



# محاضرات التشریح الشعاعي المرحلة الثانية

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## Radiological Anatomy

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### Anatomy :

Is the study of the structure and morphology of the body

### Radiological Anatomy:

uses the imaging modalities to demonstrate the anatomy ,mainly by the x-ray , other modalities like fluoroscopy , CT scan MRI and Ultrasound ( All except ultrasound are parts of the electromagnetic spectrum ) .

### Surface of the body described by : Planes and Lines :

The Anatomical planes are imaginary transection of the body ,in order to describe the location of structures or the direction of movements.

The Anatomical lines are imaginary lines drawn through structures to localize an area .

### The Four main body planes are :

#### Sagittal plane :

divides the entire body or a body part into right and left segments. The plane passes vertically through the body from front to back

The midsagittal plane is a specific sagittal plane that passes through the midline of the body and divides it into equal right and left halves

## Coronal plane :

divides the entire body or a body part into anterior and posterior segment .  
The plane passes through the body vertically from one side to the other  
The midcoronal plane is a specific coronal plane that passes through the midline of the body, dividing it into equal anterior and posterior halves.

## Horizontal plane:

passes through the body or a body part at right angles to the longitudinal axis. It is positioned at a right angle to the sagittal and coronal planes. This plane divides the body into superior and inferior portion . Often it is referred to as a transverse or axial plane.

## Oblique plane

passes through a body part at any angle between the three mentioned planes.

## The most common anatomical lines are :

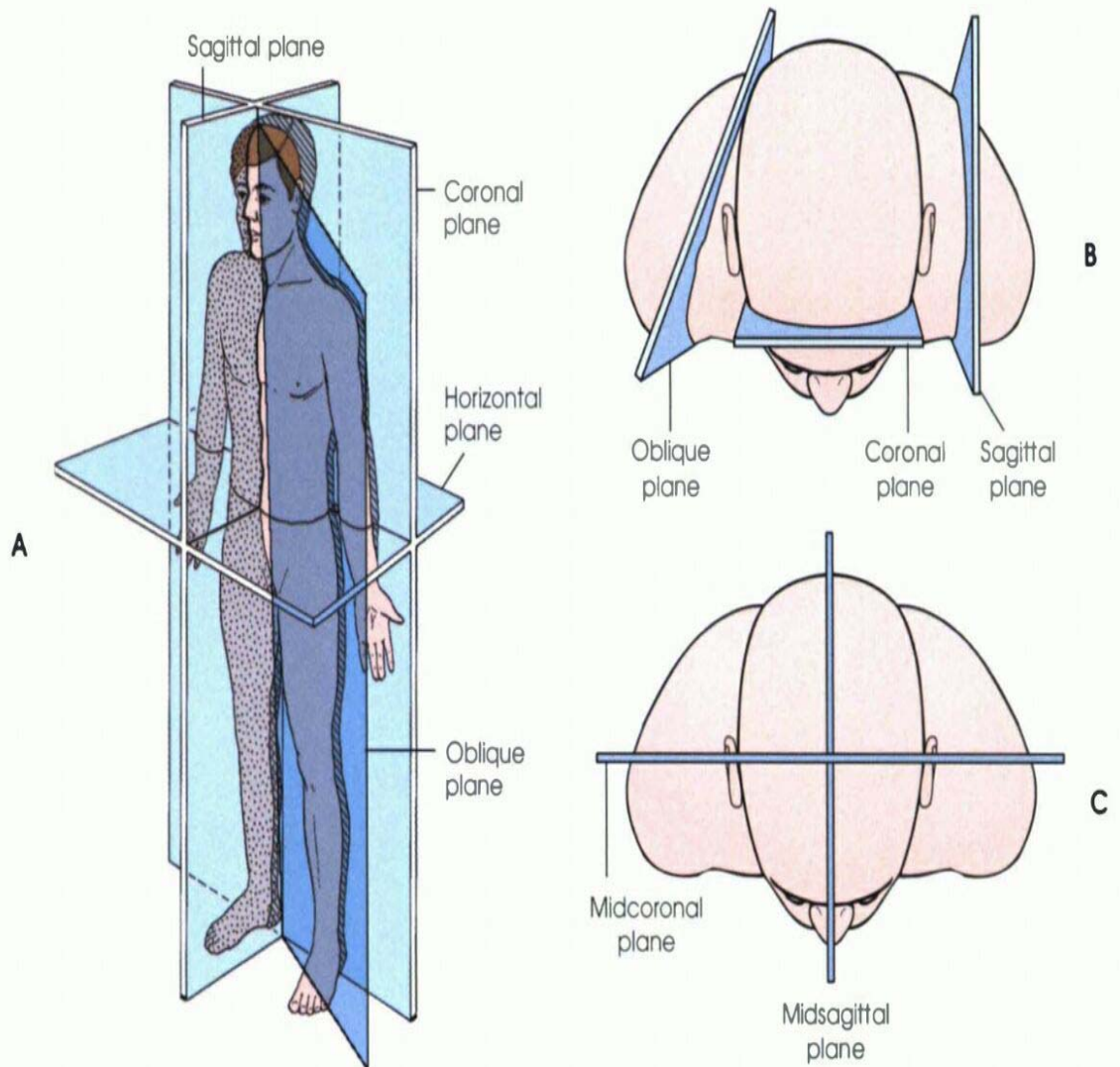
Anterior axillary line

Mid axillary lines

Posterior axillary line

Mid clavicular line

Mid inguinal line



**Fig. 3-1** Planes of the body. **A**, Patient in anatomic position with four planes identified. **B**, Top-down perspective of patient's body showing a sagittal plane through the left shoulder, a coronal plane through the anterior head, and an oblique plane through the right shoulder. **C**, Midsagittal plane dividing the body equally into right and left halves and midcoronal plane dividing the body equally into anterior and posterior halves. Note that sagittal, coronal, and horizontal planes are always at right angles to one another.

A



