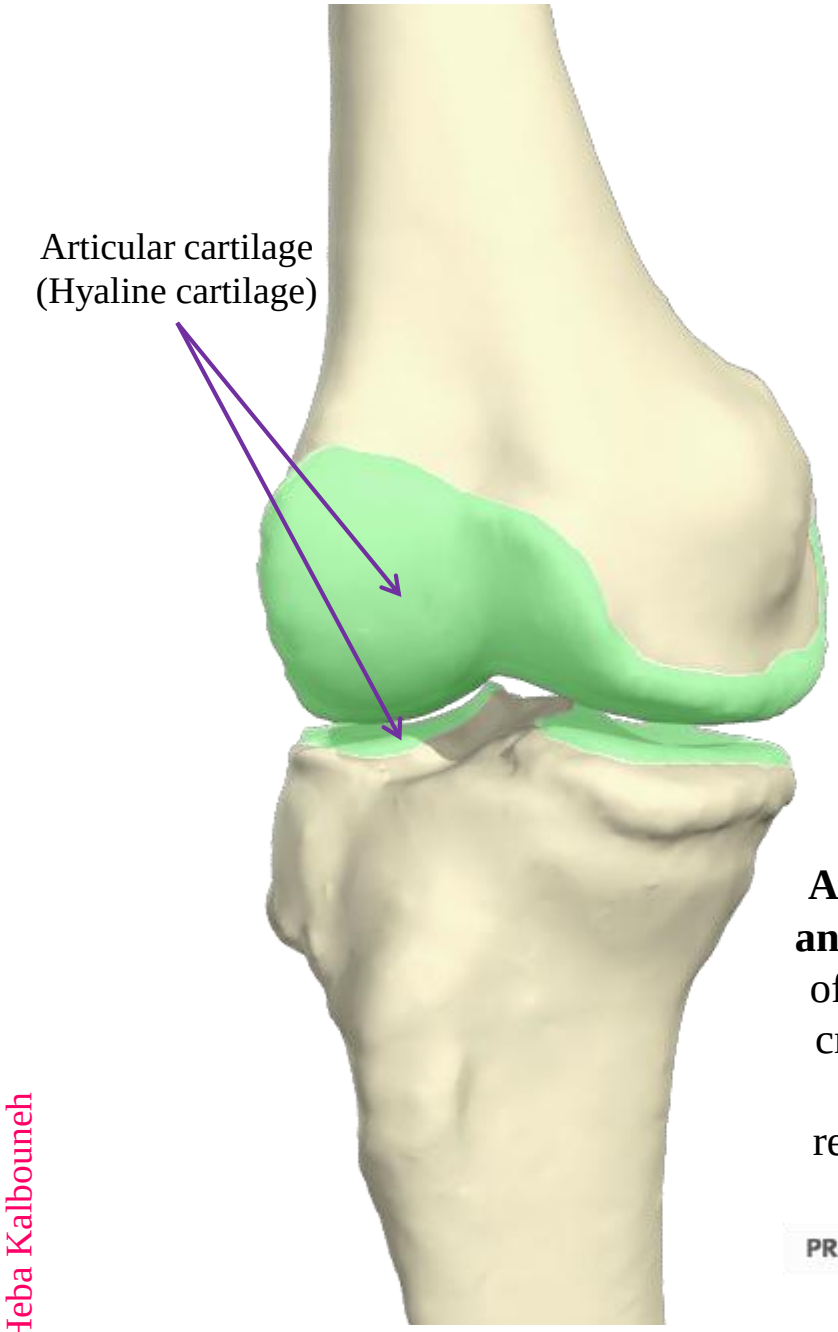
Synovial joints

Synovial joints are most commonly found throughout the limbs.

In order for the joint to be classified as synovial:

✓ Both adjacent bones participating in the joint must be lined with **hyaline cartilage (articular cartilage)**
✓ The joint is encompassed in a **capsule** that encases the joint cavity.
✓The interior of the capsule is lined with a **synovial membrane** that is responsible for producing and secreting **synovial fluid**
✓ **Synovial fluid** lubricates the joint, which aids in reducing the friction between the bones' ends as they articulate with each other
✓Further reinforcement of the capsule is provided by **ligaments**, **tendons** and **skeletal muscle**

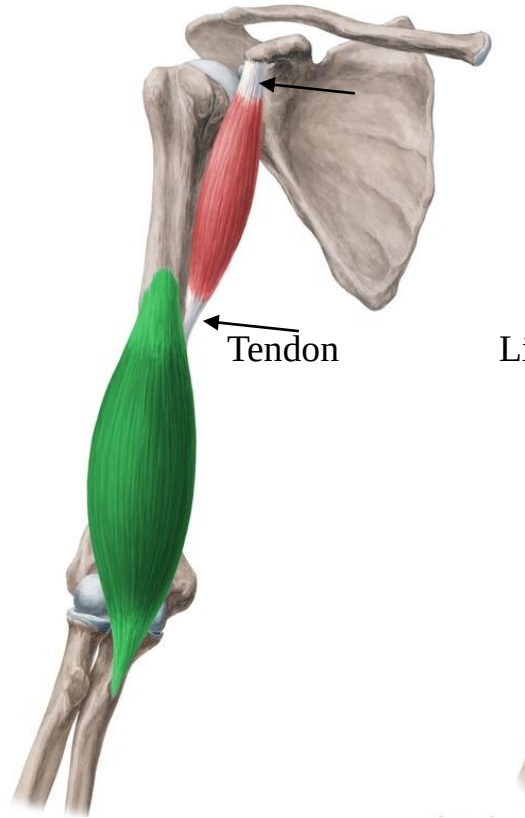


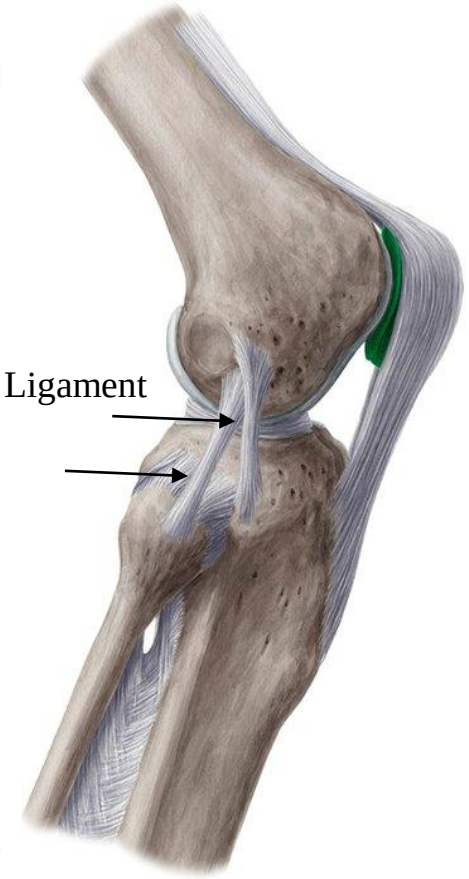


Articular cartilage is a smooth, **firm, and slippery** tissue that covers the ends of bones in a **synovial joint**. It plays a crucial role in facilitating smooth and pain-free movement of joints by reducing friction and absorbing shock

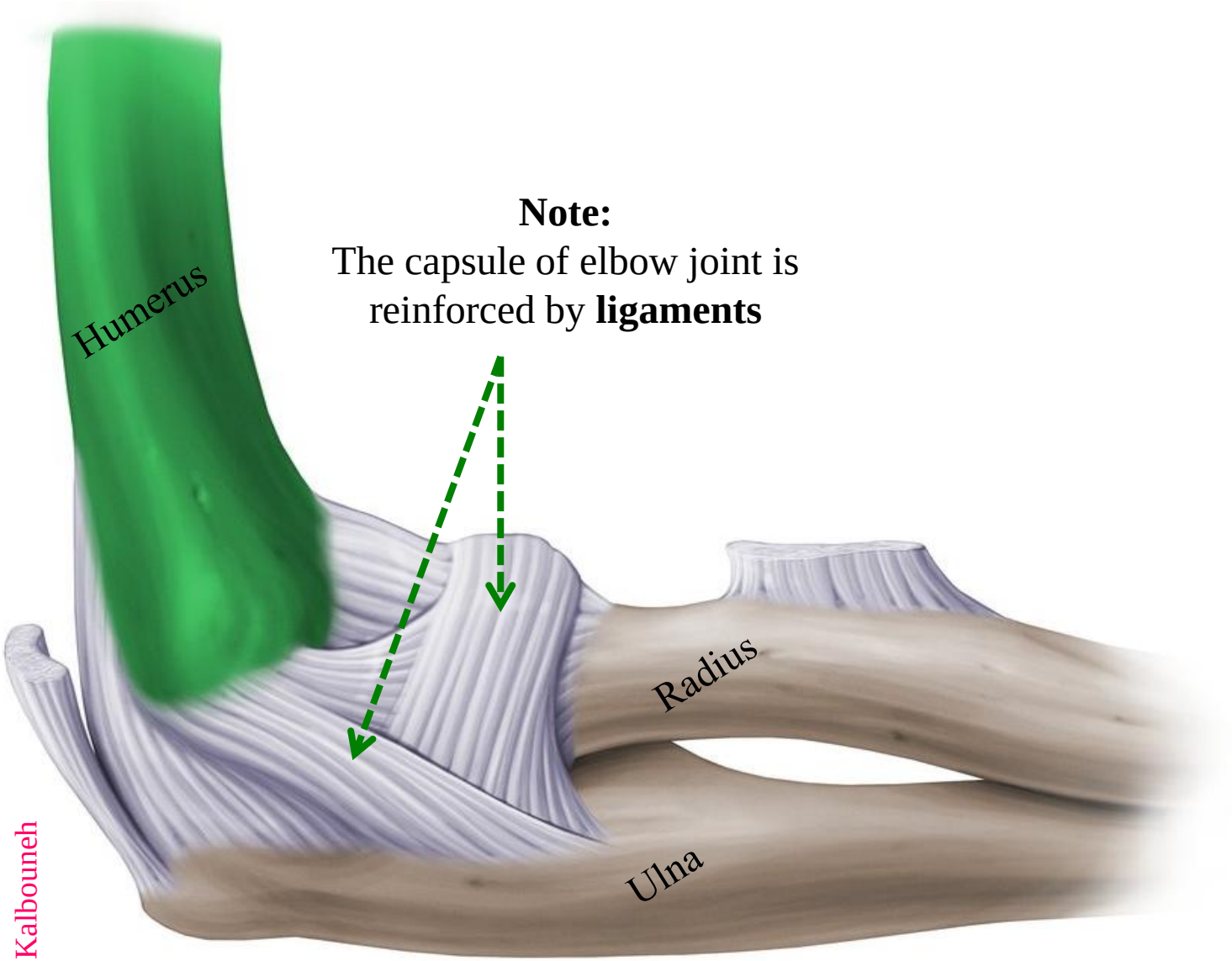
PRIMAL PICTURES

Note: tendons and ligaments are made of dense fibrous connective tissue.
Ligaments connects **bone to bone** (stabilizes joints)
While
Tendons connects **muscle to bone** (facilitates movement).

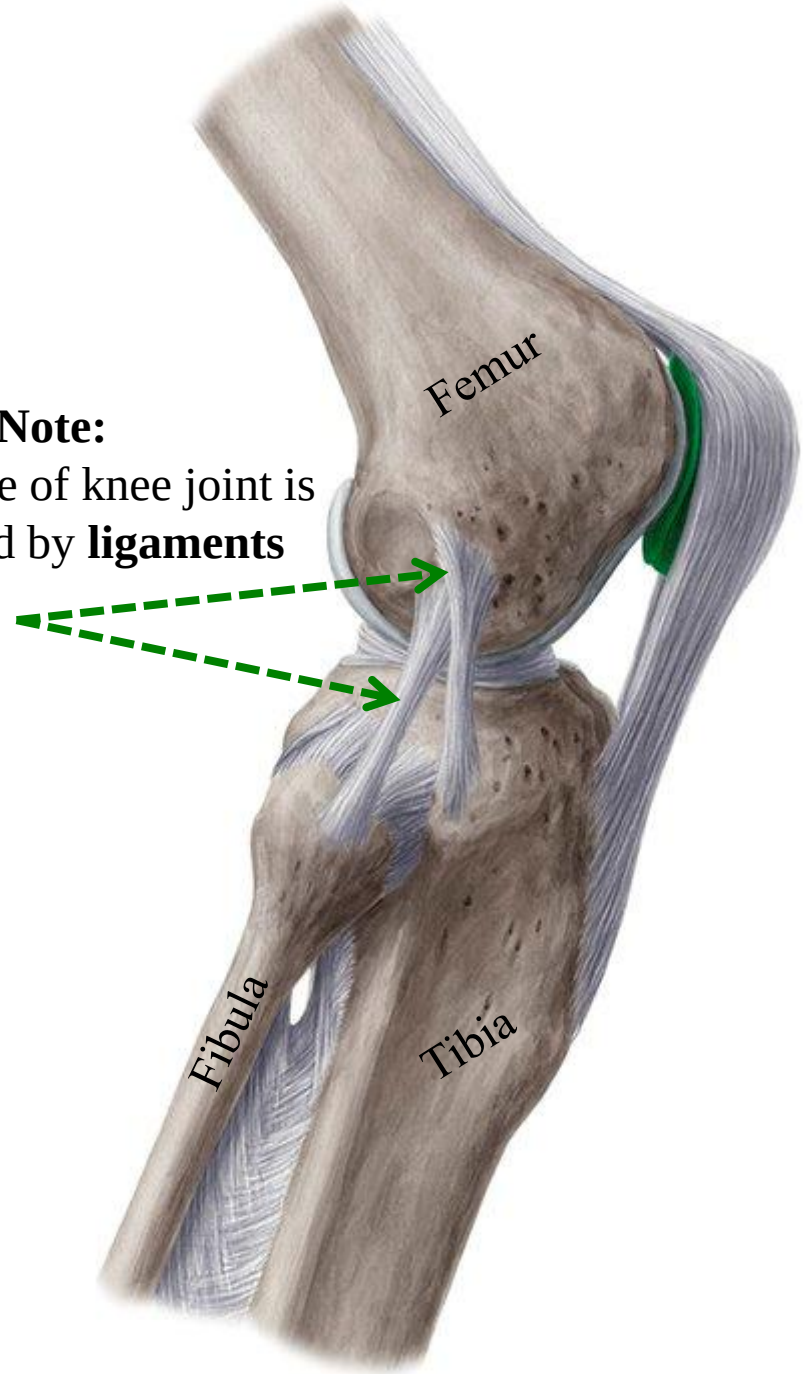




Note:
The capsule of elbow joint is reinforced by **ligaments**



Note:
The capsule of knee joint is reinforced by **ligaments**

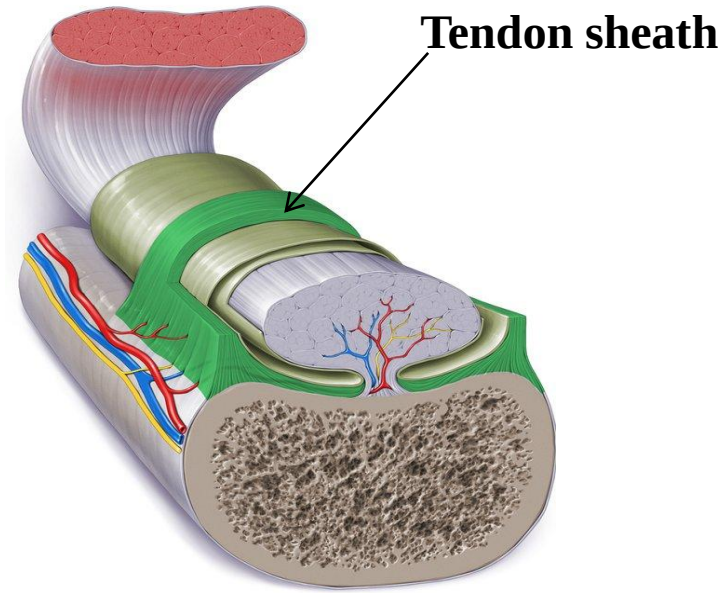


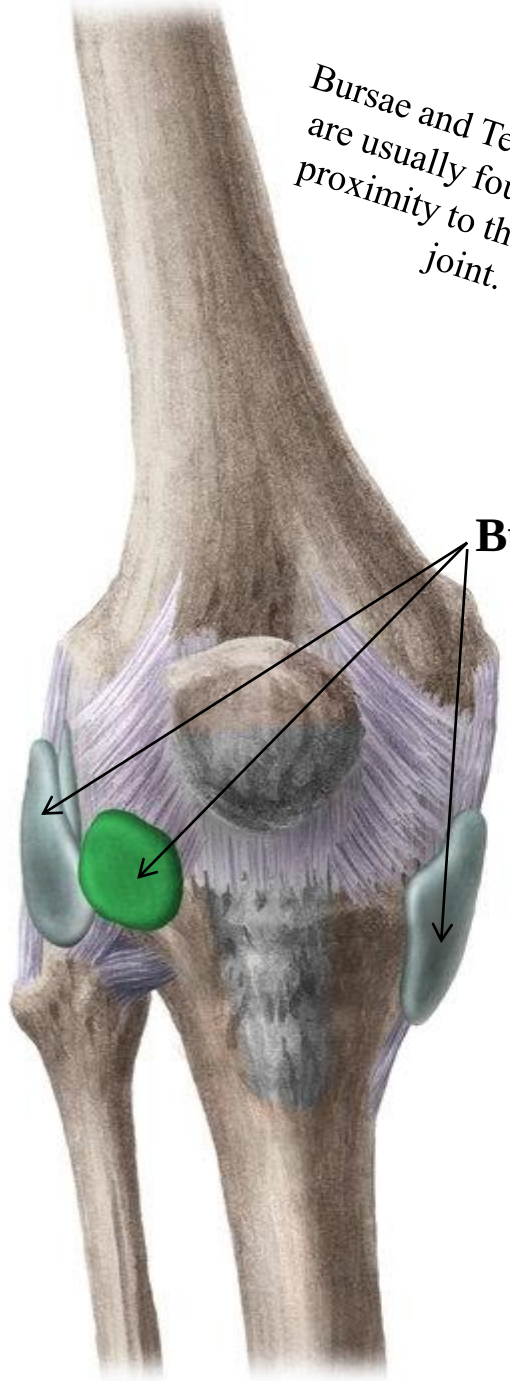
Bursae and Tendon sheaths

Bursae are fibrous, slightly flattened sacs, lined with synovial membrane and containing a thin film of synovial fluid.

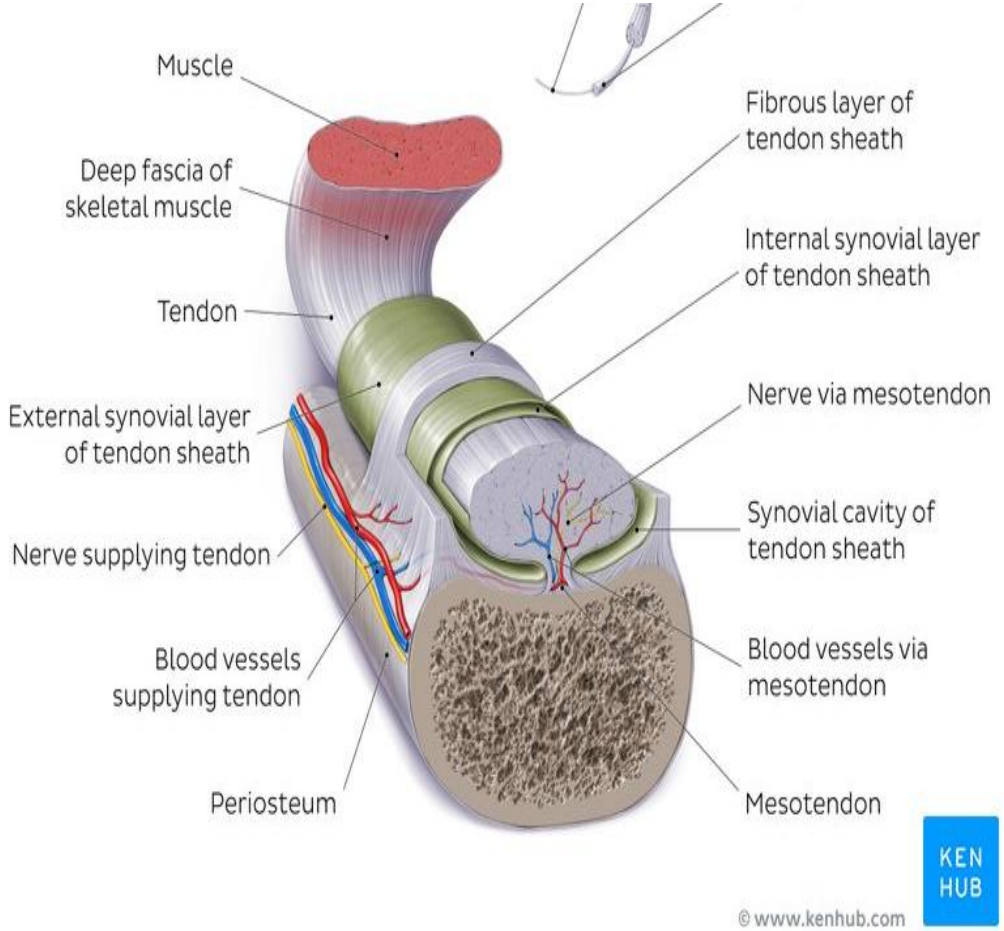
These structures are usually found between bone and other tissues, such as skin, tendons, muscles, and ligaments.

Bursae function to cushion the movement between these structures as they rub together.

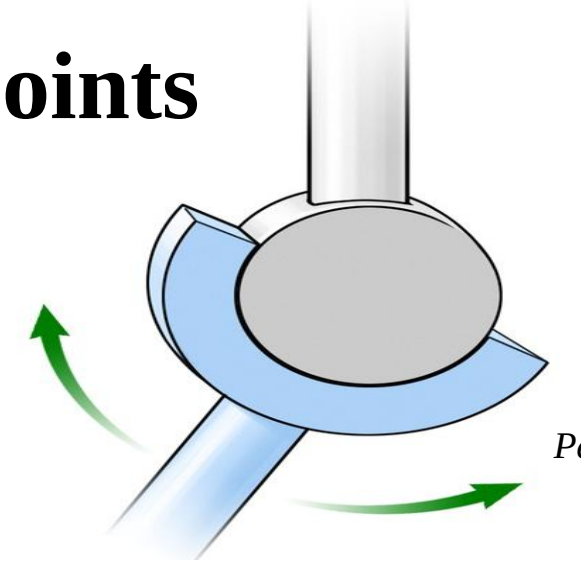




A **tendon sheath** is a membrane that wraps around a tendon, which allows the tendon to stretch and prevents it from adhering to the overlying fascia. This sheath also produces a **synovial fluid**, which keeps the tendon moist and lubricated.



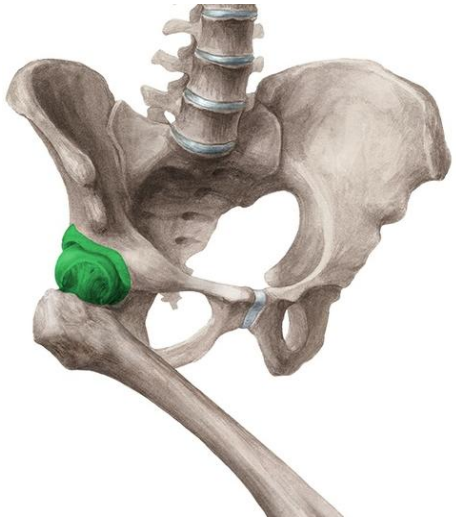
Synovial joints

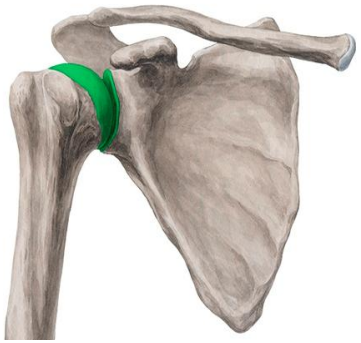


Permits flexion and extension only

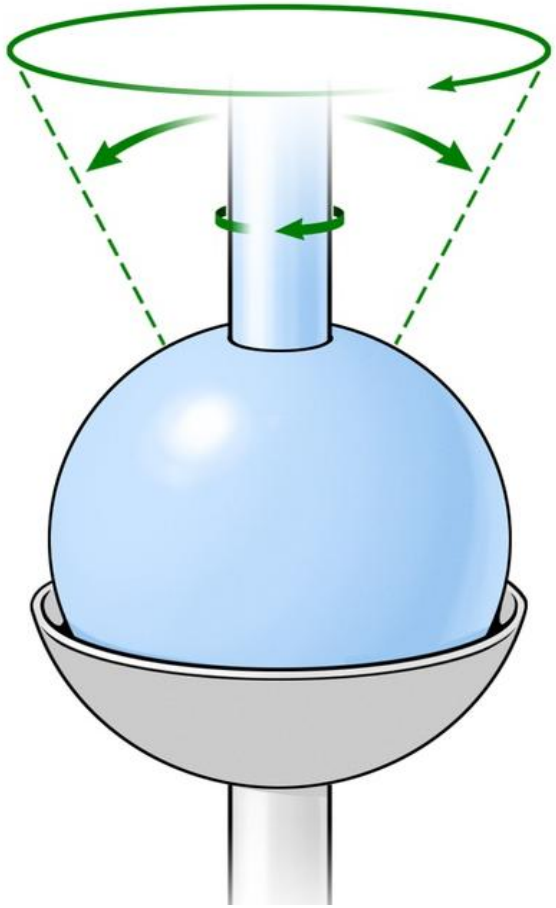
Hinge Joint (Uniaxial)

Example: elbow and knee joints





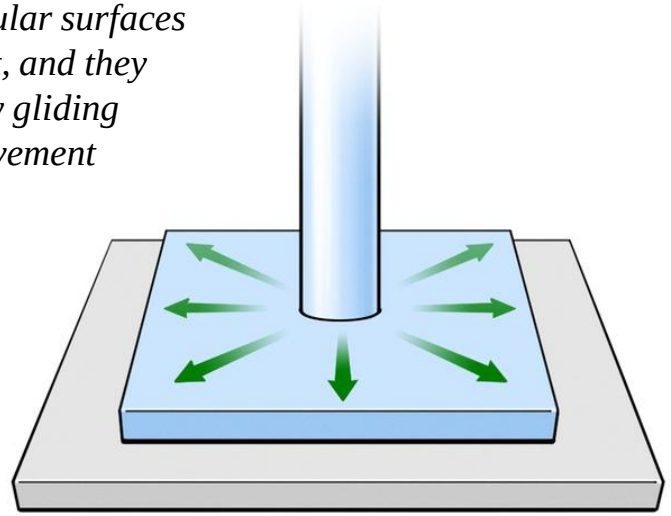
Spherical or hemispherical head of one bone articulates with the cuplike socket of another



Ball and Socket Joint (Multiaxial)

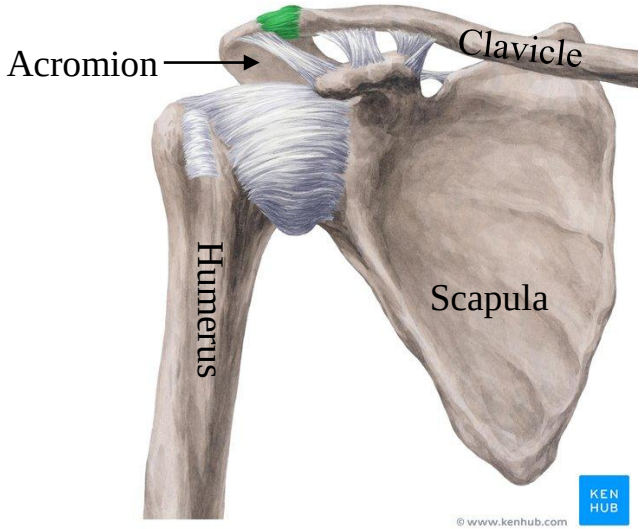
Example: shoulder and hip joints

The articular surfaces are flat, and they allow gliding movement

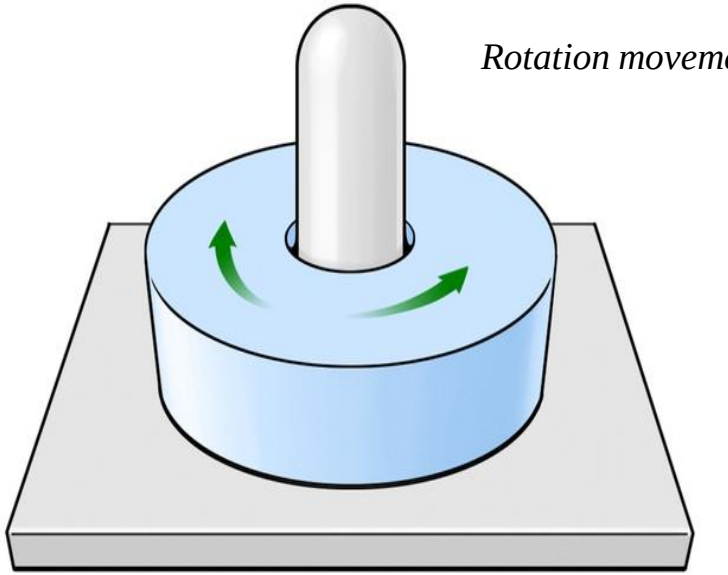


Gliding (plane) Joint (Uniaxial)

Example: acromioclavicular joint

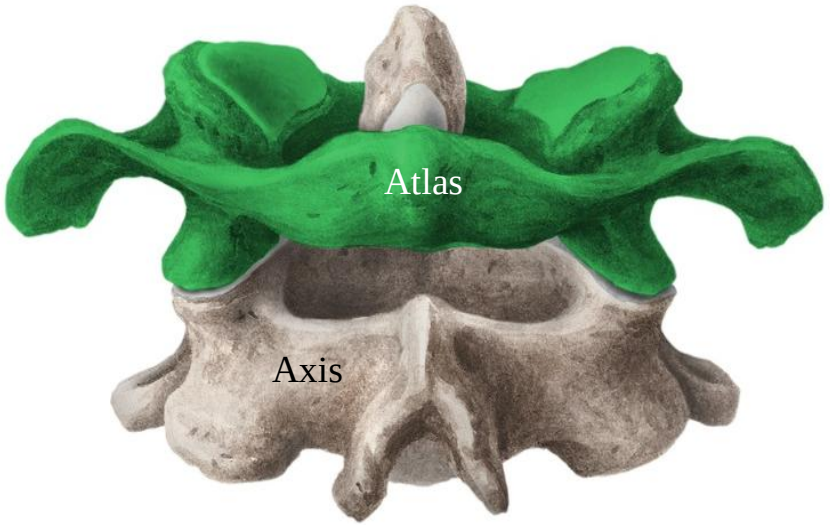


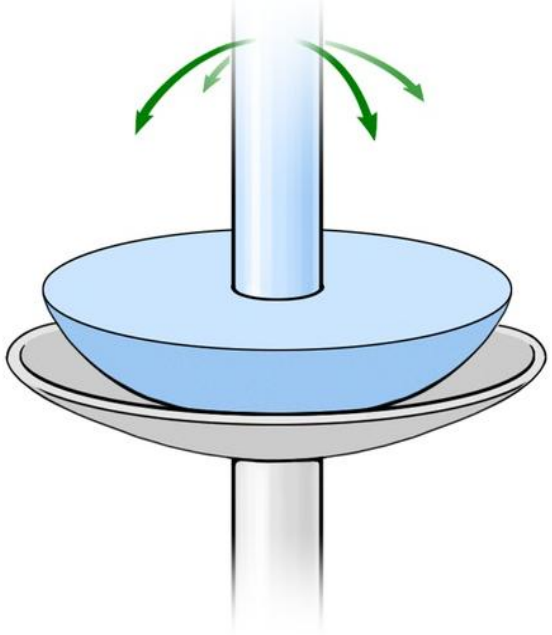
Rotation movement



Pivot Joint (Uniaxial)

Example: atlanto-axial joint, proximal & distal radioulnar joints

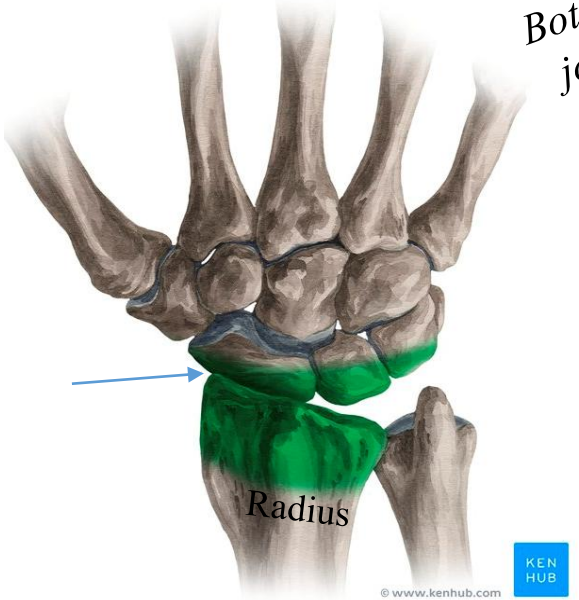




A **condyloid joint** has an oval-shaped, convex surface of one bone that fits into a corresponding oval-shaped concave surface of the other bone.

Ellipsoid (condyloid) Joint (Biaxial)

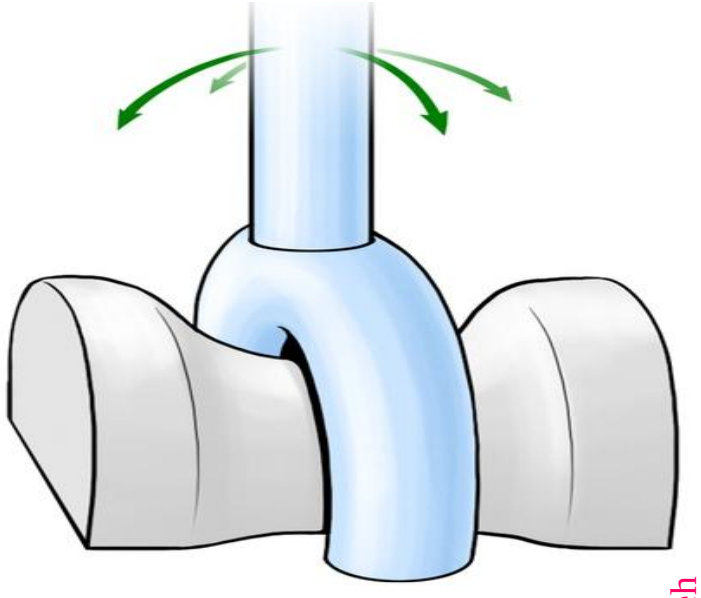
Example: wrist joint



Both condyloid and saddle joints have concave and convex articular areas. Both permit flexion/extension, abduction/adduction & circumduction. However, condyloid joints have slightly more limited range of motion compared to saddle joints.

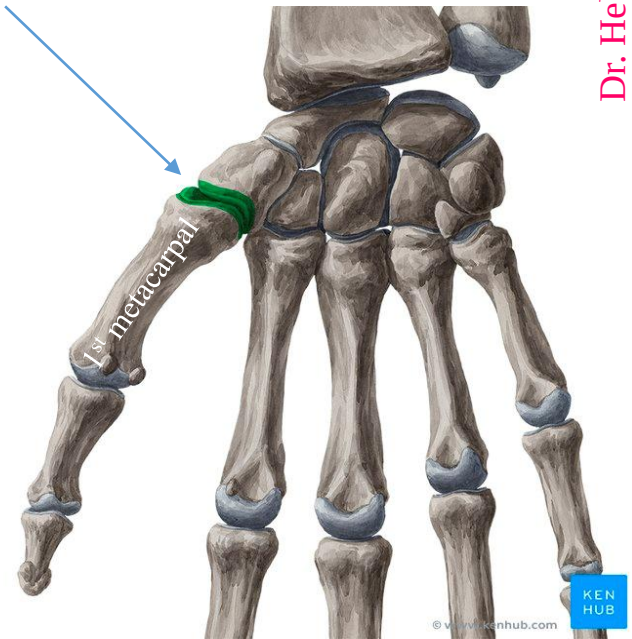
A **saddle joint** is shaped like a **saddle**, where one bone has a concave surface and the other has a convex surface.

The two bones fit together like a rider sitting on a saddle, allowing them to move in multiple directions.



Saddle Joint (Biaxial)

Example: carpometacarpal joint of thumb

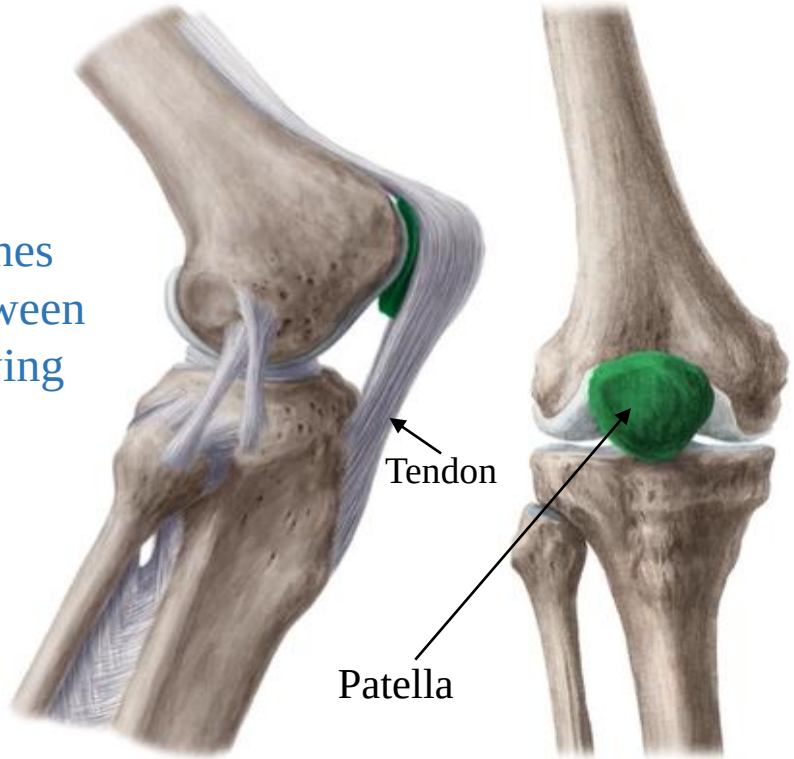


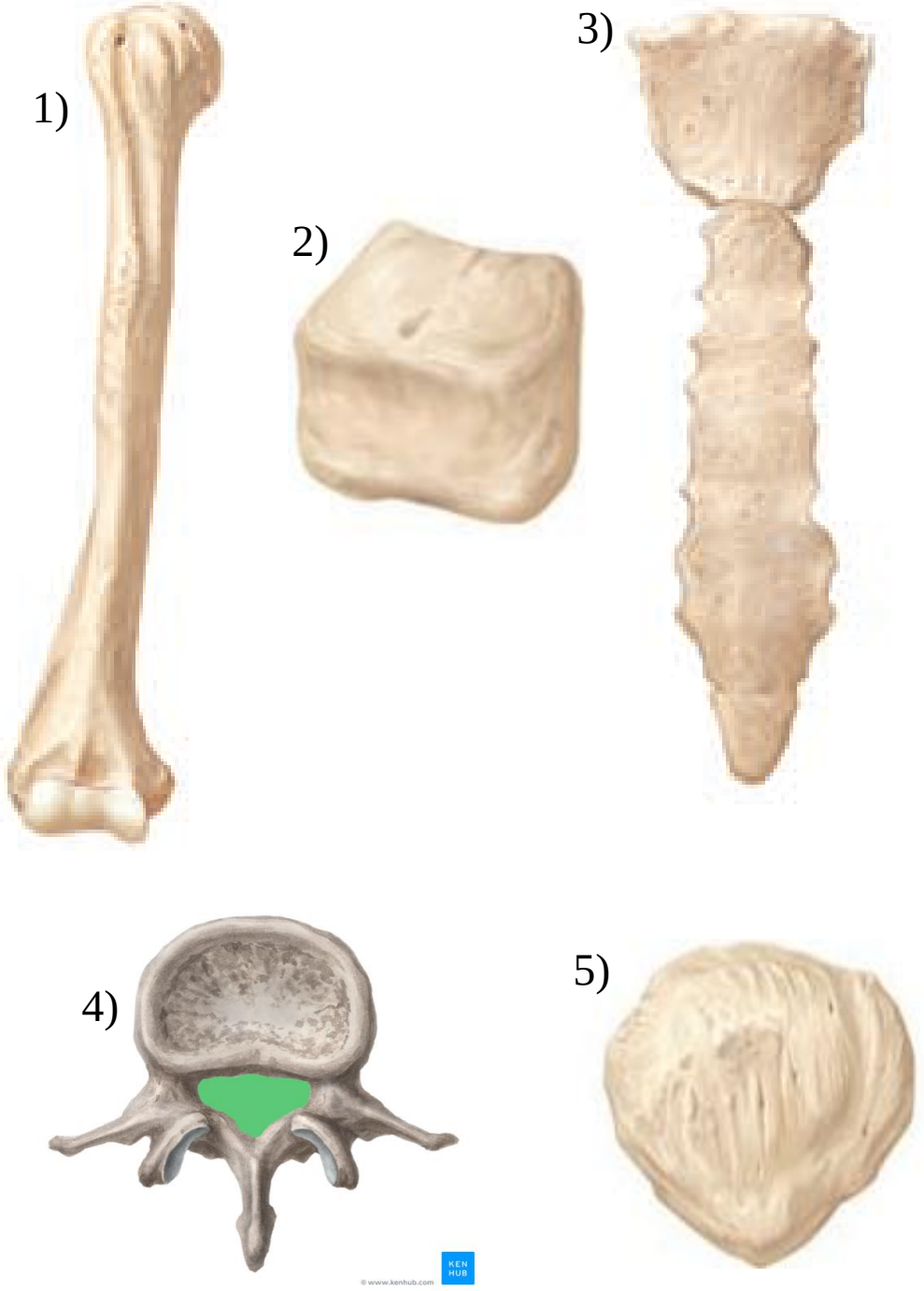
Dr. Heba Kalbouneh

TYPES OF BONES

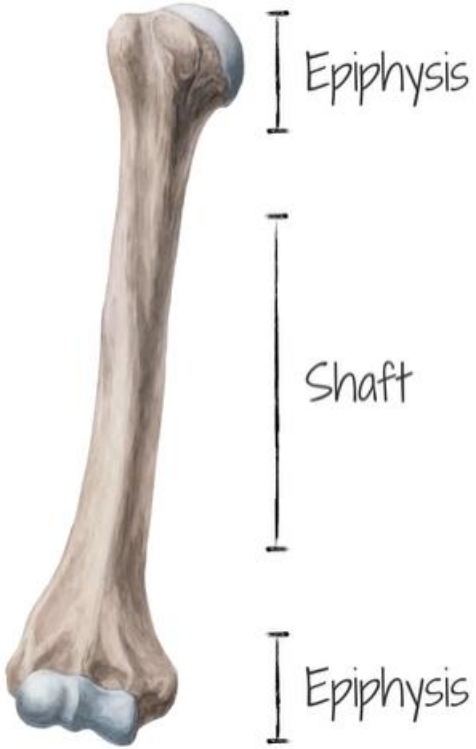
1) **Long bones:** Humerus, ulna, radius, femur
2) **Short bones:** Carpal (wrist) bones and most tarsal (ankle) bones
3) **Flat bones:** Cranial bones, sternum and ribs, and the scapulae
4) **Irregular bones:** Vertebrae, certain facial bones, and the calcaneus
5) **Sesamoid bones:** Patellae (kneecap)

Note: Sesamoid bones diminish friction between tendons and underlying bones.





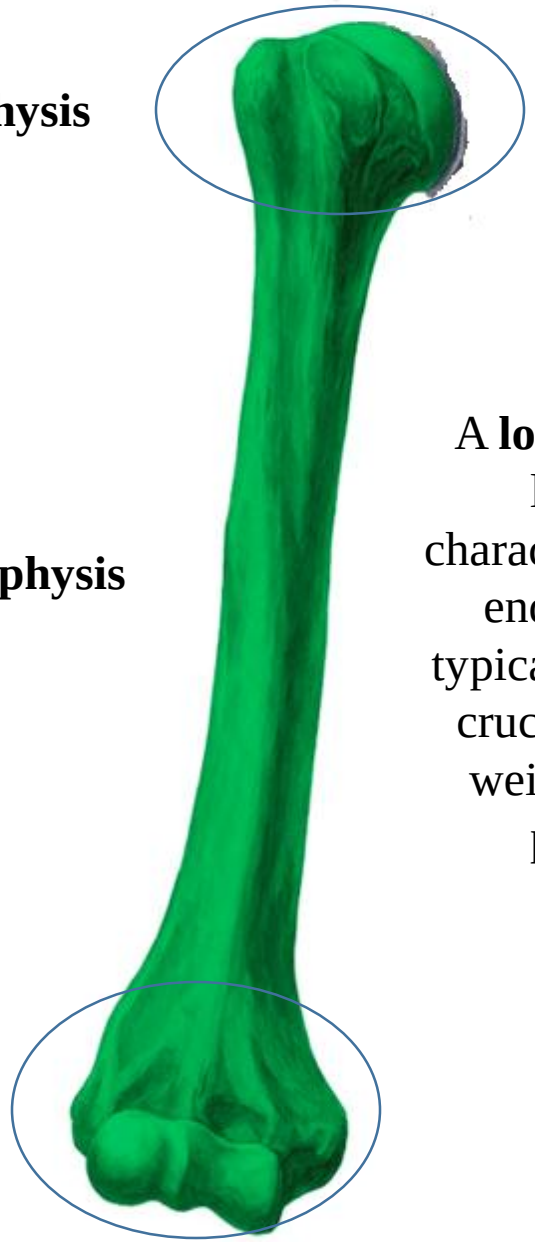
Dr. Heba Kalbouneh



Head, Proximal end, Epiphysis

Shaft , Body, Diaphysis

Distal end, Epiphysis



Long Bones

A **long bone** is a type of bone that is longer than it is wide, with a characteristic **shaft** (diaphysis) and two ends (epiphyses). Long bones are typically found in the **limbs** and play a crucial role in supporting the body's weight, facilitating movement, and providing structural support.

Bones of The Upper Limb

- **Shoulder girdle:**

Clavicle

Scapula

- **Arm:**

Humerus

- **Forearm:**

Ulna (M)

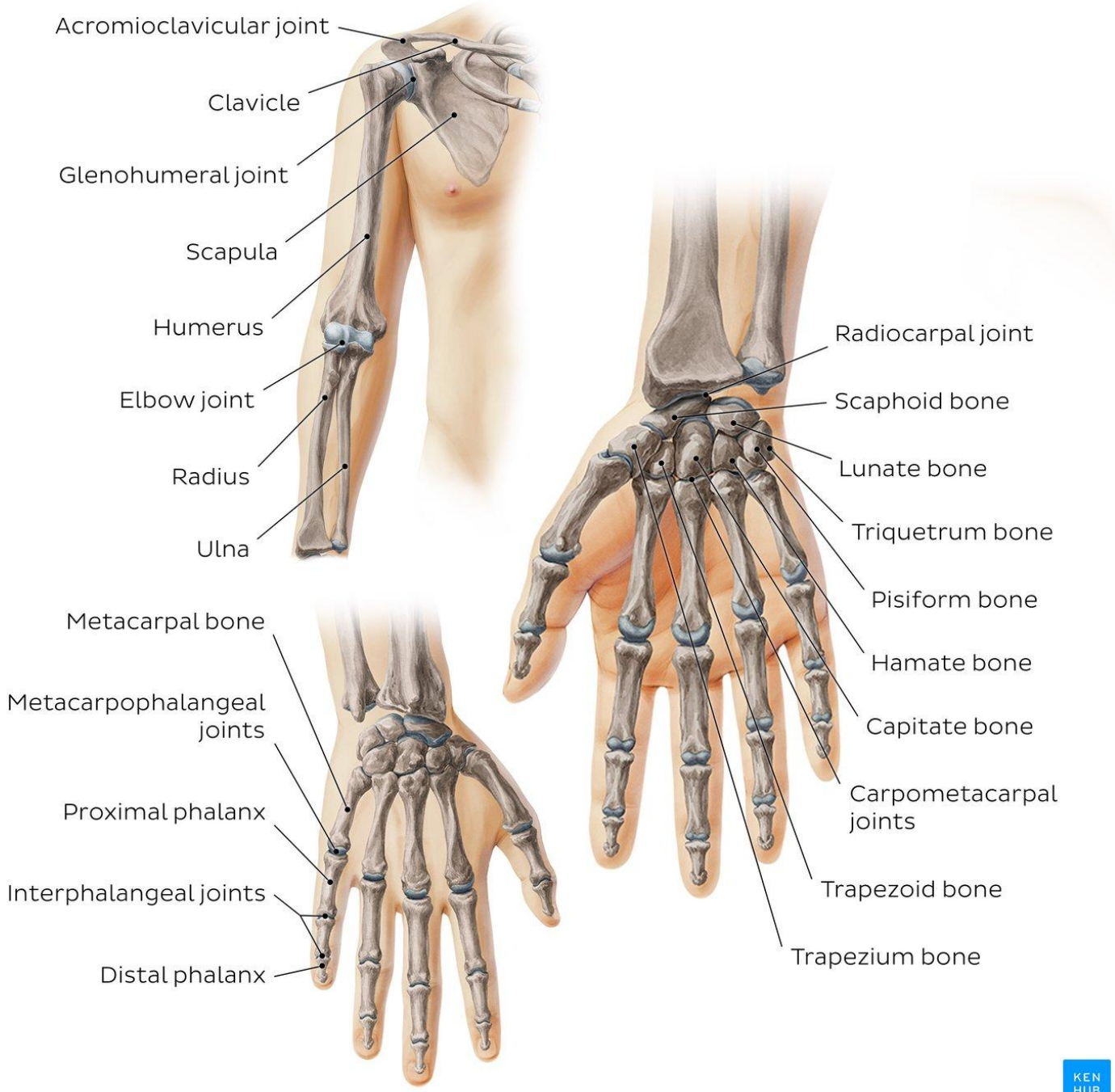
Radius (L)

- **Hand: (27 bones)**

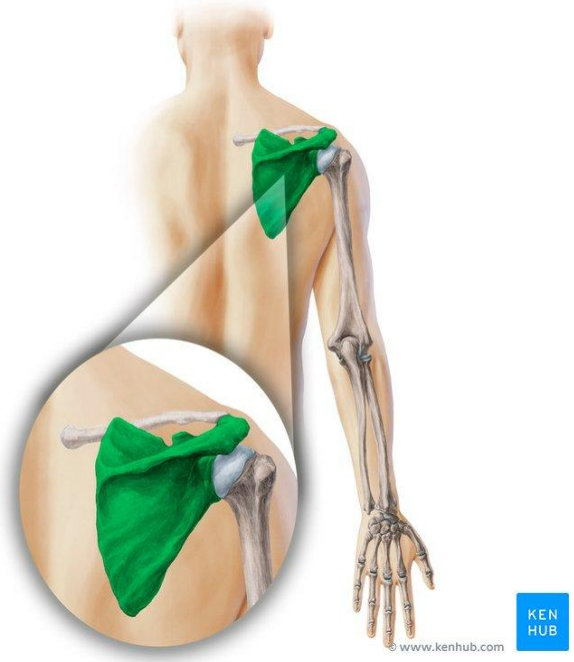
Carpal bones (8)

Metacarpals (5)

Phalanges (14)

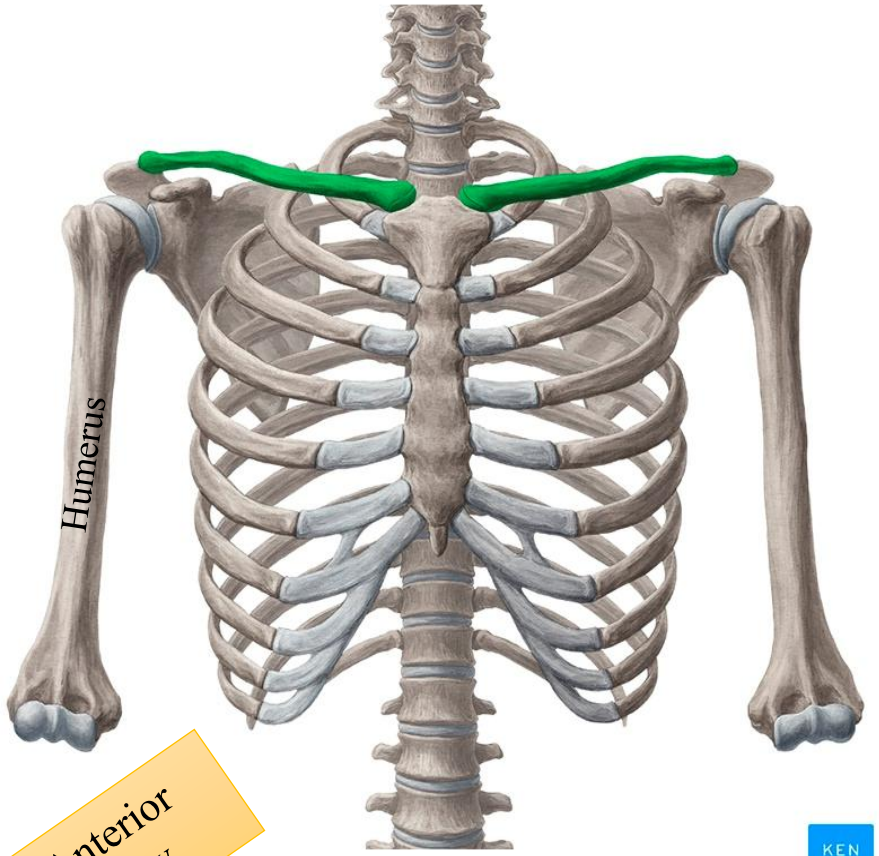


Scapula لوح الكتف



Posterior view

Clavicle الترقوة



Anterior view

Dr. Heba Kalbouneh

Clavicle

- ✓ The clavicle is a long, slender bone that lies horizontally across the root of the neck just beneath the skin.
- ✓ It articulates with the sternum and first costal cartilage **medially** and with the acromion process of the scapula **laterally**.
- ✓ The clavicle acts as a strut that holds the arm away from the trunk. It also transmits forces from the upper limb to the axial skeleton and provides attachment for muscles.

It consists of three main parts: the shaft, sternal end, and acromial end.

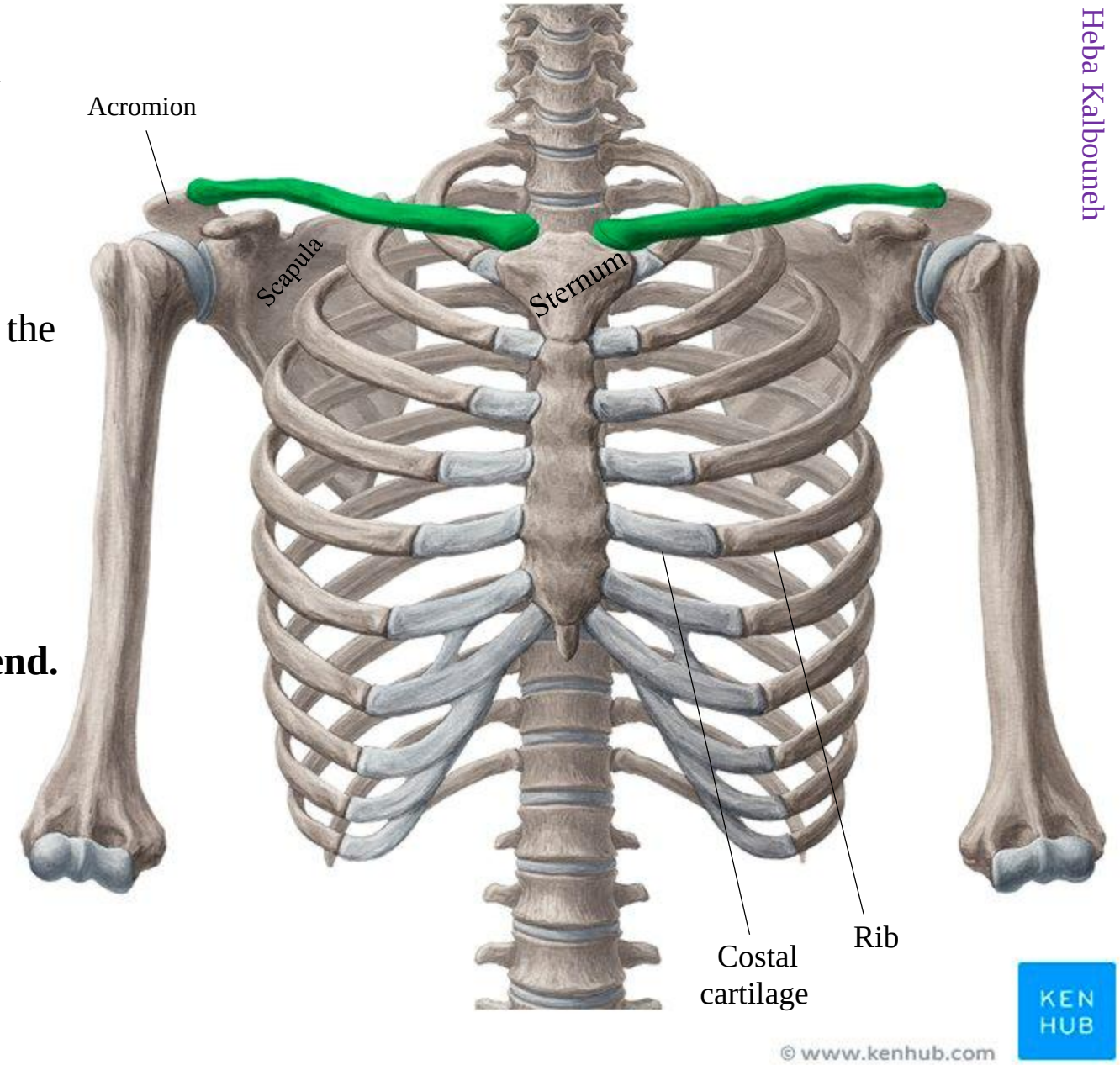
The 2 ends are **medial (sternal) end** & **lateral (acromial) end.**

- ✓ Medial end is **bulky**
- ✓ Lateral end is **flat**

The shaft:

• It has 2 surfaces (upper & lower) & 2 borders (anterior & posterior).

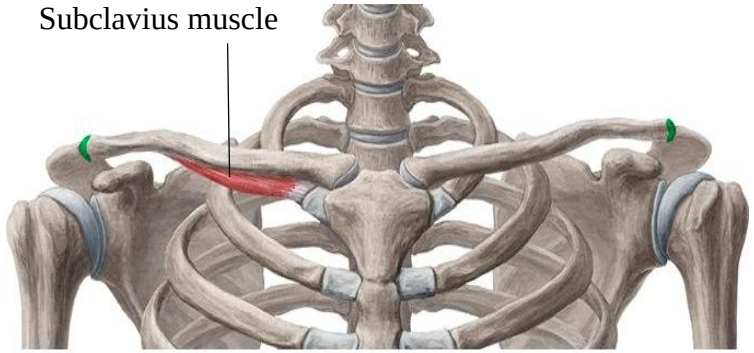
• Its medial 2/3 are convex anteriorly and its lateral 1/3 is convex posteriorly.



Dr. Heba Kalbouneh

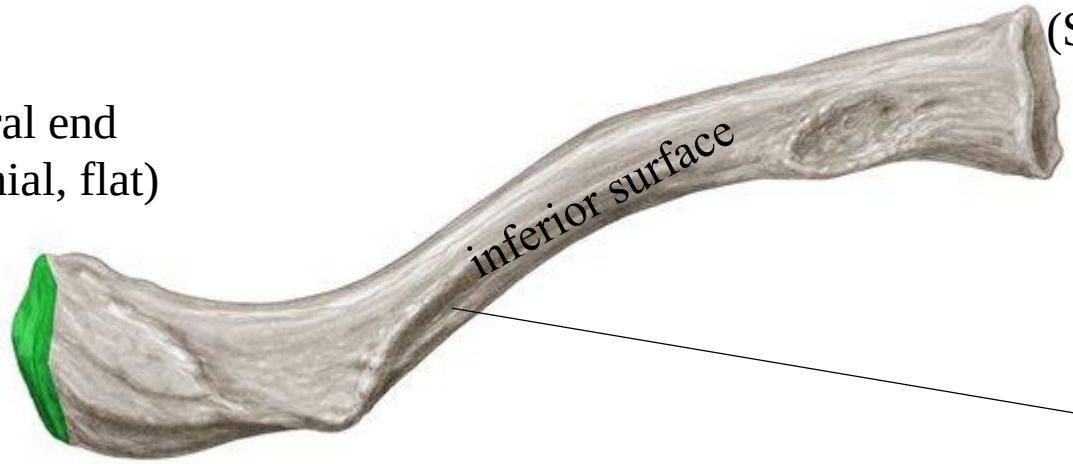
Lateral end
(Acromial, flat)

Medial end
(Sternal, bulky)



Medial end
(Sternal, bulky)

Lateral end
(Acromial, flat)

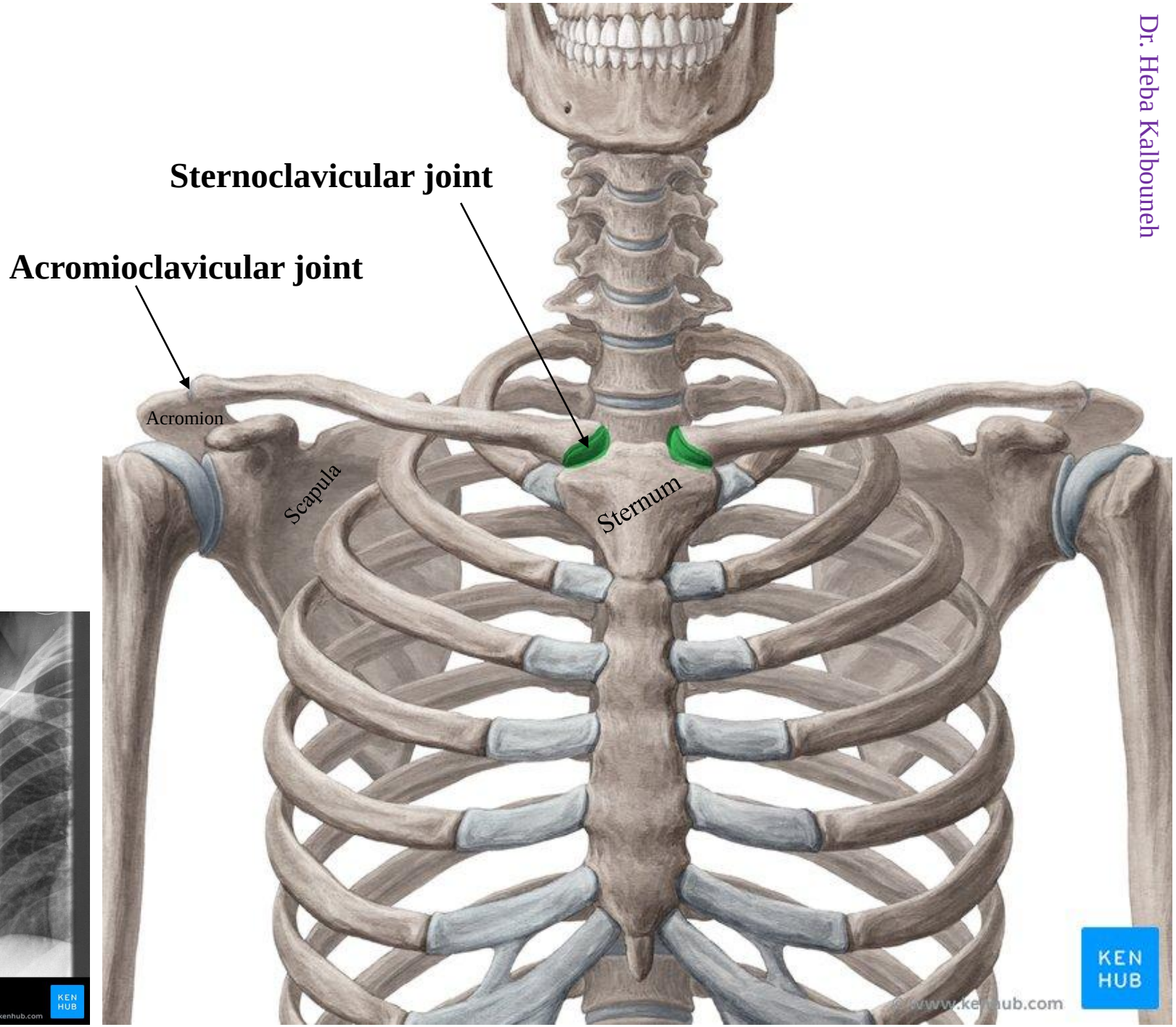


The superior surface of the clavicle is generally smooth and lies just deep to the skin. In contrast, its inferior surface is rough, contains **subclavius groove**

Articulation of clavicle

1-Sternoclavicular joint
is formed between the medial aspect of the clavicle and the manubrium of the sternum.
Type: Synovial plane joint.

2- Acromioclavicular joint
is formed between the lateral aspect of clavicle and the acromion process of scapula
Type: Synovial plane joint.



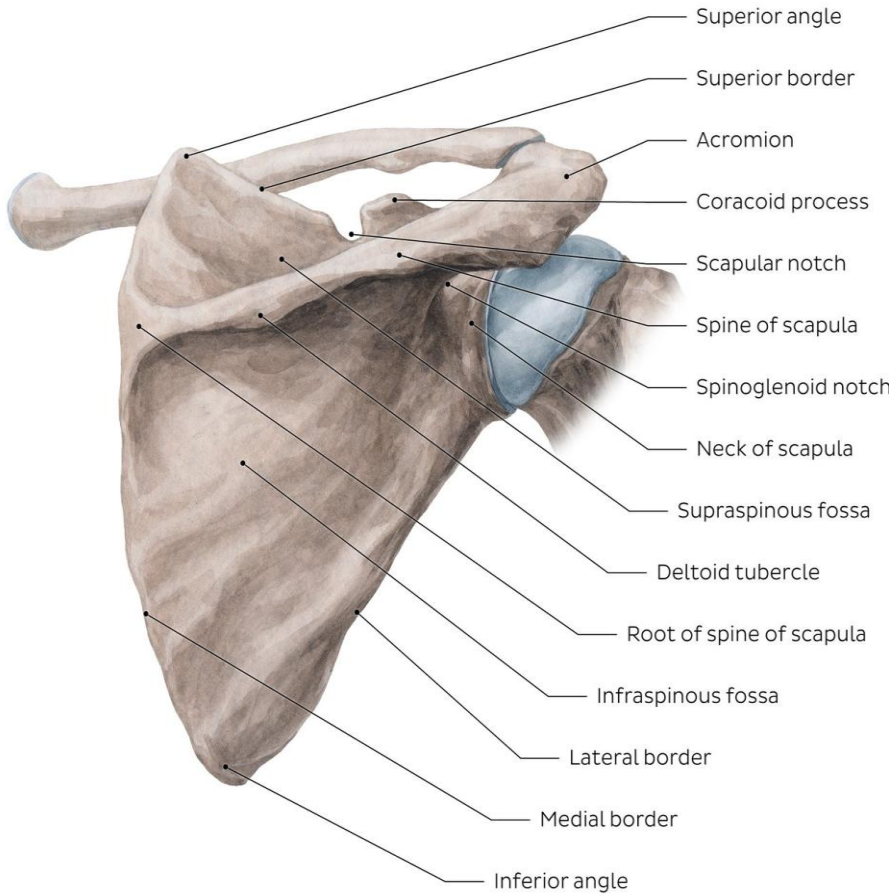
Applied anatomy:
Clavicle is the commonest bone to be fractured in the upper limb

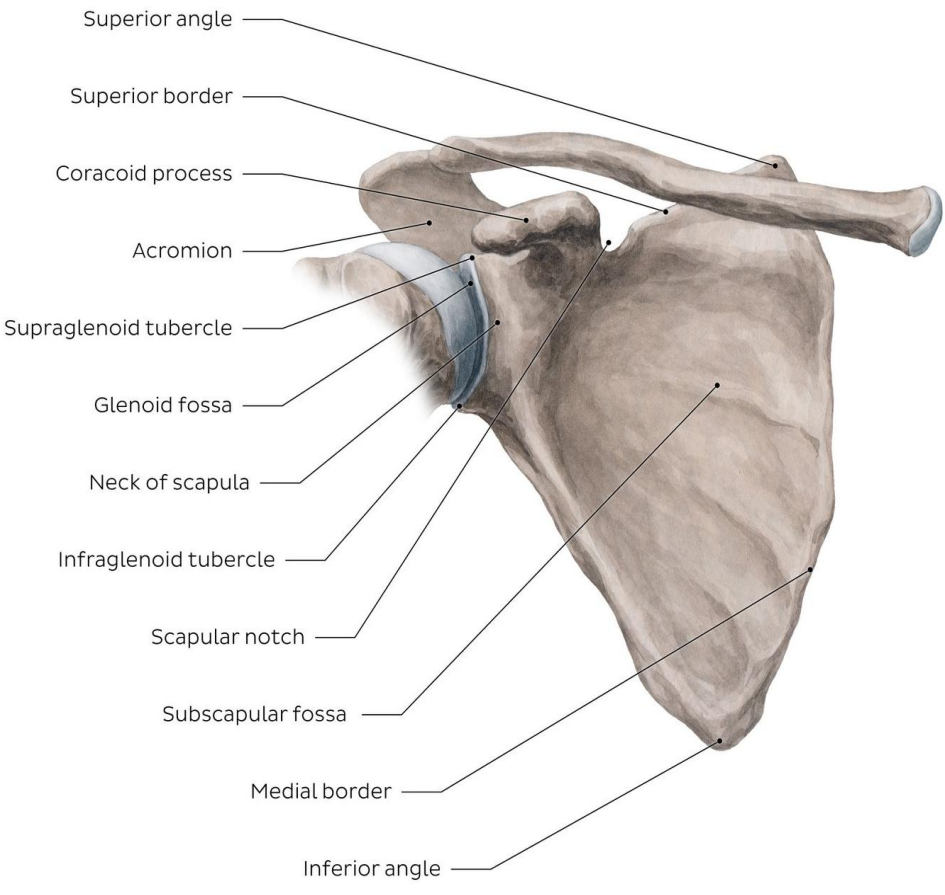
The middle 1/3 is the commonest site to be fractured.

Dr. Heba Kalbouneh

Scapula

- ✓ The scapula is a flat triangular bone that lies on the posterior chest wall **between the second and the seventh ribs.**
- ✓ On its posterior surface, the spine of the scapula projects backward. The lateral end of the spine is free and forms the **acromion**, which articulates with the clavicle.

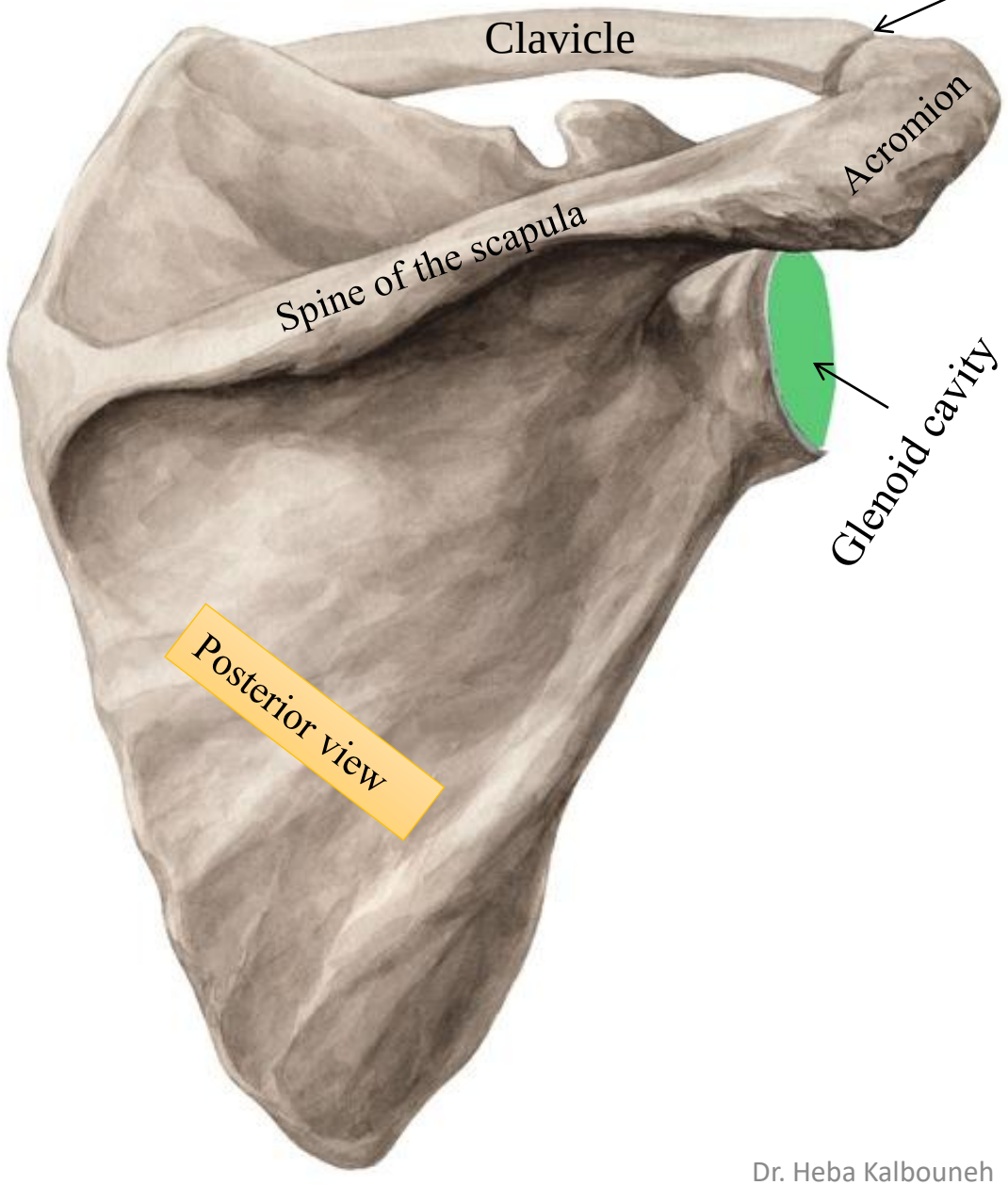


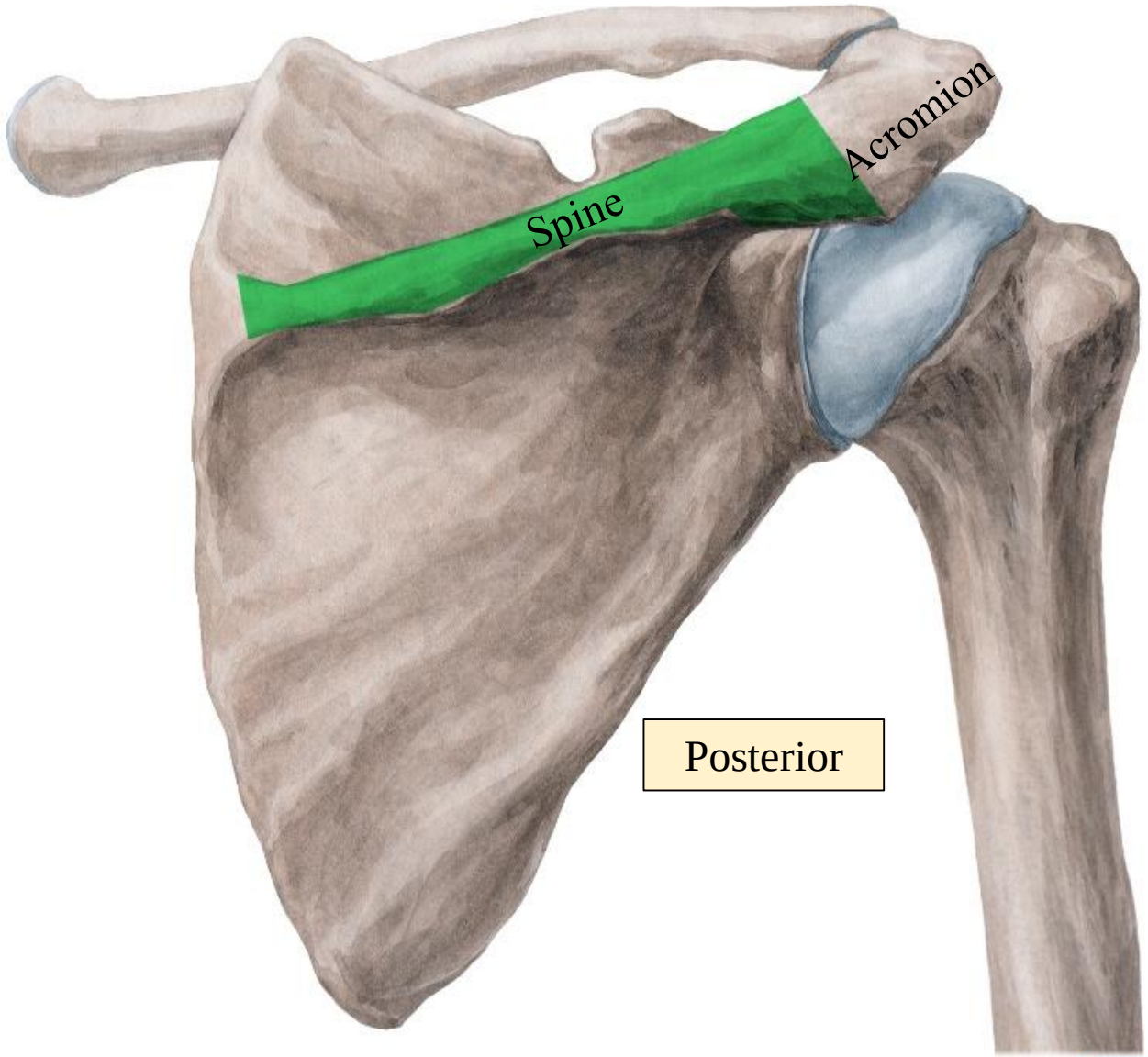


- ✓ The lateral angle of the scapula forms the pear-shaped **glenoid cavity, or fossa**, which articulates with the head of the humerus at the shoulder joint.
- ✓ The **coracoid** process projects upward and forward above the glenoid cavity. Medial to the base of the coracoid process is the suprascapular notch.
- ✓ The inferior angle of the scapula can be palpated easily in the living subject and **marks the level of the seventh rib and the spine of the seventh thoracic vertebra.**

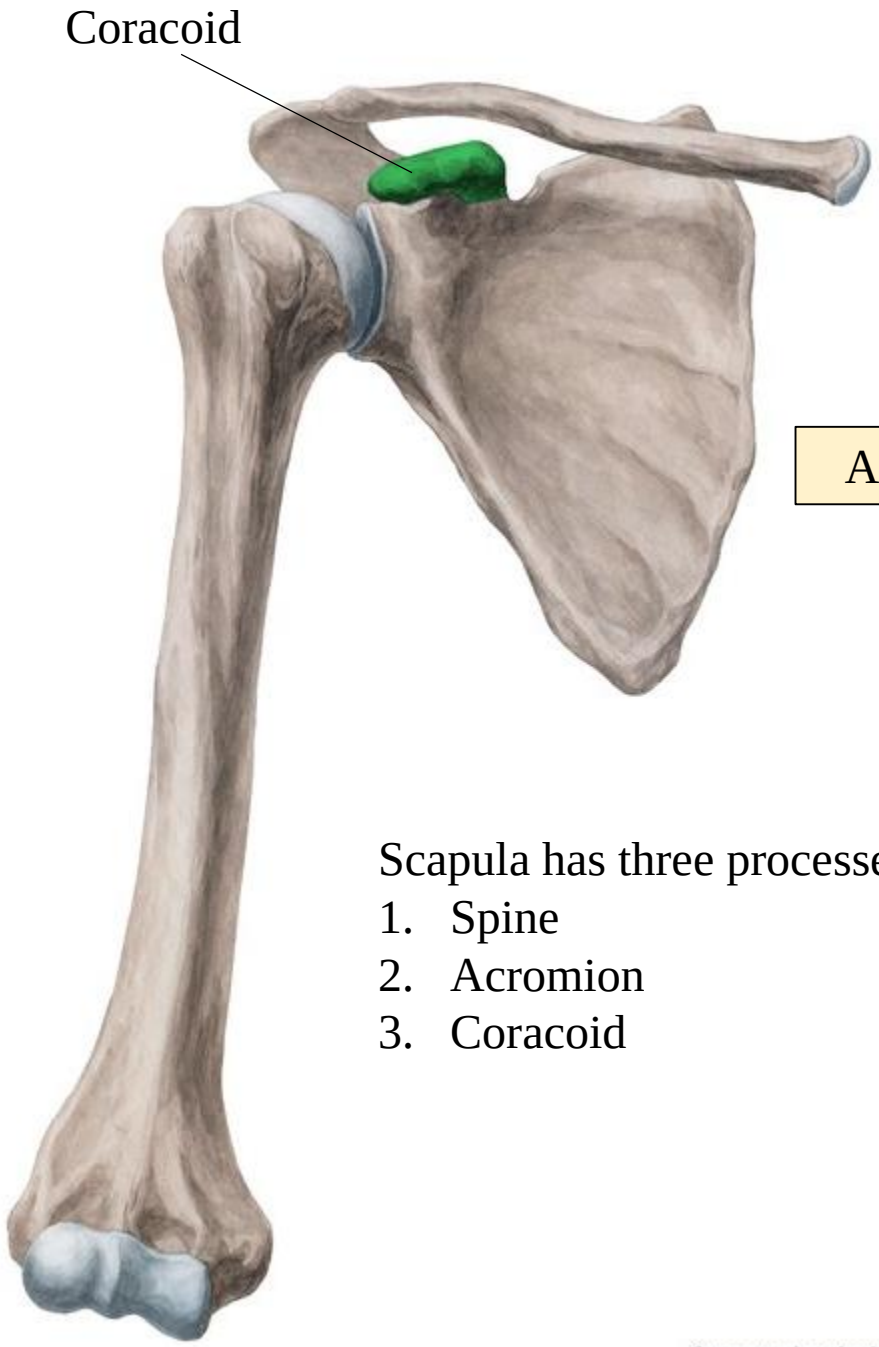
Dr. Heba Kalbouneh

Scapula articulates with the head of humerus at **Shoulder joint** (glenohumeral joint) and with the clavicle at **acromioclavicular joint**





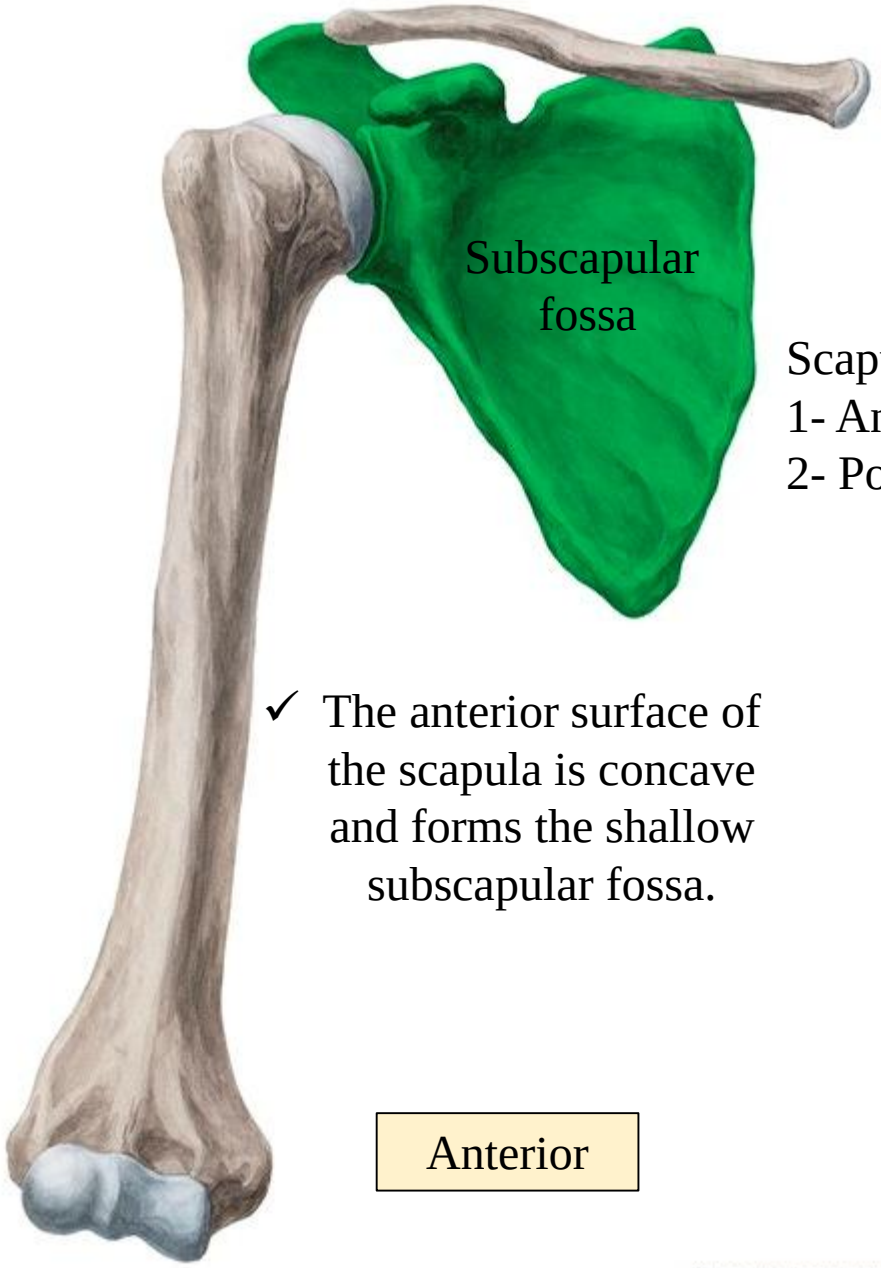
Posterior



Anterior

Scapula has three processes:

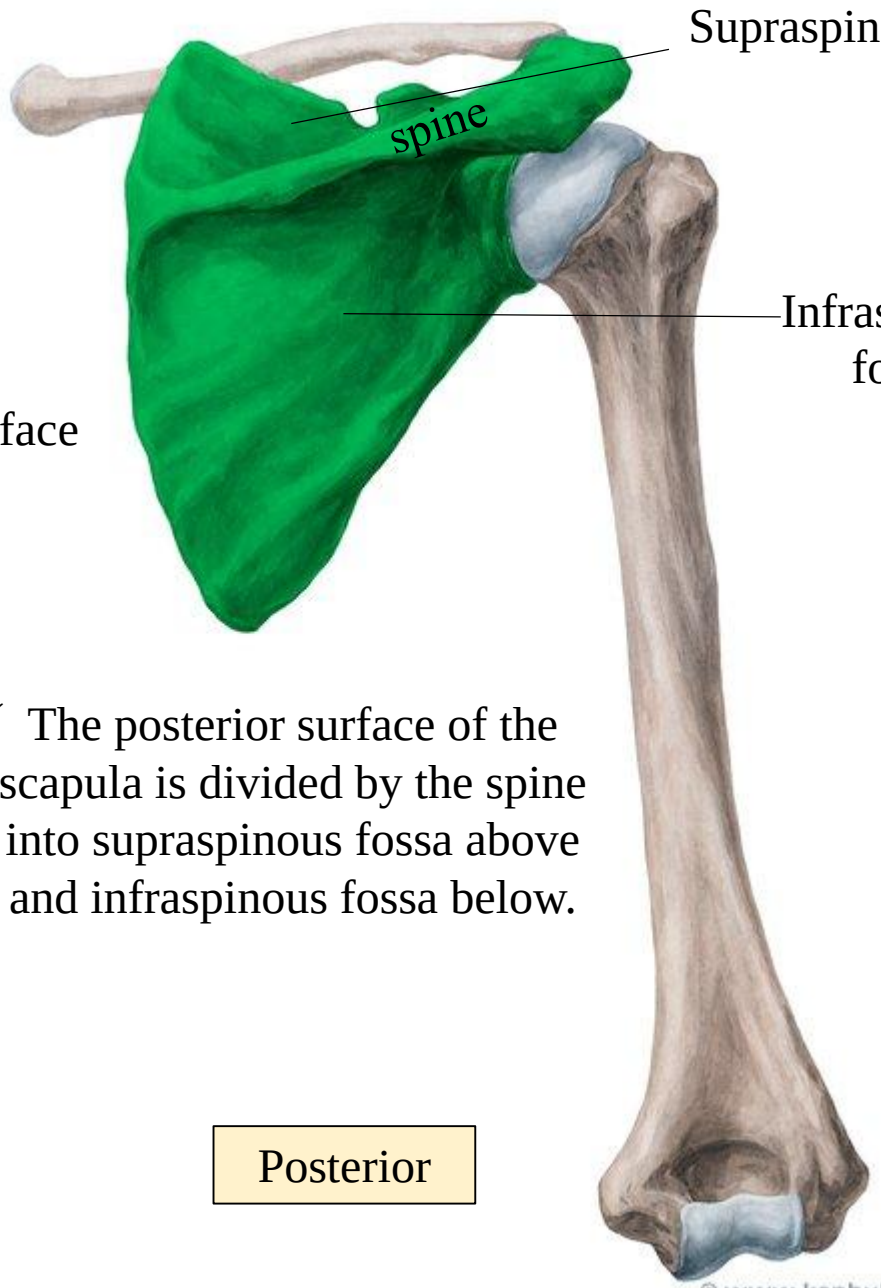
1. Spine
2. Acromion
3. Coracoid



Scapula has 2 surfaces:
1- Anterior (ventral or costal) surface
2- Posterior (dorsal) surface

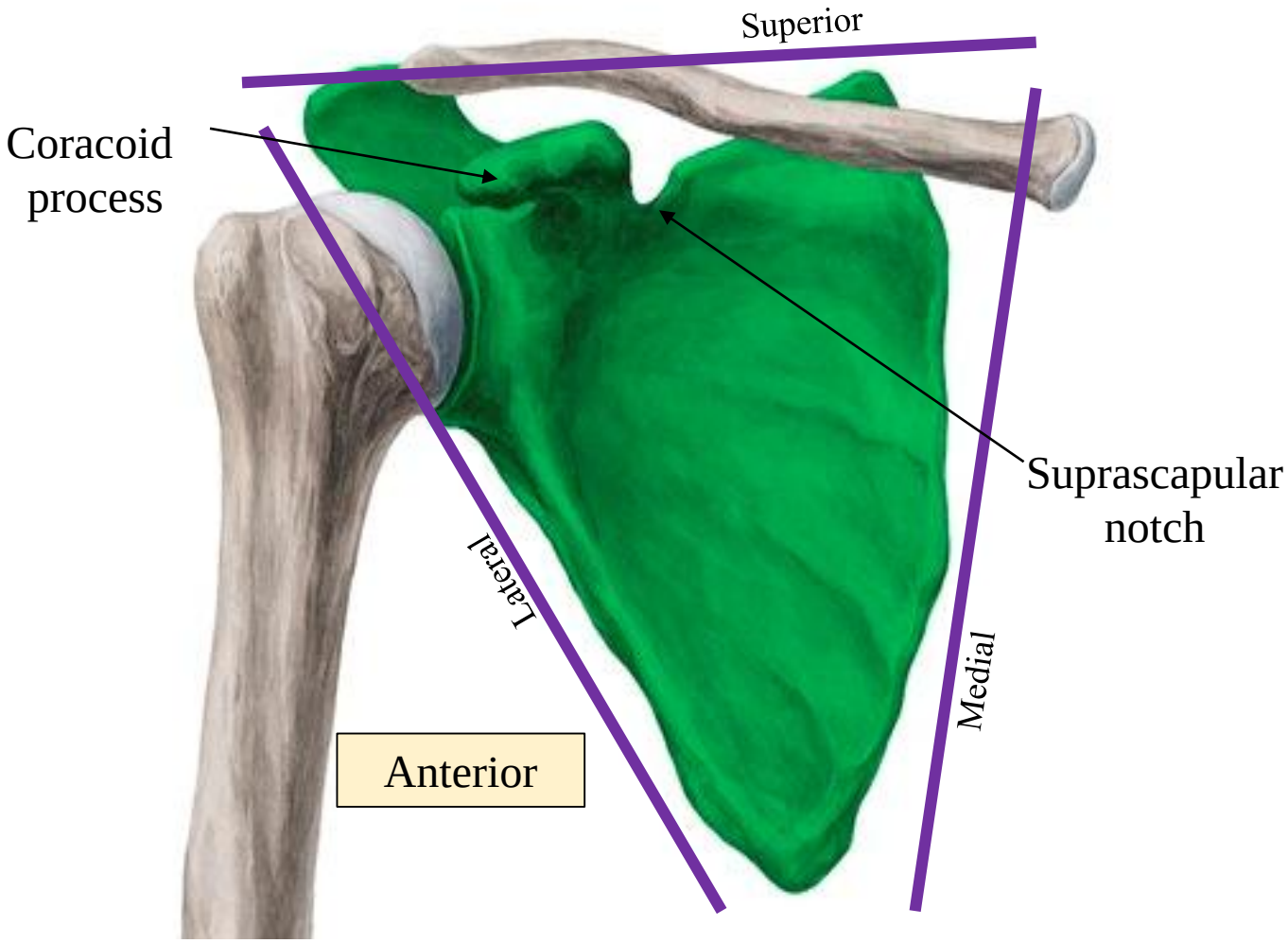
✓ The anterior surface of the scapula is concave and forms the shallow subscapular fossa.

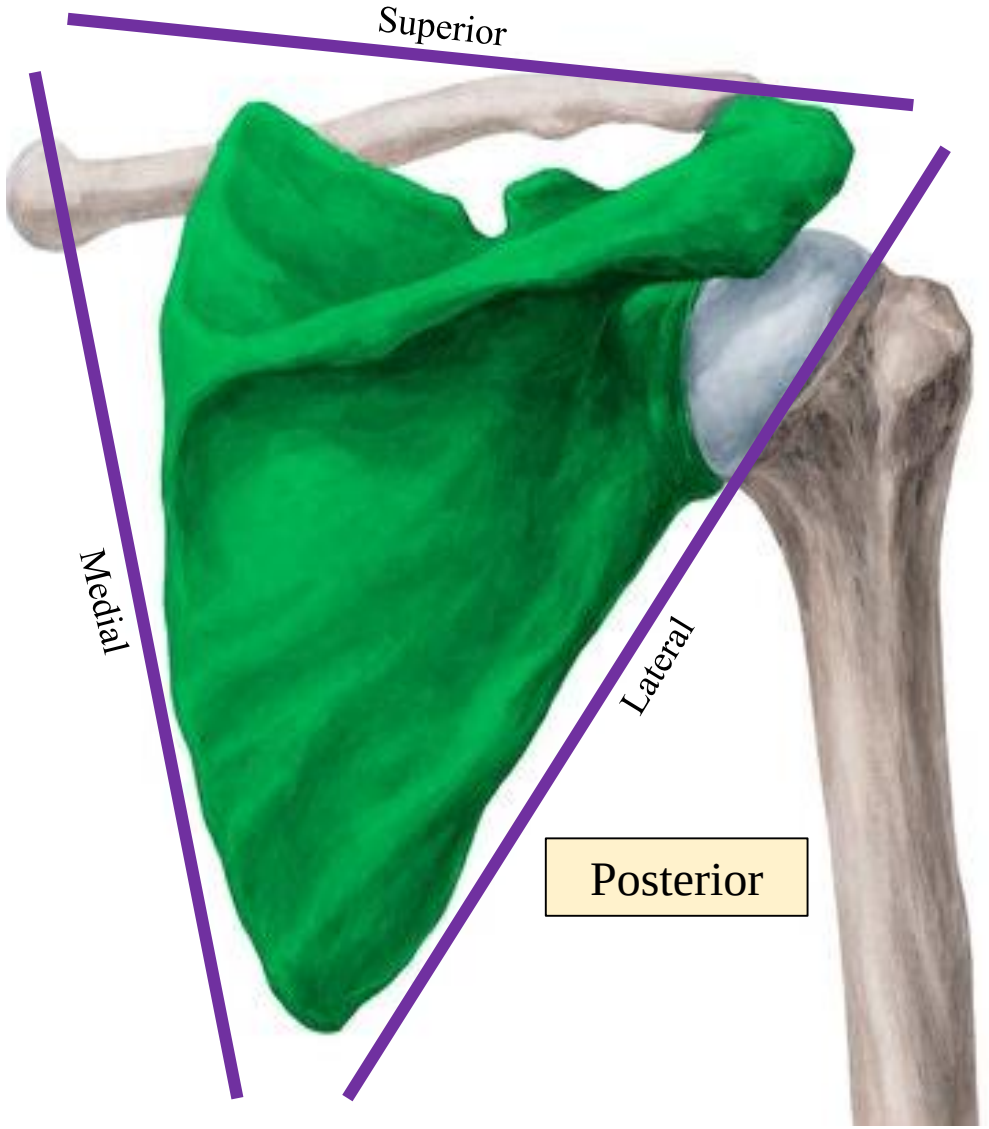
Anterior



✓ The posterior surface of the scapula is divided by the spine into supraspinous fossa above and infraspinous fossa below.

Posterior





Scapula has three borders:

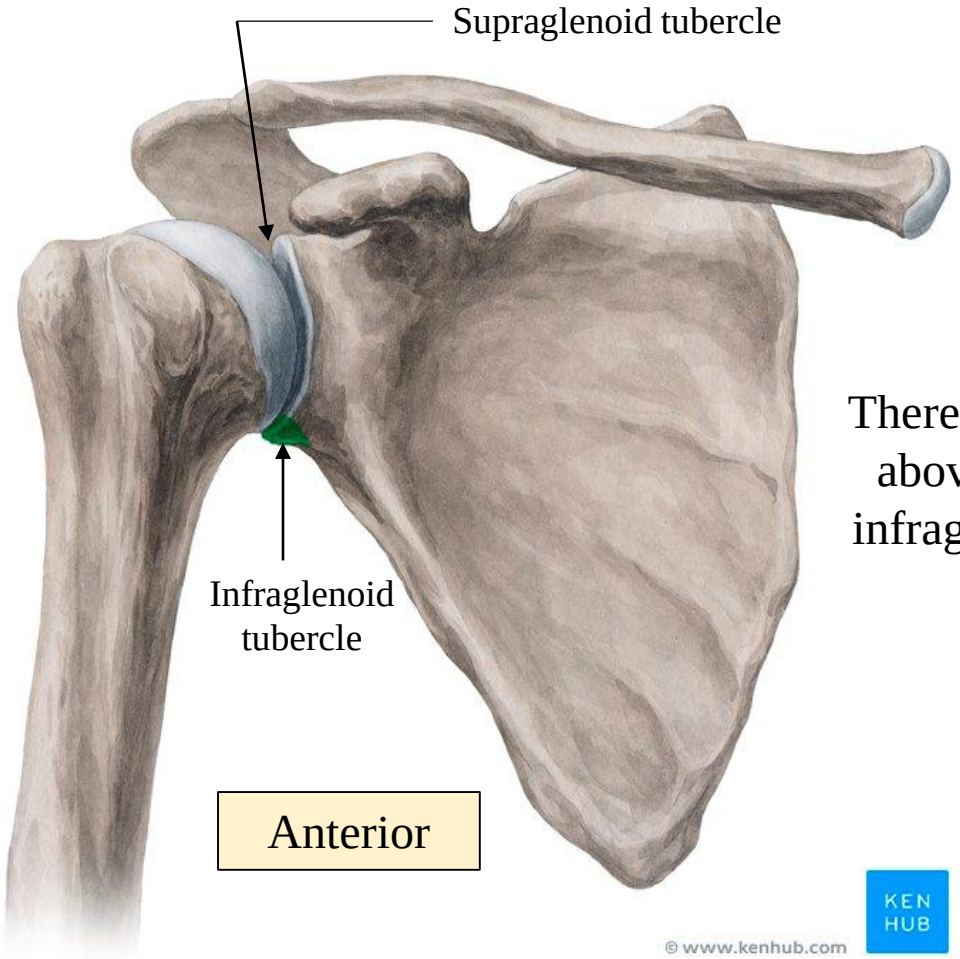
A. Medial (vertebral)

B. Lateral

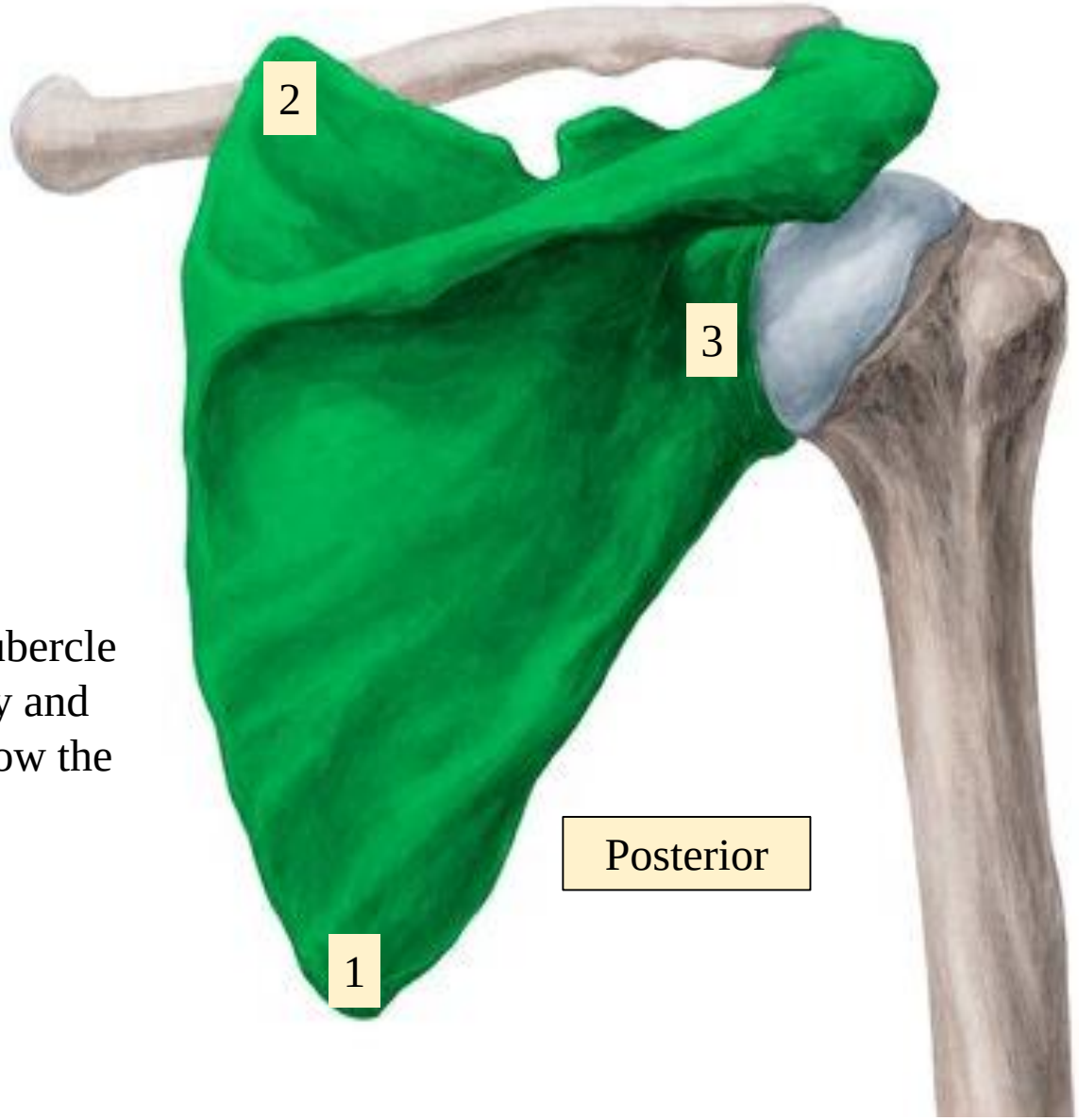
C. Superior (which presents the supra-scapular notch and lateral to it is the coracoid process).

Scapula has three angles :

1. Inferior at 7th Thoracic spine
2. Superior at 2nd thoracic spine
3. Lateral (glenoid cavity)



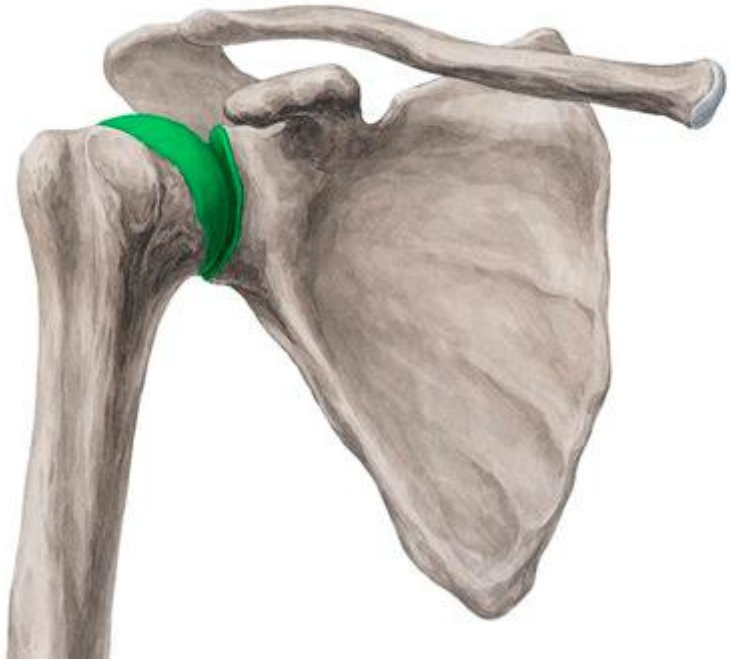
There are supraglenoid tubercle above the glenoid cavity and infraglenoid tubercle below the glenoid cavity .



Articulation of Scapula

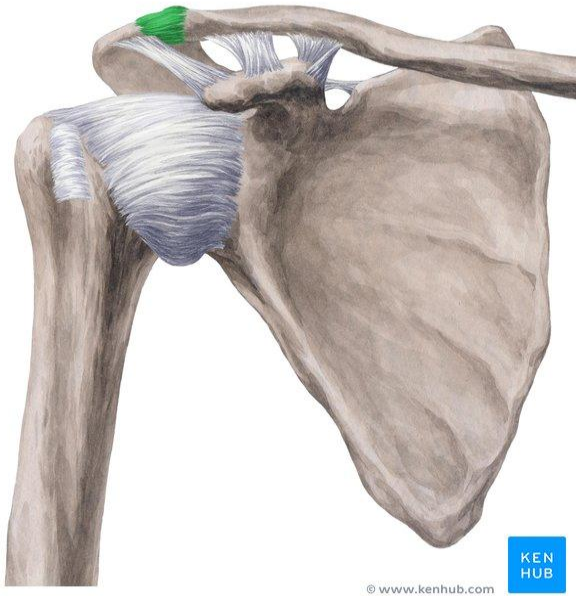
Dr. Heba Kalbouneh

1- Shoulder Joint (glenohumeral joint)
Is formed between the head of humerus and glenoid cavity of scapula
Type: Ball and socket synovial plane joint.



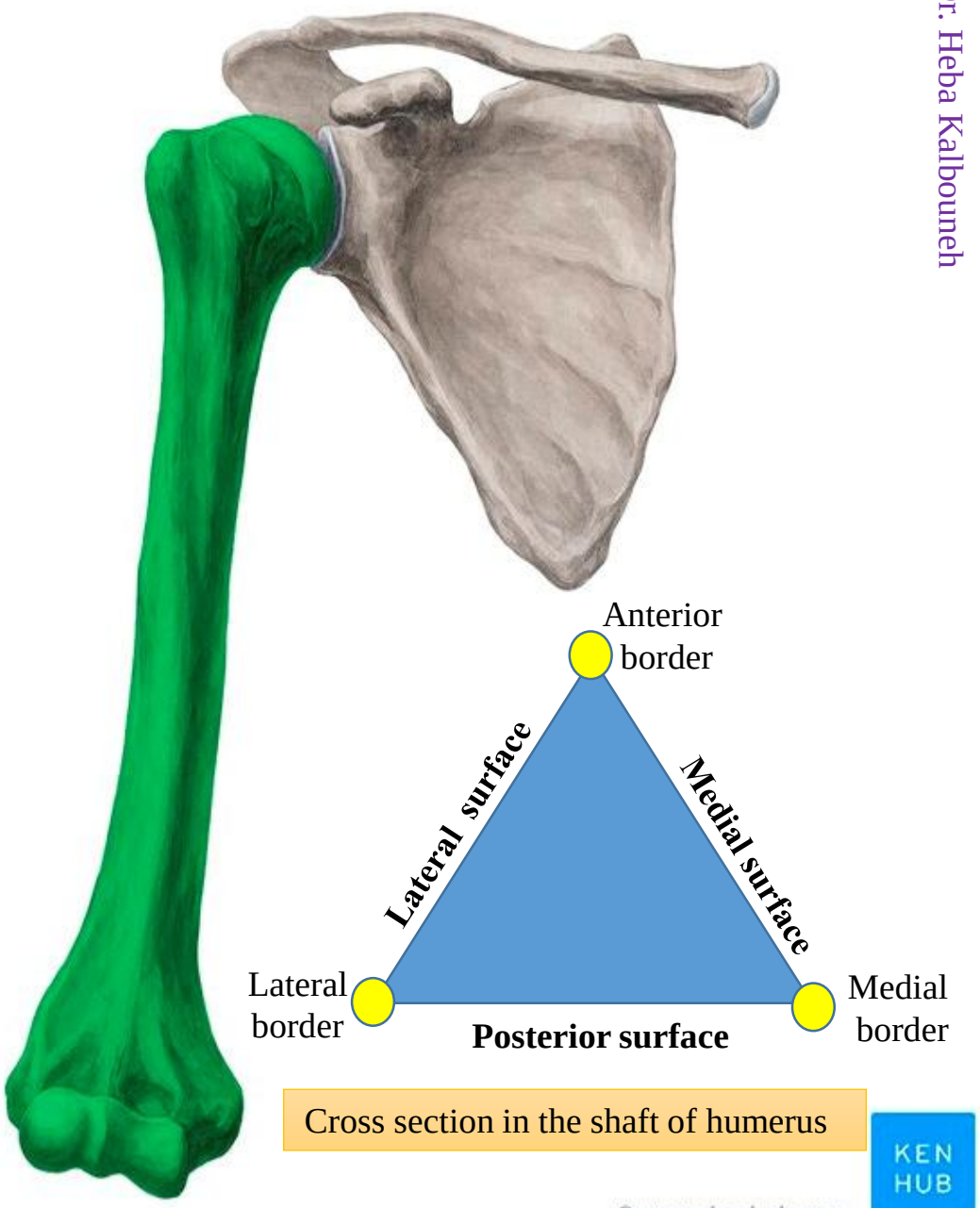
Moverments of shoulder OR arm
1. Flexion and extension
2. Abduction and adduction
3. Medial and lateral rotation
4. Circumduction

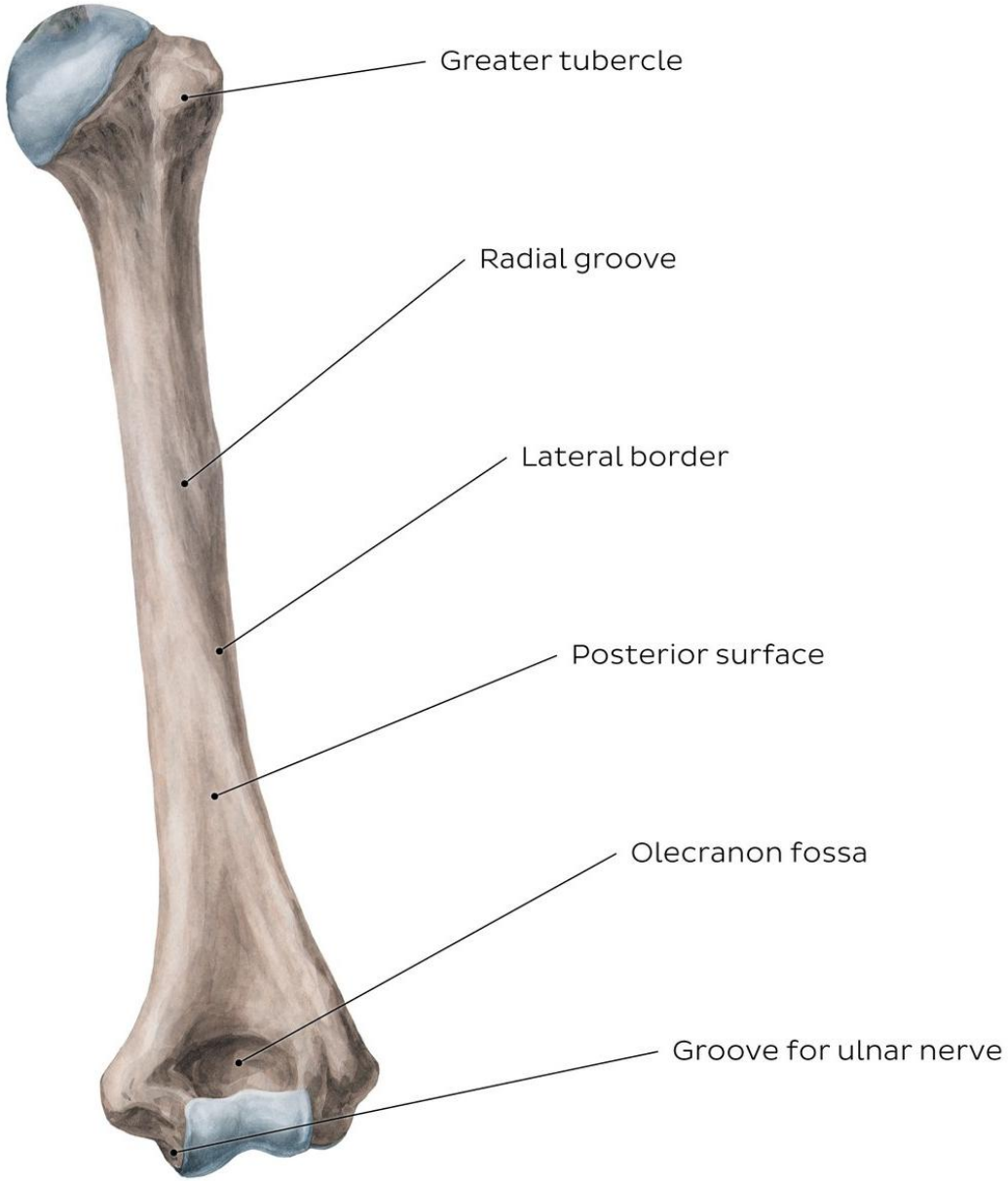
2- Acromioclavicular Joint
Is formed between the lateral end of the clavicle and acromion of scapula
Type: Synovial plane joint.

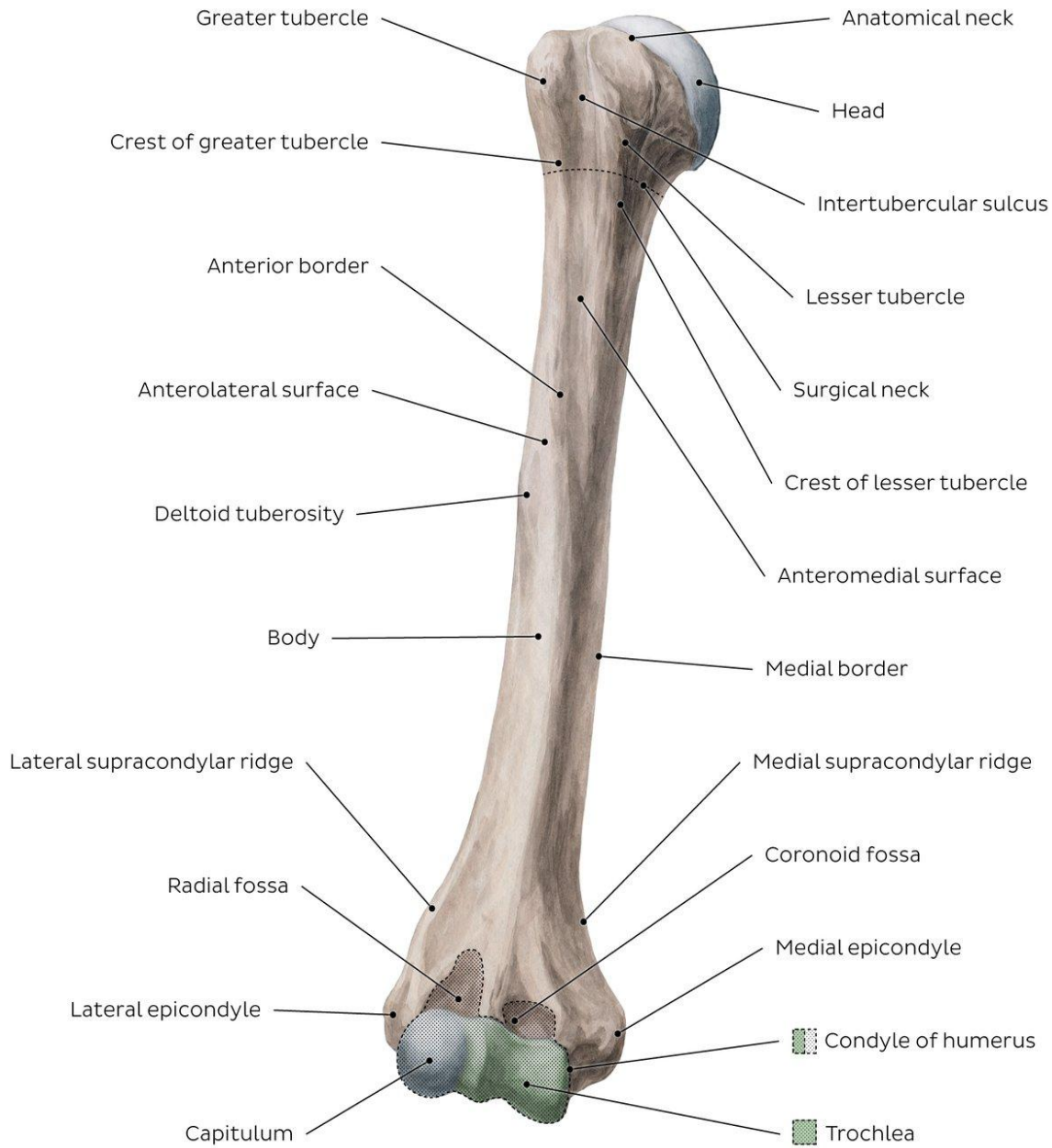


Humerus

- ✓ The humerus articulates with the scapula at the shoulder joint and with the radius and ulna at the elbow joint.
- ✓ The upper end of the humerus has a **head**, which forms about one third of a sphere and articulates with the glenoid cavity of the scapula.
- ✓ Immediately below the head is the **anatomic neck**.
- ✓ Below the neck are the **greater and lesser tuberosities**, separated from each other by the **bicipital groove**.
- ✓ Where the upper end of the humerus joins the shaft is a narrow **surgical neck.**
- ✓ About halfway down the lateral aspect of the shaft is a roughened elevation called the **deltoid tuberosity**.
- ✓ Behind and below the tuberosity is a **spiral groove**, which accommodates **the radial nerve**.
- ✓ The lower end of the humerus possesses the **medial and lateral epicondyles** for the attachment of muscles and ligaments, the rounded **capitulum** for articulation with the **head of the radius**, and the pulley-shaped **trochlea** for articulation with the **trochlear notch of the ulna**. Above the capitulum is the **radial fossa**, which receives the head of the radius when the elbow is flexed. Above the trochlea anteriorly is the **coronoid fossa**, which during the same movement receives the coronoid process of the ulna. Above the trochlea posteriorly is the **olecranon fossa**, which receives the olecranon process of the ulna when the elbow joint is extended.



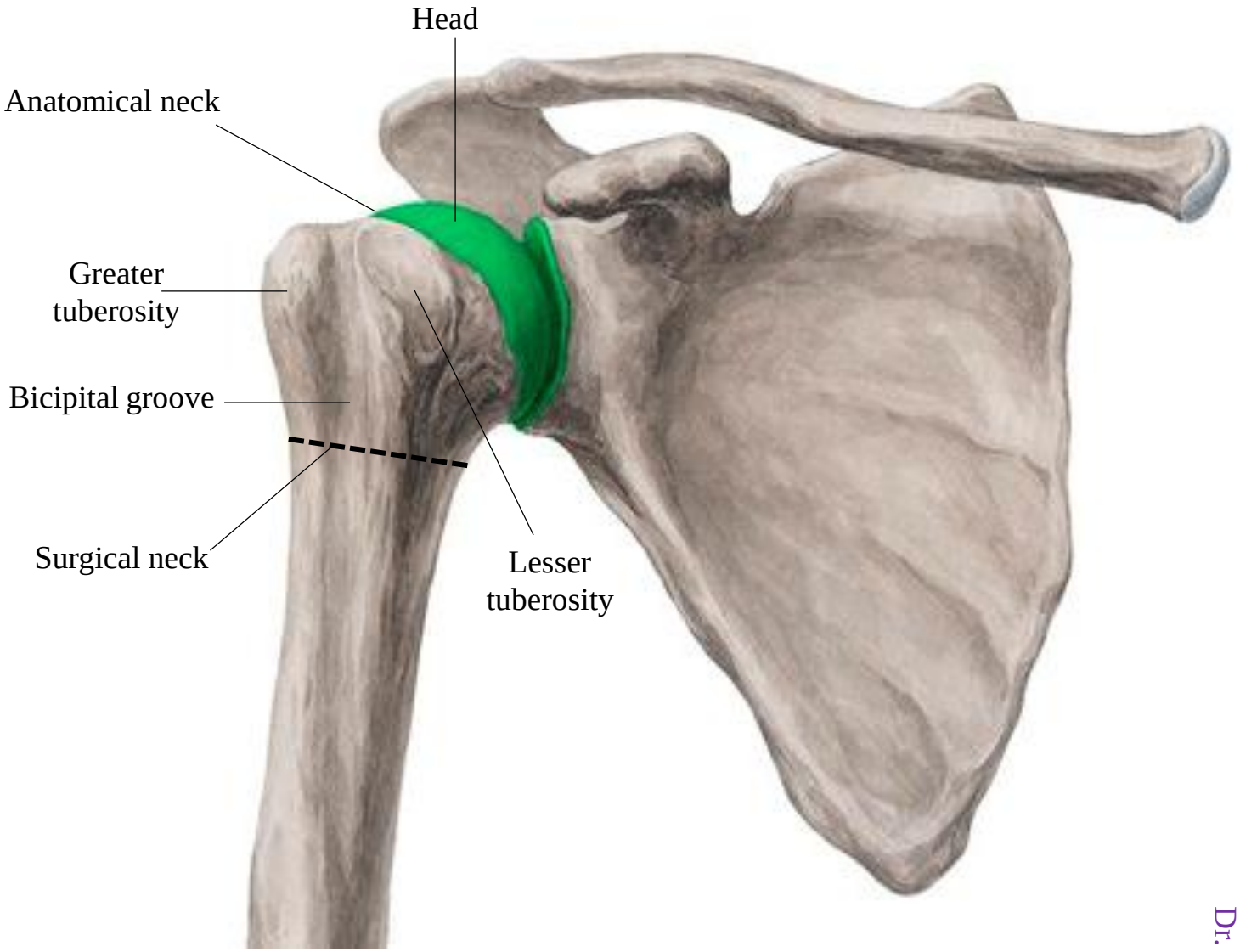




Humerus is a long bone, has two ends and a shaft

The upper end of humerus consists of:

- ✓ Head
- ✓ Greater tuberosity (tubercle)
- ✓ Lesser tuberosity (tubercle)
- ✓ Inter-tubercular (bicipital) groove (which is located in front of upper part of the shaft)
- ✓ Surgical neck
- ✓ Anatomical neck



The bicipital groove has lateral lip, medial lip and floor

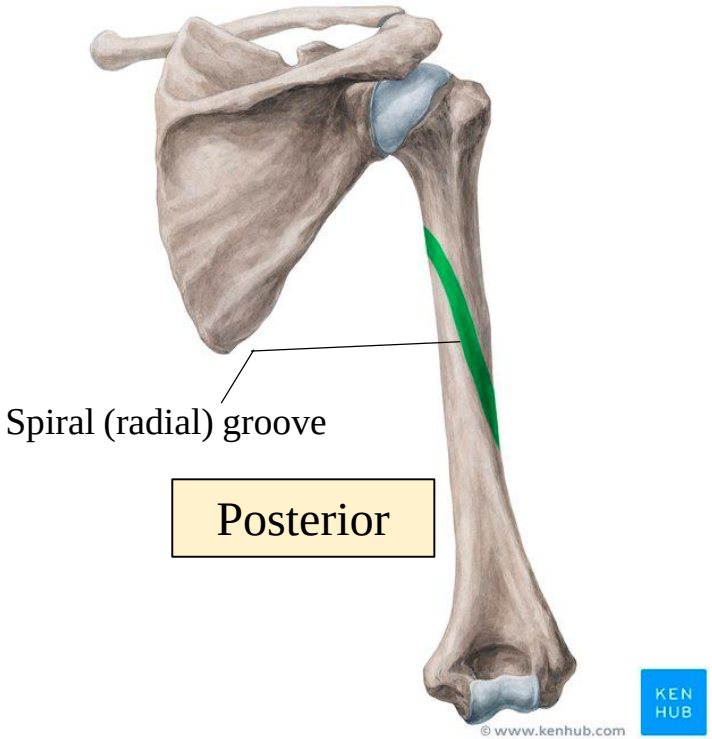
The shaft of humerus has:

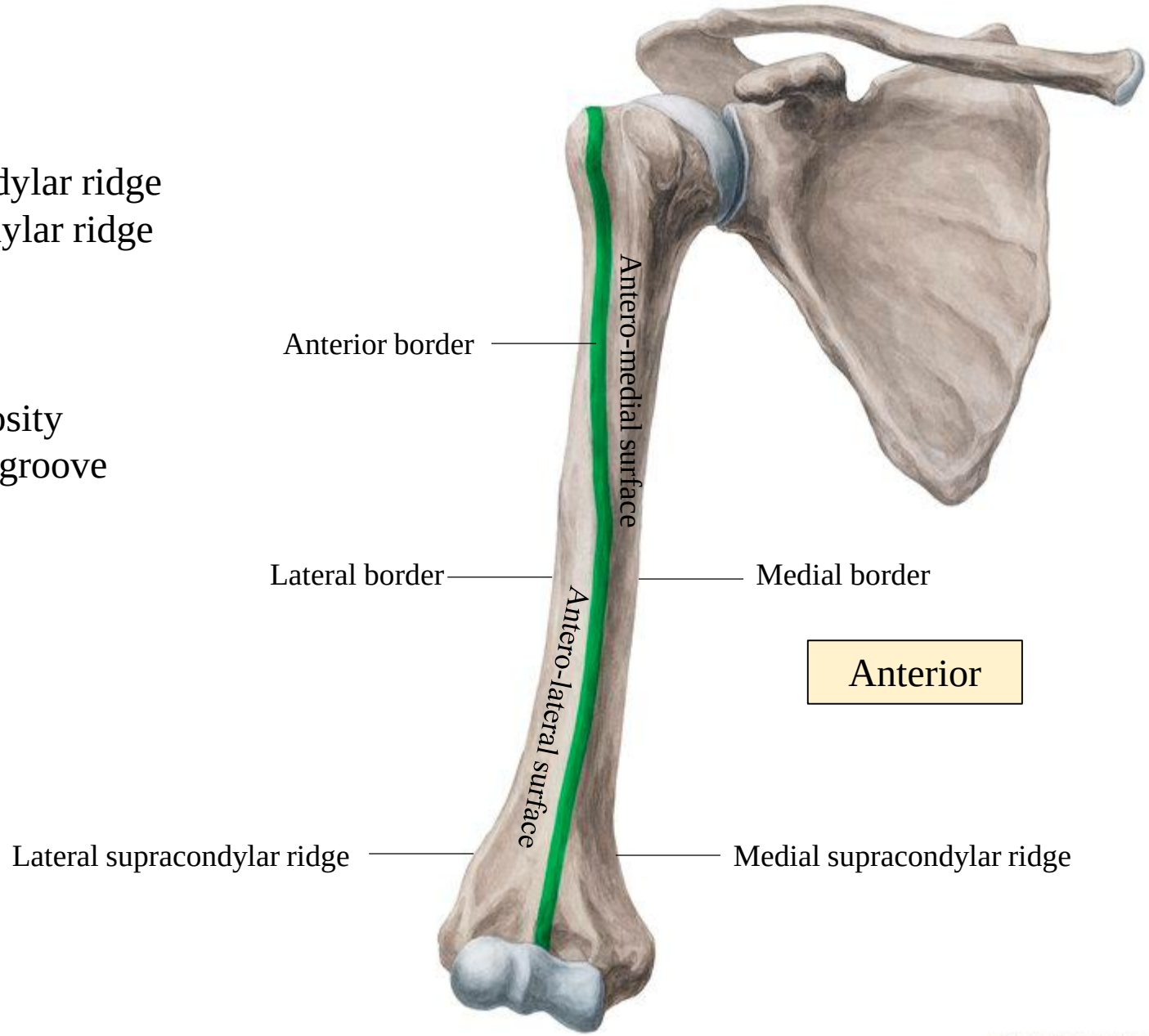
Three borders:

1. Anterior border
2. Medial border forming medial supracondylar ridge
3. Lateral border forming lateral supracondylar ridge

Three surfaces:

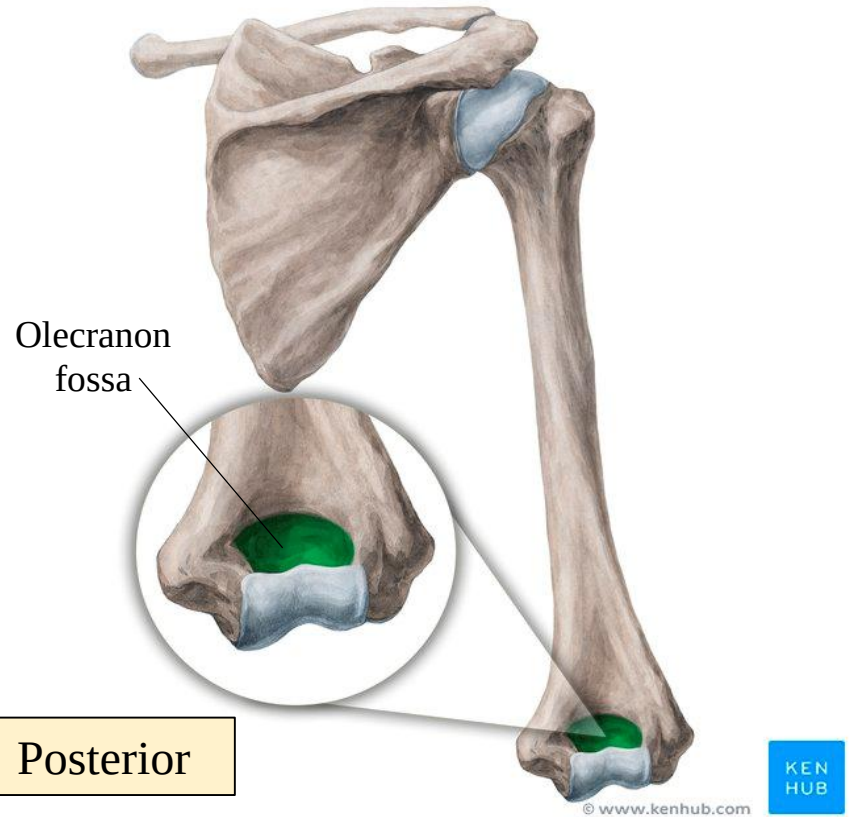
1- Medial surface
2- Lateral surface: shows the deltoid tuberosity
3- Posterior surface: shows spiral or radial groove



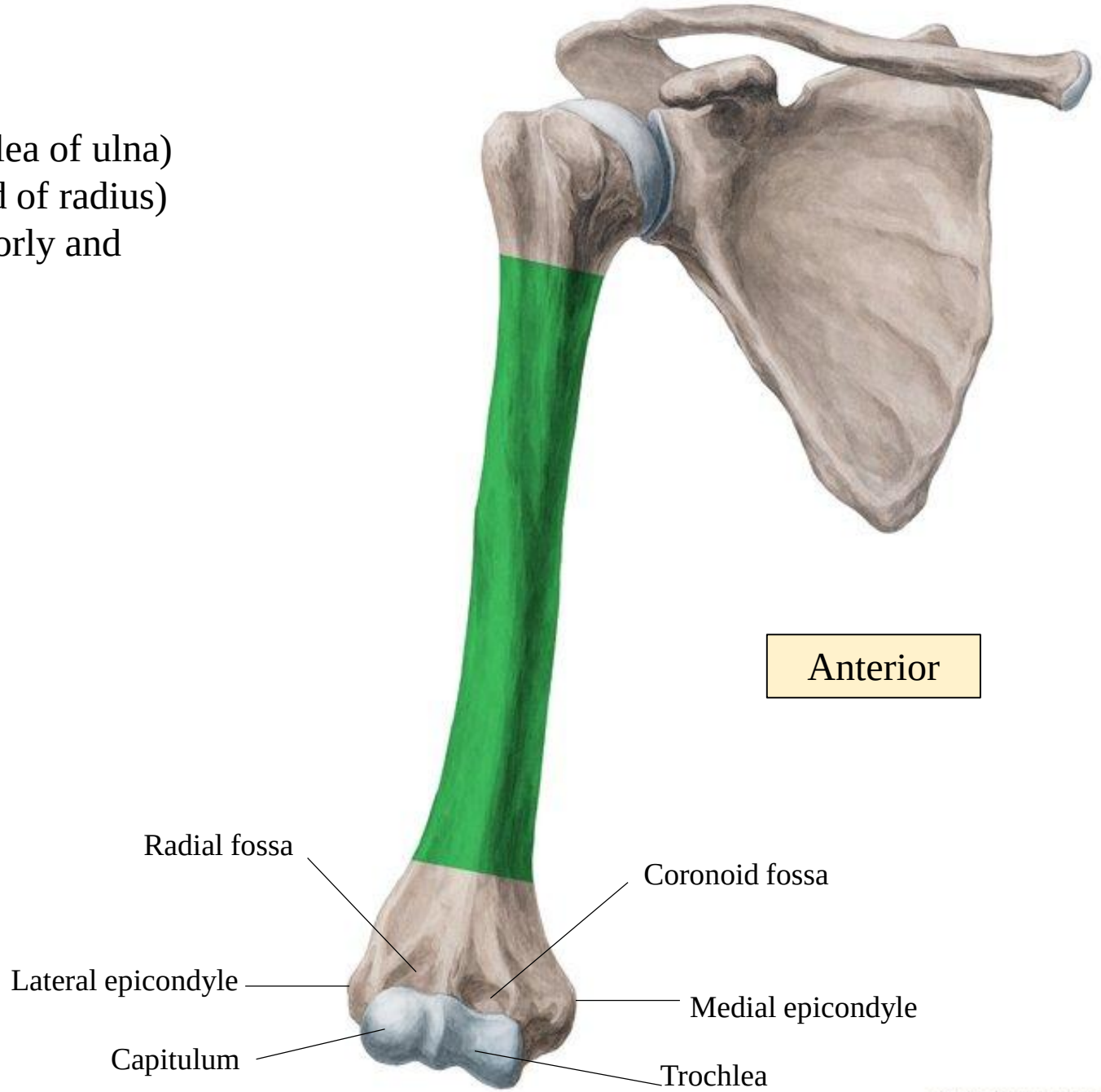


The **lower end of humerus consists of:**

A. 2 epicondyles (medial & lateral)
B. Trochlea (medially for articulation with trochlea of ulna)
C. Capitulum (laterally for articulation with head of radius)
D. Three fossae (radial & coronoid fossae anteriorly and olecranon fossa posteriorly).

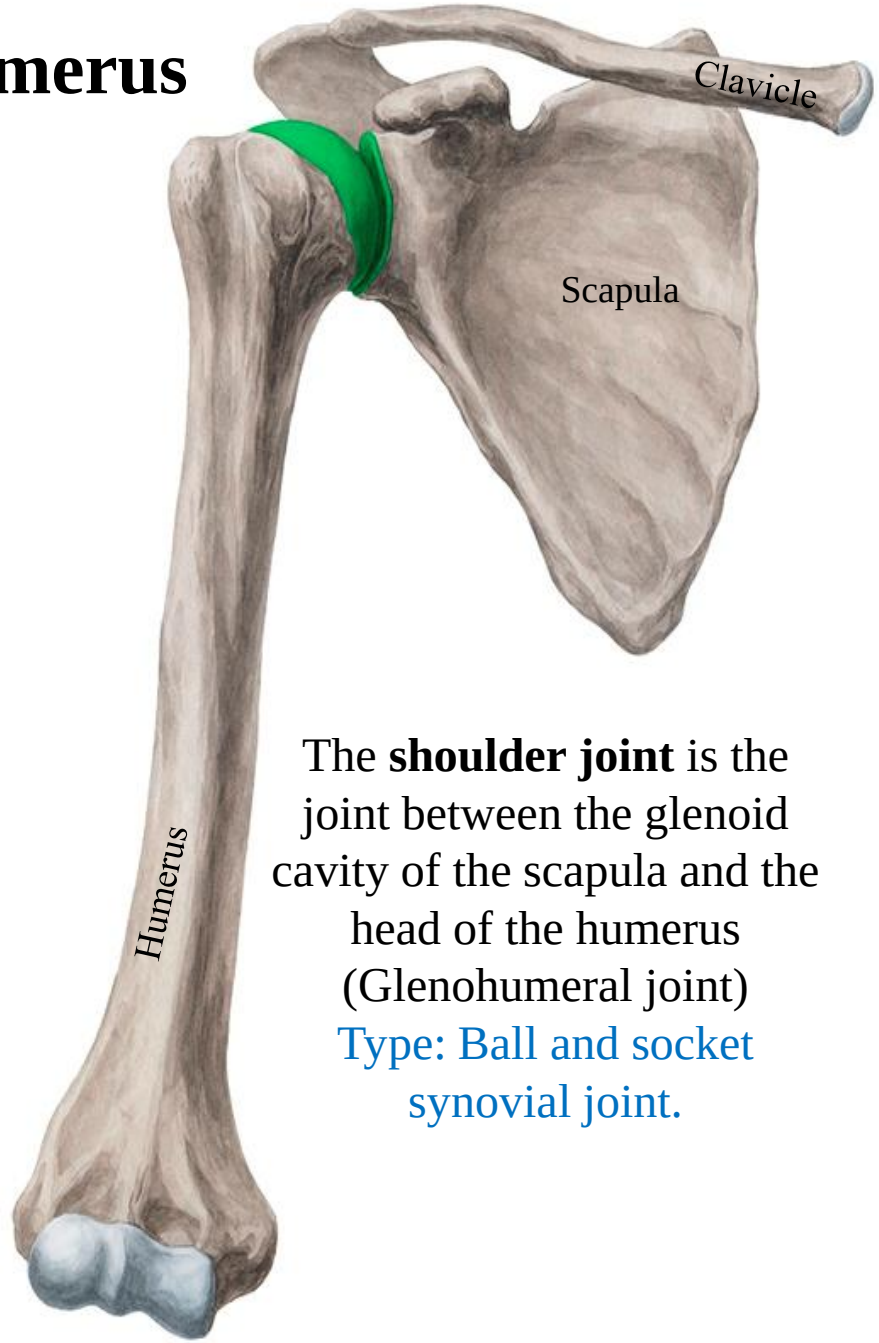


Posterior



Anterior

Articulation of Humerus

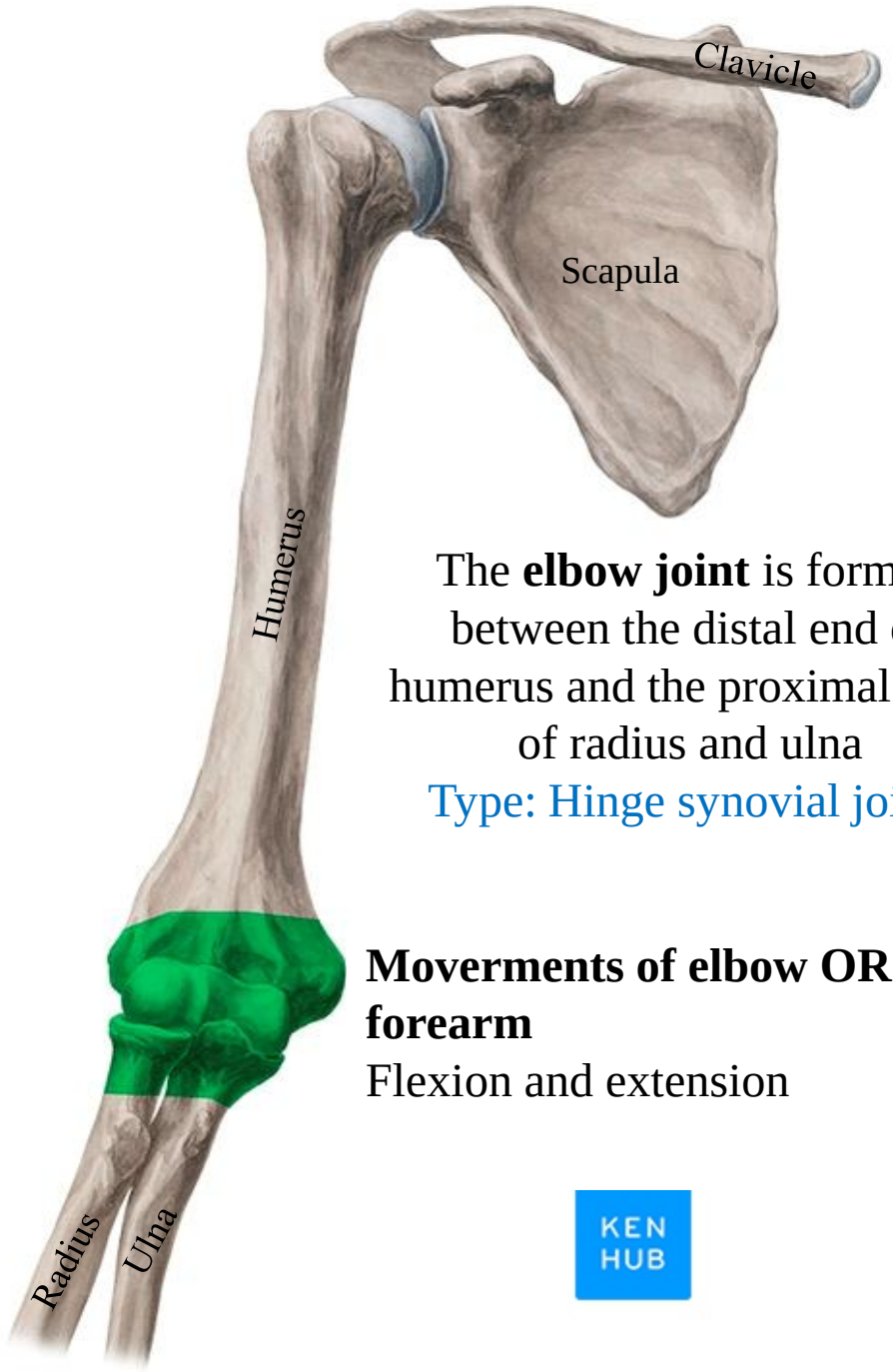


Moverments of shoulder OR arm

1. Flexion and extension
2. Abduction and adduction
3. Medial and lateral rotation
4. Circumduction

The **shoulder joint** is the joint between the glenoid cavity of the scapula and the head of the humerus (Glenohumeral joint)

Type: Ball and socket synovial joint.



The **elbow joint** is formed between the distal end of humerus and the proximal ends of radius and ulna

Type: Hinge synovial joint.

Moverments of elbow OR forearm

Flexion and extension

Dr. Heba Kalbouneh

Ulna

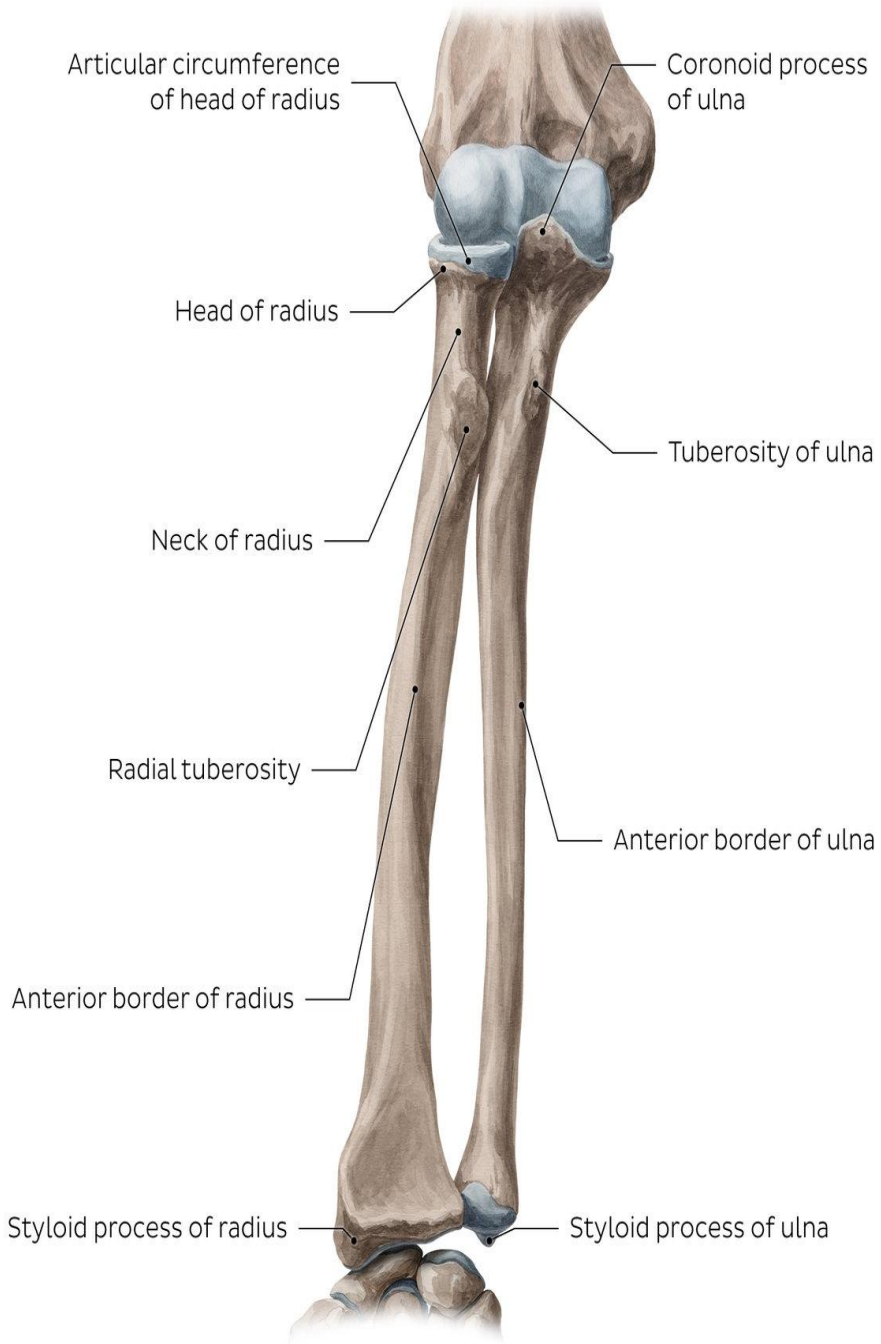
The medial bone of the forearm

Radius

The lateral bone of the forearm

Radius

- ✓ The radius is the **lateral bone of the forearm**.
- ✓ Its proximal end articulates with the humerus at the elbow joint and with the ulna at the proximal radioulnar joint.
- ✓ Its distal end articulates with the scaphoid and lunate bones of the hand at the wrist joint and with the ulna at the distal radioulnar joint.
- ✓ At the proximal end of the radius is the small circular **head**. The upper surface of the head is concave and articulates with the convex **capitulum of the humerus**. The circumference of the head articulates with the radial notch of the ulna.
- ✓ Below the head the bone is constricted to form the **neck**.
- ✓ Below the neck is the **radial (bicipital) tuberosity** for the insertion of the biceps muscle.
- ✓ It has a sharp interosseous border medially for the attachment of the interosseous membrane that binds the radius and ulna together.
- ✓ At the distal end of the radius is the styloid process; this projects distally from its lateral margin
- ✓ On the medial surface of the distal end is the ulnar notch, which articulates with the round head of the ulna.
- ✓ The inferior articular surface of the distal end articulates with the scaphoid and lunate bones.



Radius:

It is a **long bone** forming the **lateral bone of forearm.**

Articulates with capitulum of humerus

Articulates with radial notch of the ulna

Upper end consists of:

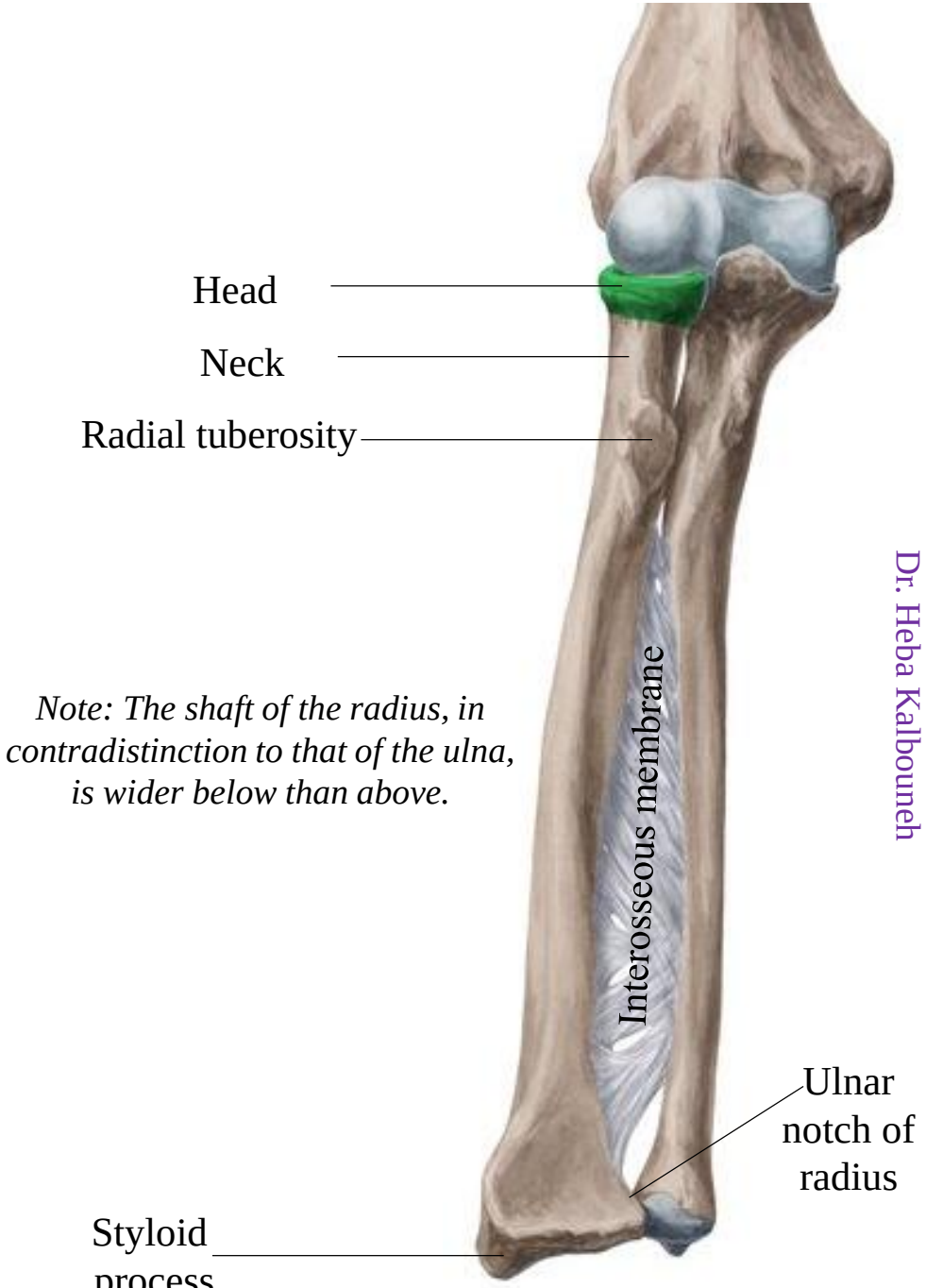
A. Head: has 2 articular surfaces (upper surface & its circumference)
B. Neck
C. Radial tuberosity

Shaft has:

A. Three borders (anterior, posterior & medial (interosseous) borders)
B. Three surfaces (anterior, posterior & lateral)

Lower end has 5 surfaces:

A. Anterior surface
B. Posterior surface: has a dorsal tubercle
C. Lateral surface: shows styloid process
D. Medial surface: has ulnar notch of radius that articulates with head of ulna
E. Inferior surface: articulates with carpal bones (scaphoid and lunate)



Note: The shaft of the radius, in contradistinction to that of the ulna, is wider below than above.

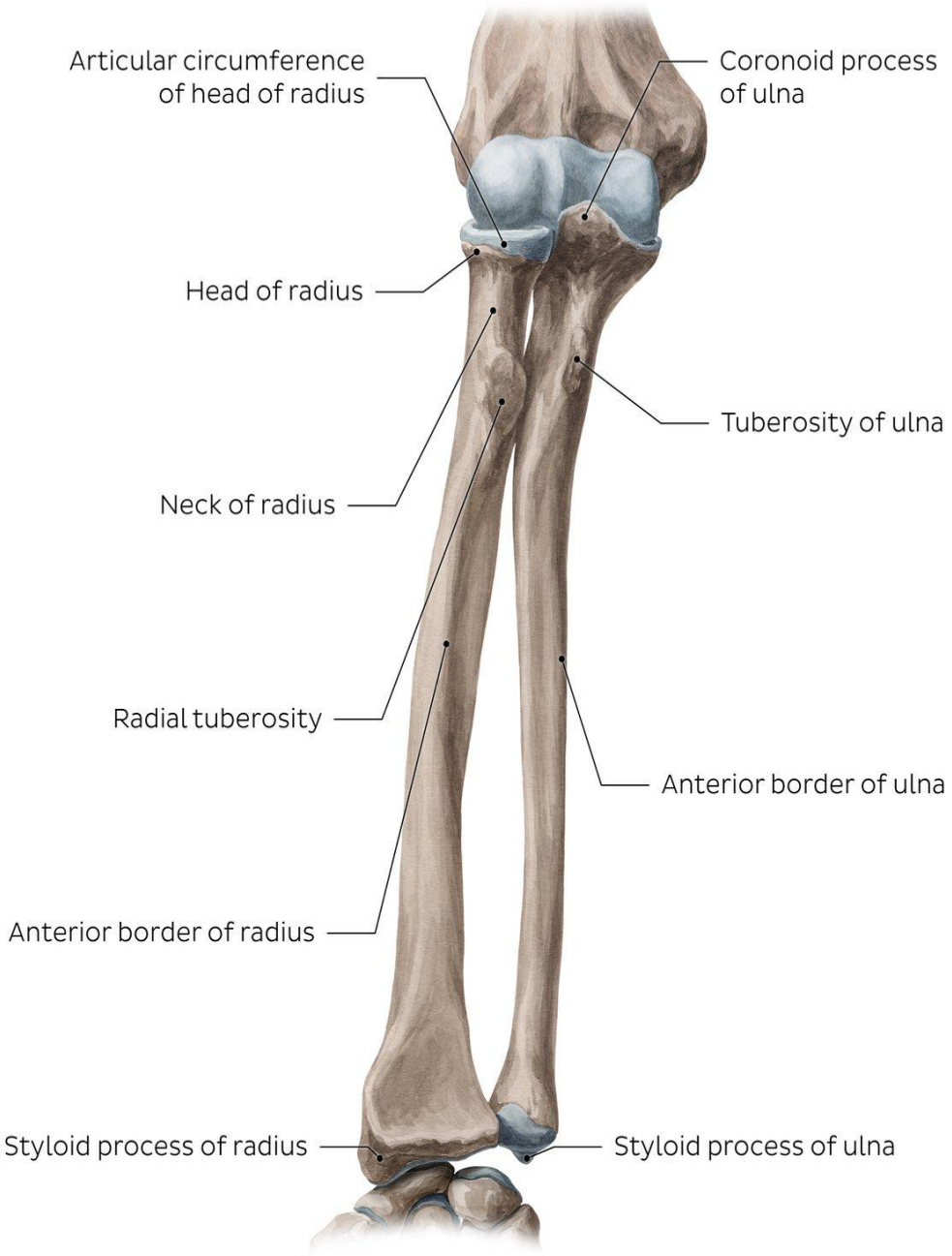
Dr. Heba Kalbouneh

Posterior view

Anterior view (Distal end)

Ulna

- ✓ The ulna is the **medial bone** of the forearm.
- ✓ Its proximal end articulates with the humerus at the elbow joint and with the head of the radius at the proximal radioulnar joint.
- ✓ Its distal end articulates with the radius at the distal radioulnar joint, **but it is excluded from the wrist joint by the articular disc**.
- ✓ The proximal end of the ulna is large and is known as the **olecranon** process; this forms **the prominence of the elbow**. It has a notch on its anterior surface, the **trochlear notch**, which articulates with the trochlea of the humerus. Below the trochlear notch is the triangular **coronoid** process, which has on its lateral surface the radial notch for articulation with the head of the radius.
- ✓ It has a **sharp interosseous border laterally** for the attachment of the interosseous membrane.
- ✓ At the distal end of the ulna is the small rounded **head**, which has projecting from its medial aspect the styloid process.



Dr. Heba Kalbouneh

Ulna:

It is a **long bone** forming the **medial bone of forearm.**

Upper end consists of:

A. Two processes:
- Olecranon process → Large and posterior
- Coronoid process → Small and anterior

B. Two notches:
- Trochlear notch → Articulates with the trochlea of the humerus (elbow joint)
- Radial notch → Articulates with the head of radius (proximal radioulnar joint)

C. Ulnar tuberosity

Shaft has:

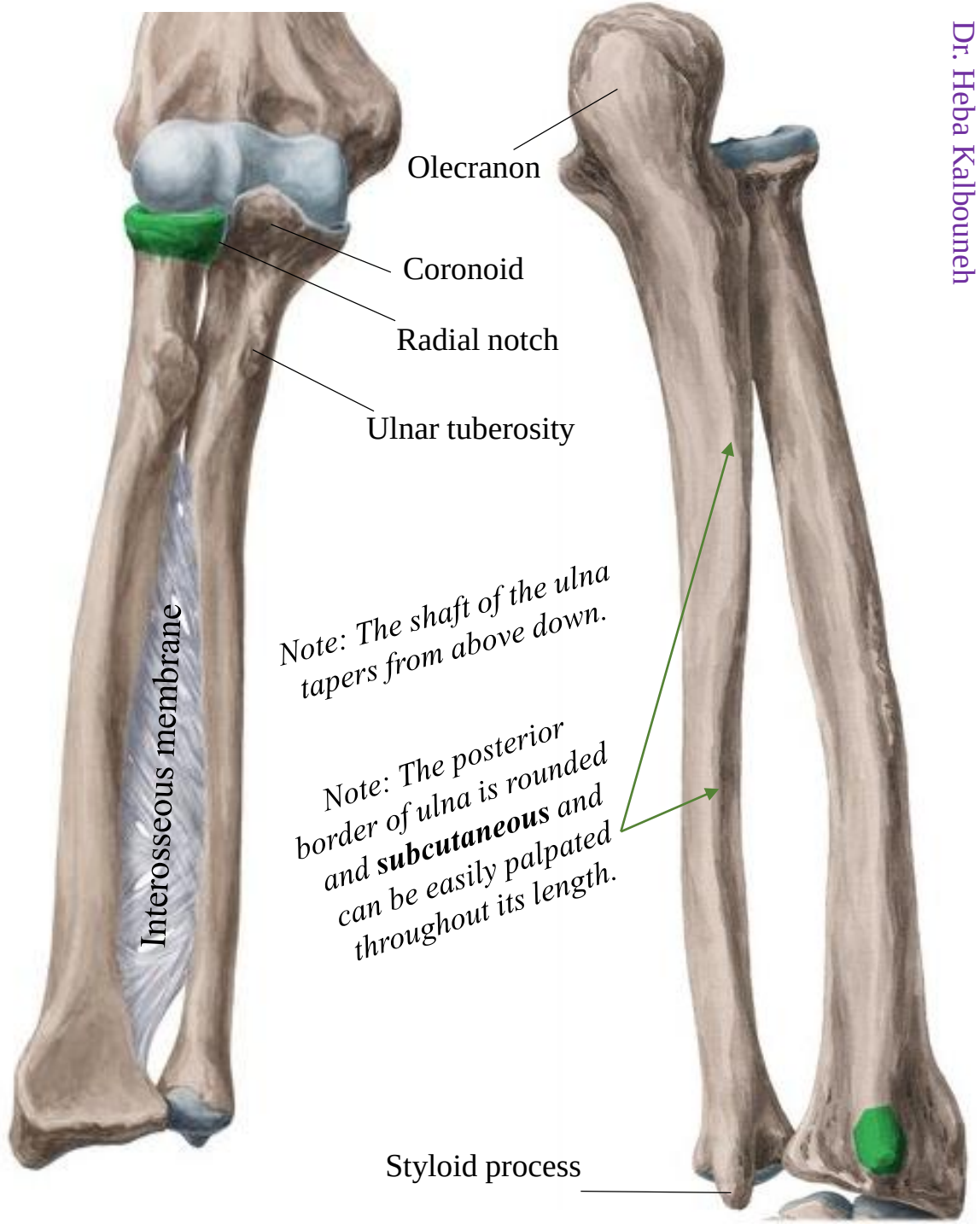
A. Three surfaces (anterior, posterior & medial surfaces)

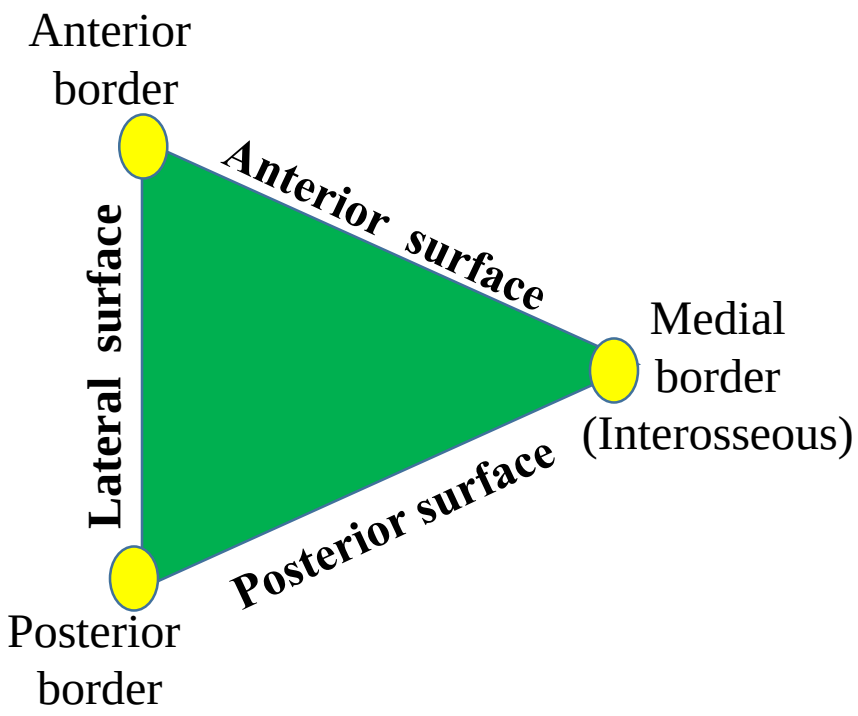
B. Three borders (anterior, posterior & lateral (interosseous) borders)

Lower end consists of:

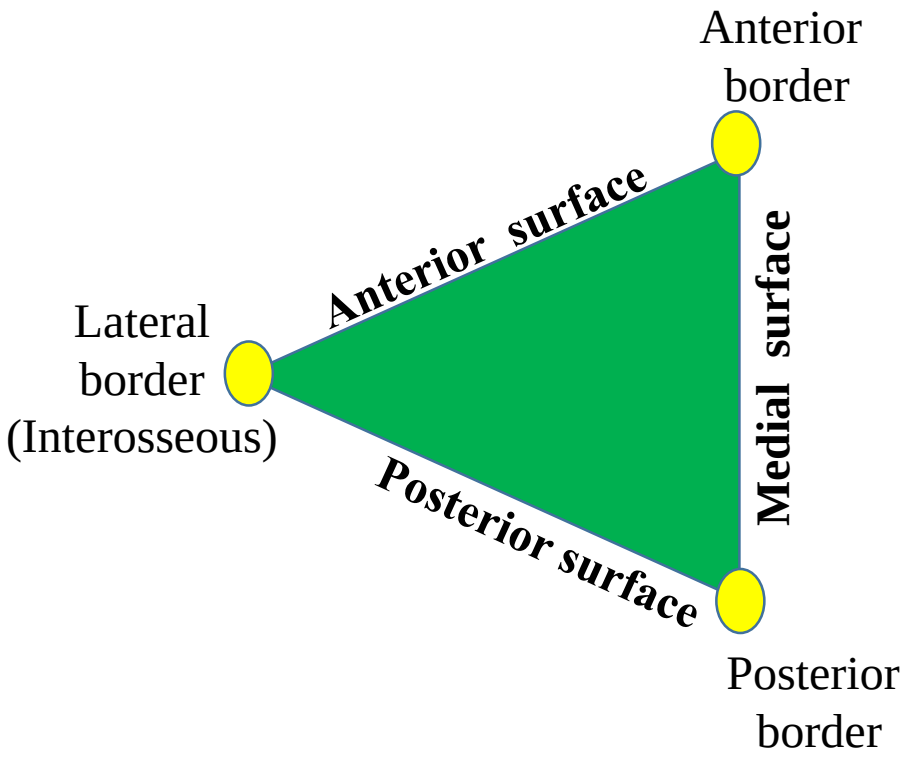
A. Head → Articulates with ulnar notch of radius (distal radioulnar joint)

B. Styloid process (which is shorter than styloid process of radius)



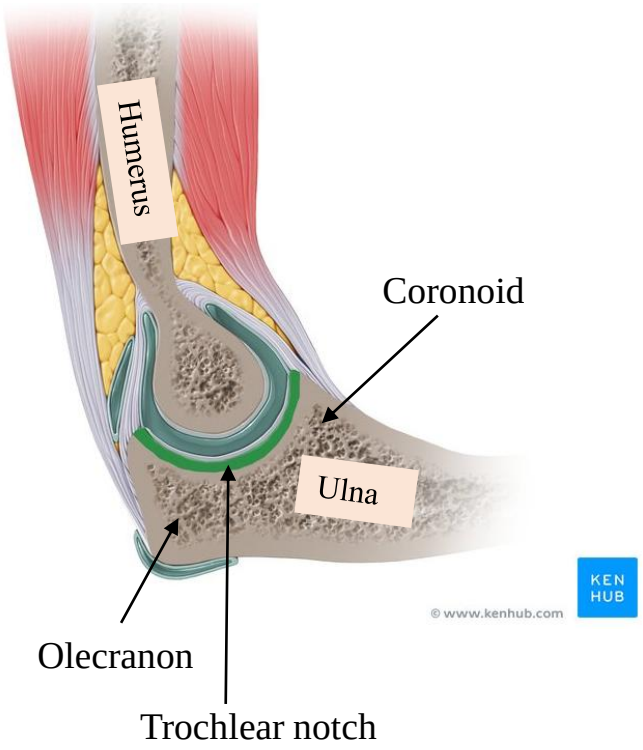


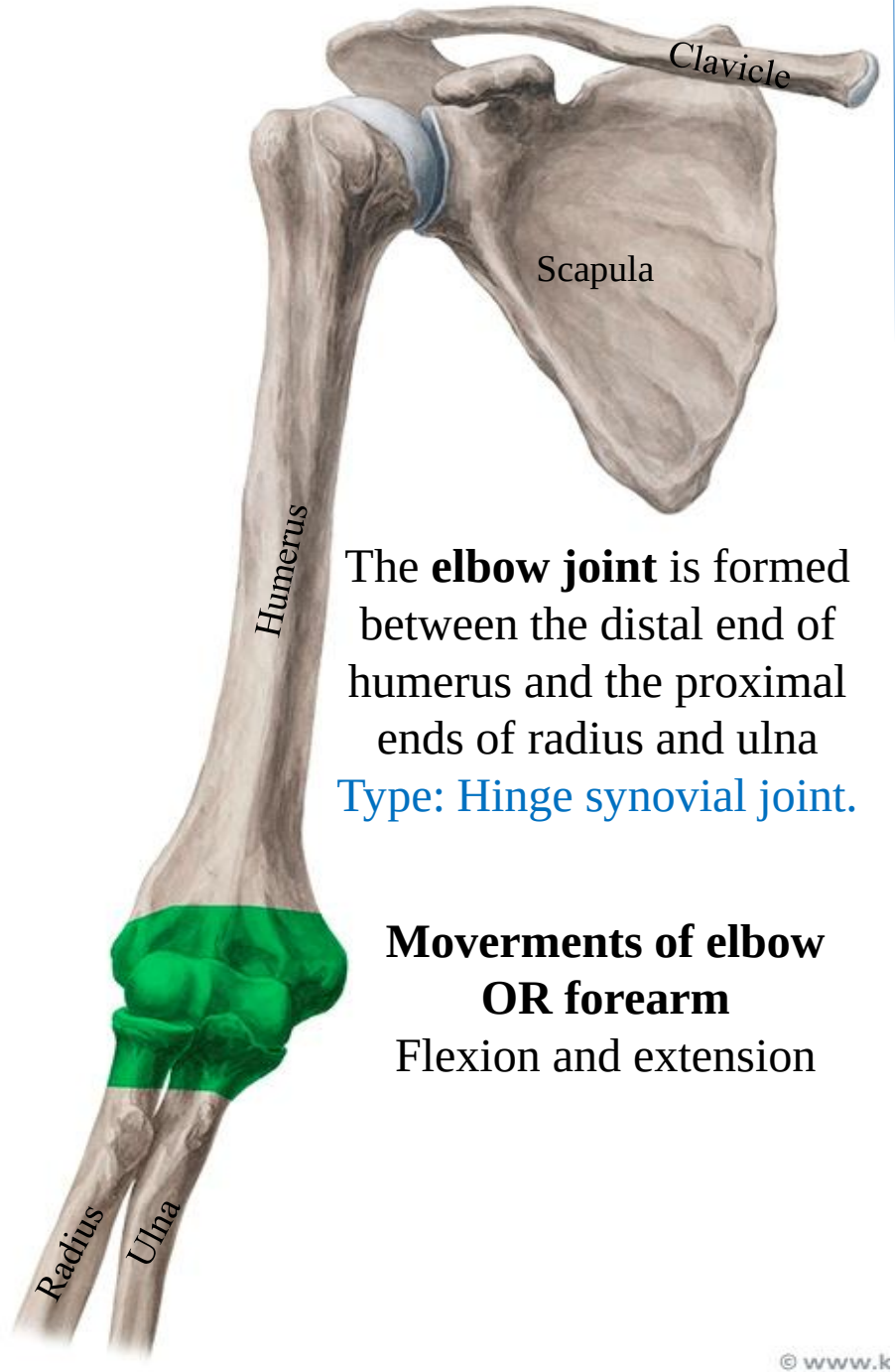
Cross section in the shaft of radius



Cross section in the shaft of ulna

Articulation of Radius & Ulna





The **elbow joint** is formed between the distal end of humerus and the proximal ends of radius and ulna

Type: Hinge synovial joint.

Moverments of elbow OR forearm

Flexion and extension

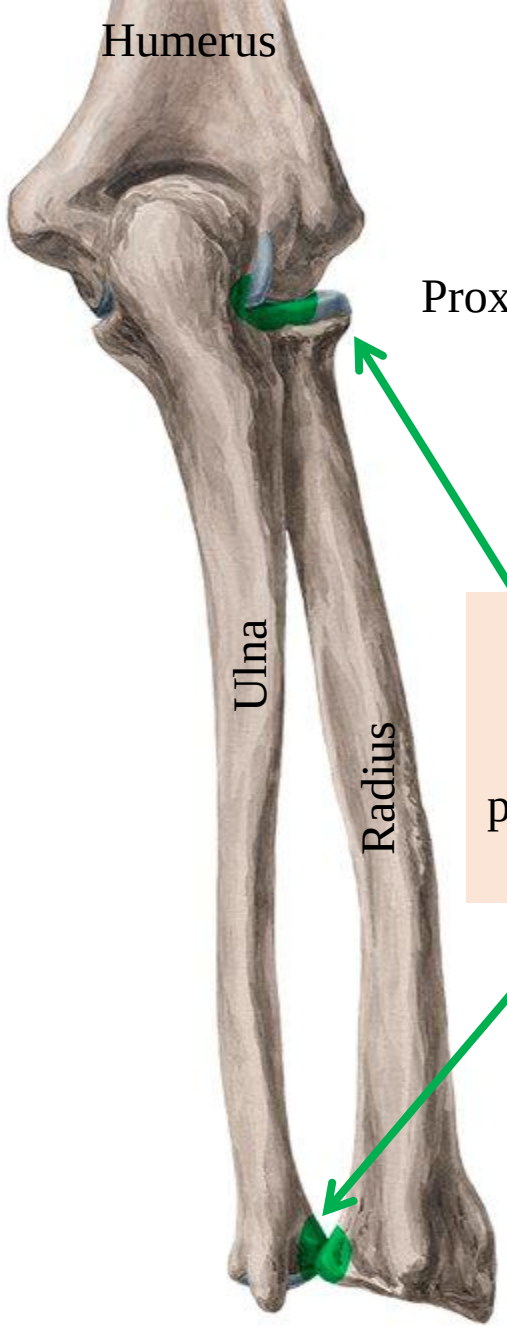
The **wrist joint** is formed between the distal end of radius and the carpal bones (scaphoid, lunate & triquetral) (Radiocarpal joint)

Type: Synovial Condyloid (ellipsoid).

Moverments of wrist OR hand

Flexion, extension, abduction, adduction

Dr. Heba Kalbouneh



Proximal radioulnar joint

Note: supination and pronation of the forearm take place at radioulnar joints

Distal radioulnar joint

The **proximal radioulnar joint** is formed between the proximal ends of the radius and ulna.

The **distal radioulnar joint** is formed between the distal ends of the radius and ulna.

Type: Synovial pivot joints

Moverments:

Supination & pronation

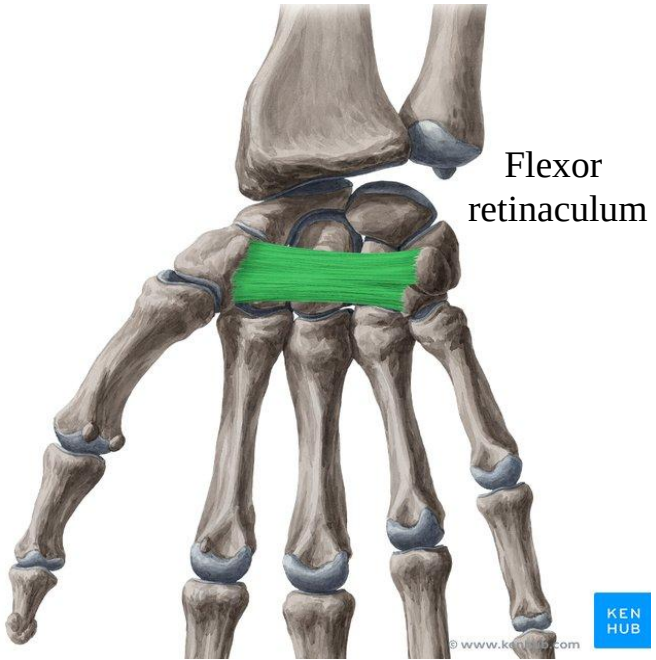
Dr. Heba Kalbouneh

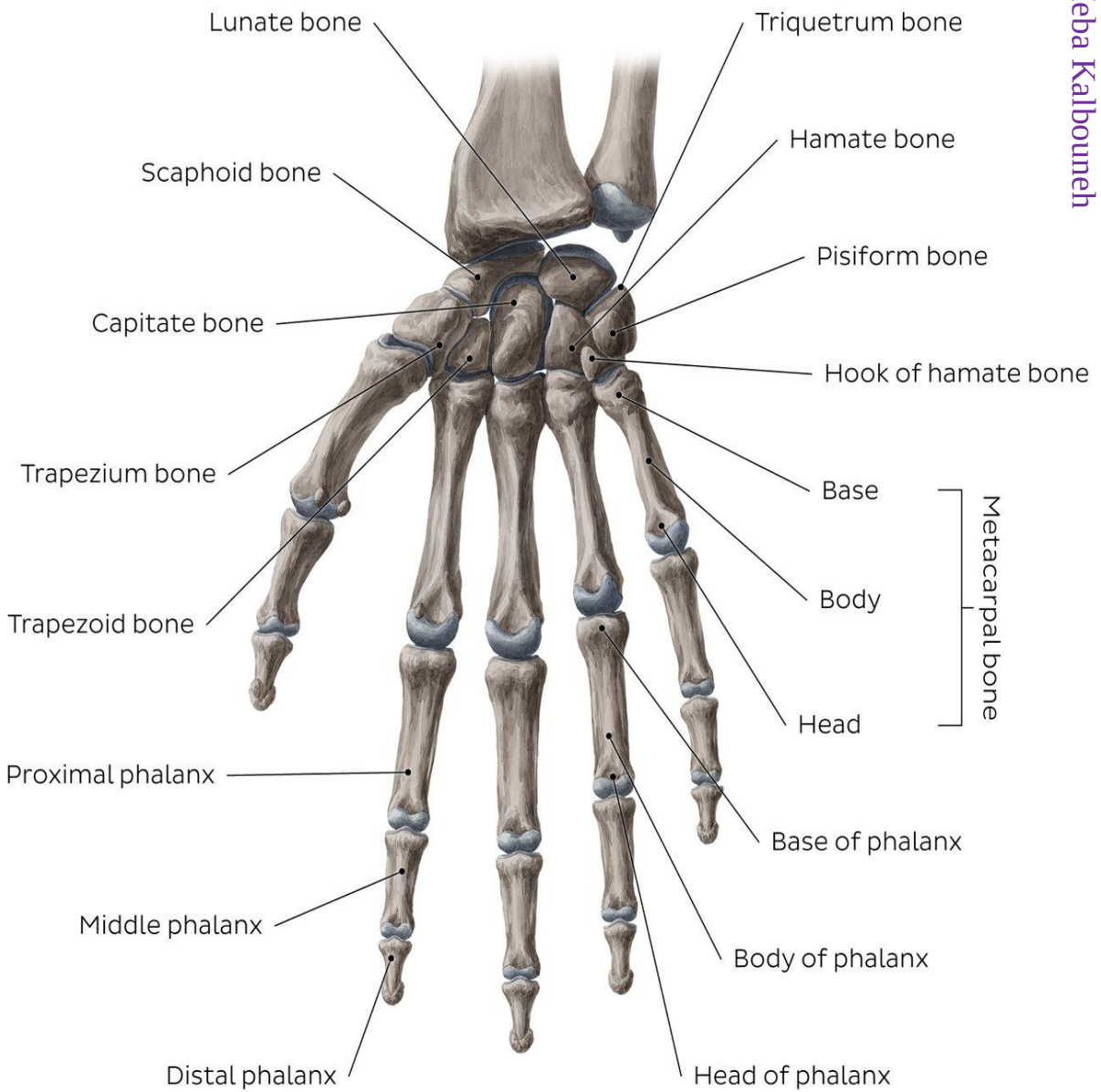
Bones of the Hand (carpals, metacarpals & phalanges)

- ✓ There are eight carpal bones, made up of two rows of four.
- ✓ **The proximal row consists of (from lateral to medial):**
  Scaphoid, Lunate, Triquetral, and Pisiform bones.
- ✓ **The distal row consists of (from lateral to medial):**
  Trapezium, Trapezoid, Capitate, and Hamate bones.

Together, the bones of the carpus present on their anterior surface a concavity, to the lateral and medial edges of which is attached a strong membranous band called the **flexor retinaculum**. In this manner, an osteofascial tunnel, the **carpal tunnel**, is formed for the passage of the median nerve and the flexor tendons of the fingers.

Carpal tunnel





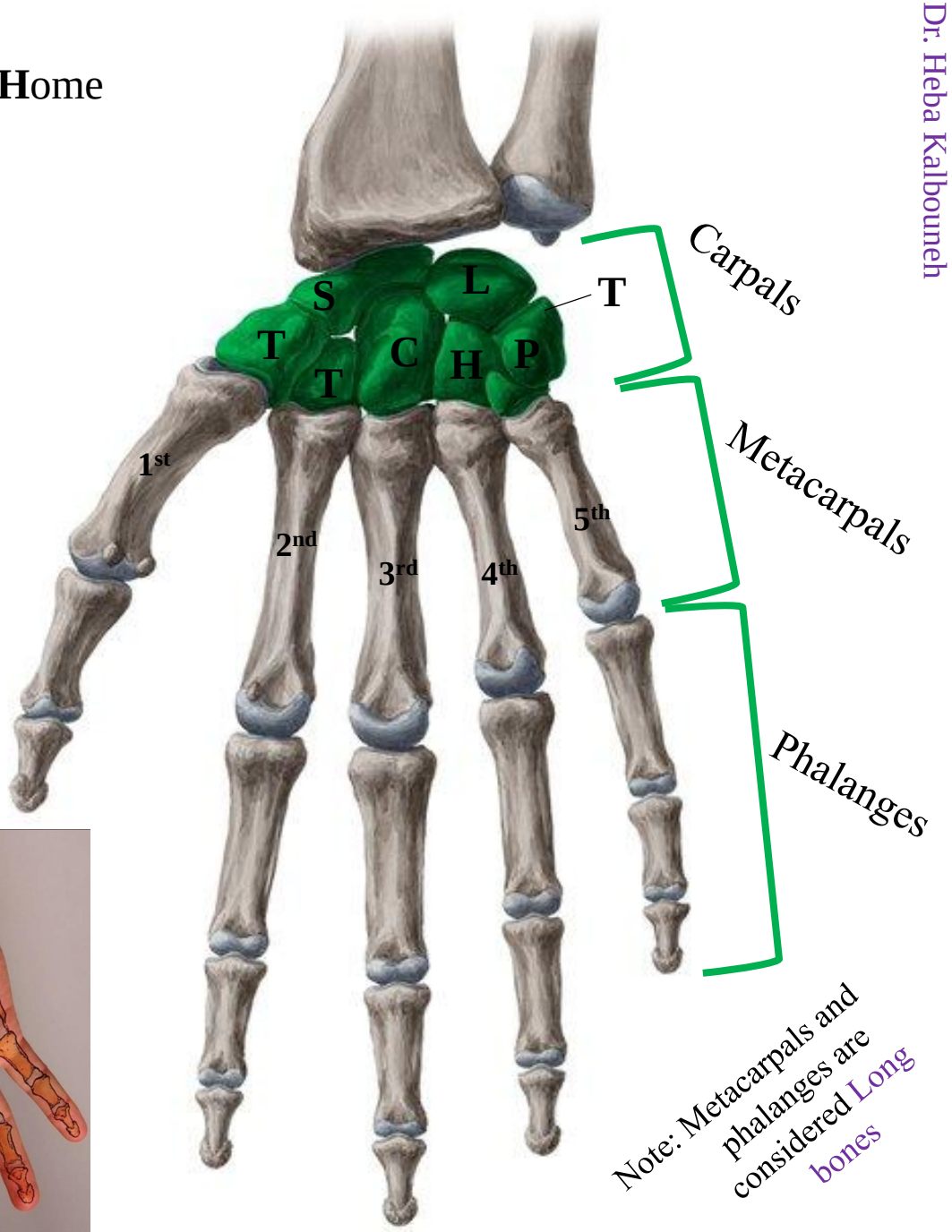
Dr. Heba Kalbouneh

Bones of the Hand

It is very easy to remember the carpal bones from lateral to medial, and from proximal to distal rows if you use the following mnemonic!

Sally **L**eft **T**he **P**arty **T**o **T**ake **C**athy **H**ome

Scaphoid
Lunate
Triquetral
Pisiform
Trapezium
Trapezoid
Capitate
Hamate



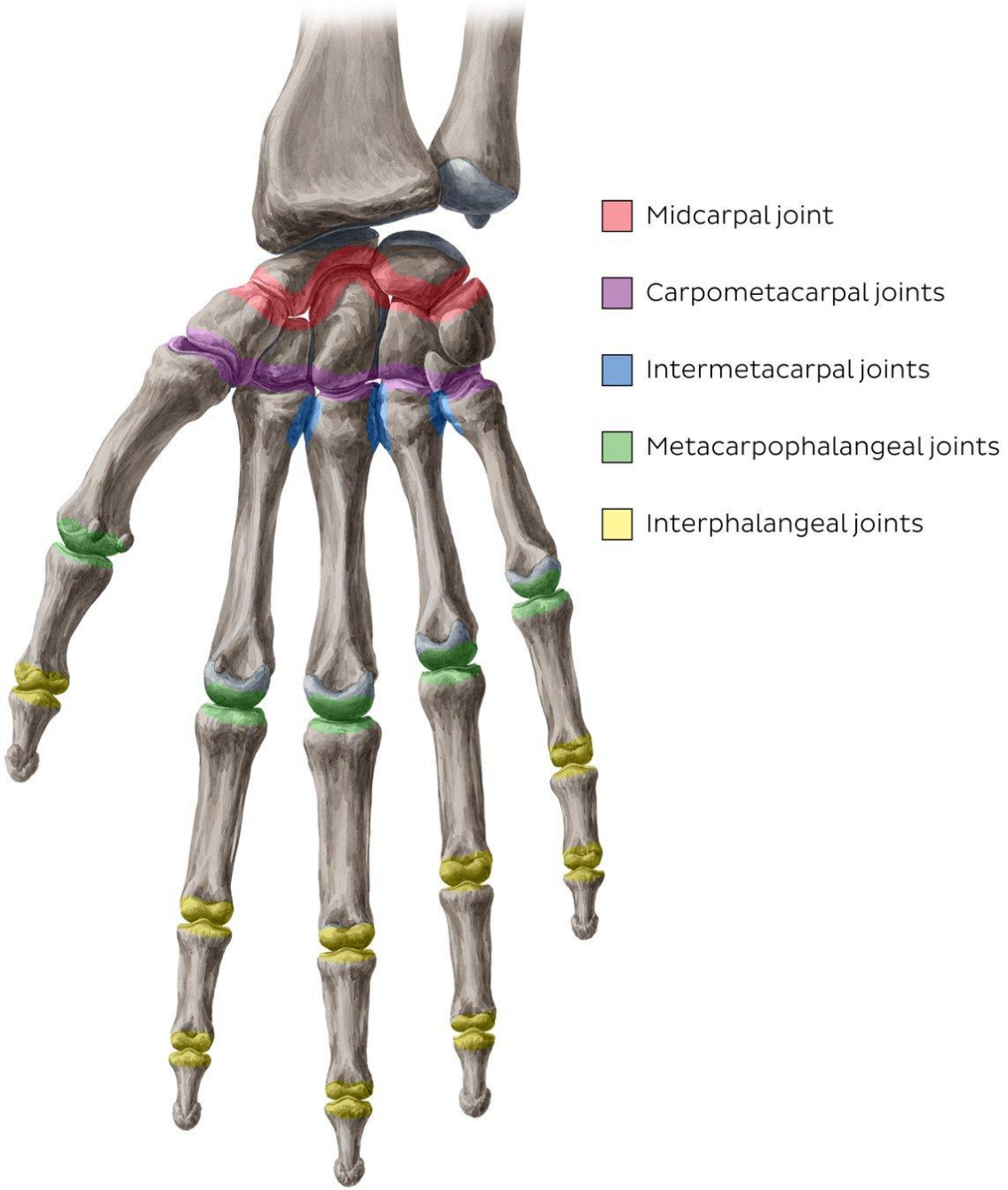
The Metacarpals and Phalanges

- There are five metacarpal bones, each of which has a base, a shaft, and a head.
- The first metacarpal bone of the thumb is the shortest and most mobile. It does not lie in the same plane as the others but occupies a more anterior position.
- The **bases** of the metacarpal bones articulate with the **distal row of the carpal bones.**
- The **heads**, which form the knuckles, articulate with the **proximal phalanges**.
- There are three phalanges for each of the fingers but only two for the thumb.

Note: Metacarpals and phalanges are considered Long bones

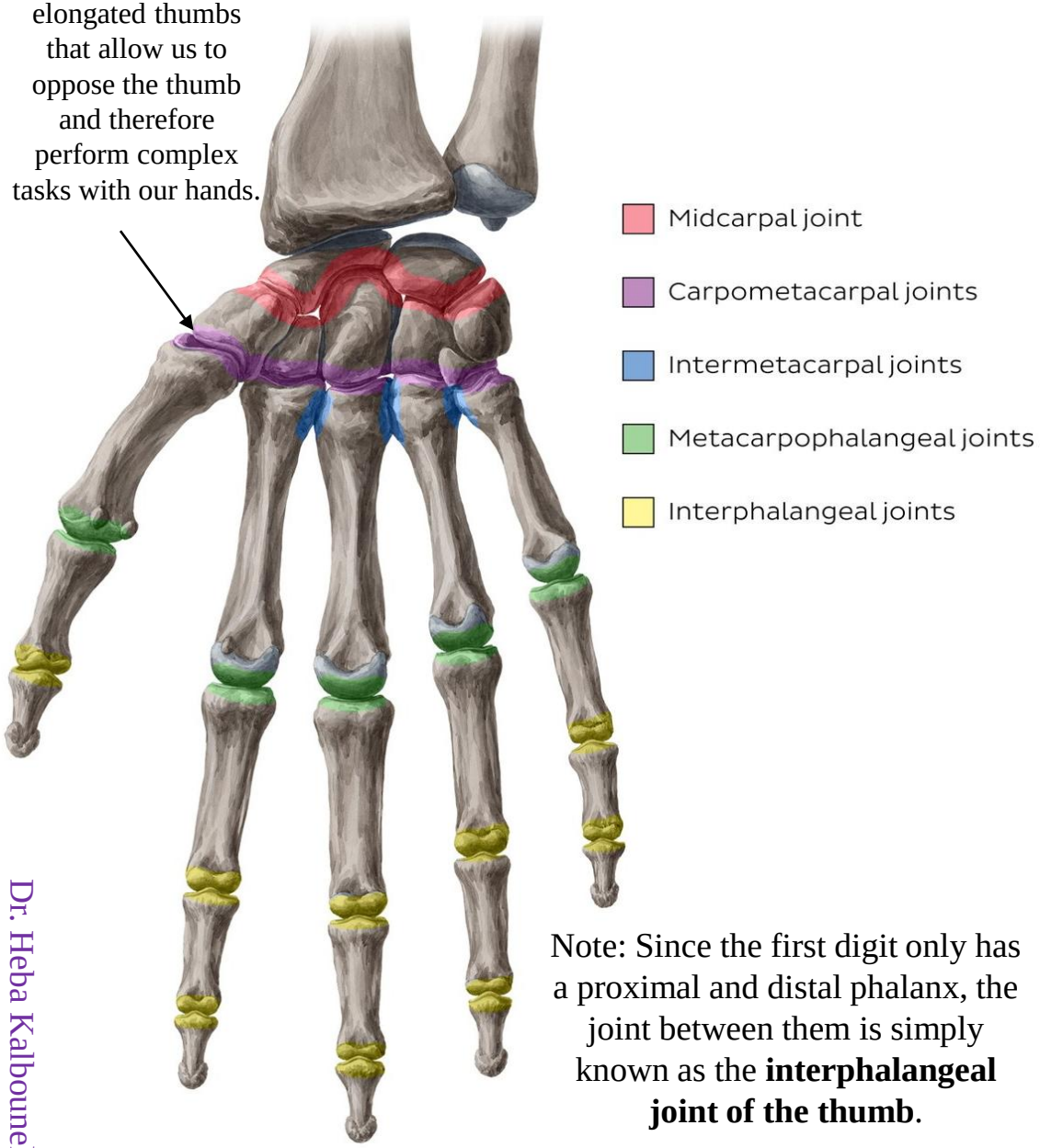
The joints of the hand

The following image shows the joints of the hand from a palmar (ventral) perspective. Notice that the joints are named according to the bones that participate in comprising them (e.g. carpometacarpal). Note that for digits 2-5, there are two sets of interphalangeal joints; proximal and distal.



Dr. Heba Kalbouneh

Note: It is the combination of this joint and our elongated thumbs that allow us to oppose the thumb and therefore perform complex tasks with our hands.



Note: Since the first digit only has a proximal and distal phalanx, the joint between them is simply known as the **interphalangeal joint of the thumb**.

Dr. Heba Kalbouneh

The joints of the hand

The **midcarpal joint** is the articulation between the proximal row of carpal bones and the distal row of carpal bones. Type: Synovial plane joint.

The **carpometacarpal (CMC) joints** are articulations between the carpal bones and metacarpal bones of the hand. There are five CMC joints in total, out of which the carpometacarpal joint of thumb (trapeziometacarpal joint) is the most specialized and flexible.
Type:
CMC 1 (of thumb): Synovial saddle joint.
Movements of 1st carpometacarpal joint: Flexion and extension, abduction and adduction, and some circumduction.
CMC 2, 3, 4, 5: Synovial plane joint.

The **metacarpophalangeal (MCP) joints** connect the metacarpus, or palm of the hand, to the fingers. There are five separate metacarpophalangeal joints that connect each metacarpal bone to the corresponding proximal phalanx of each finger. Type: Synovial condyloid joint. Movements: Flexion, extension, adduction, abduction, and some circumduction (limited).

The **interphalangeal joints (IP)** of the hand are formed between the proximal, middle, and distal phalanges of the hand.
The **proximal interphalangeal joint** is located between the proximal and middle phalanges, while the **distal interphalangeal joint** is found between the middle and distal phalanges. Type: Synovial hinge. Movements: Flexion & extension.

Radiolucent structures appear dark or black in the radiographic image

Radiopaque structures appear whitish in the radiographic image

Radiolucent – Refers to structures that are less dense and permit the x-ray beam to pass through them.. **Radiopaque** – Refers to structures that are dense and resist the passage of x-rays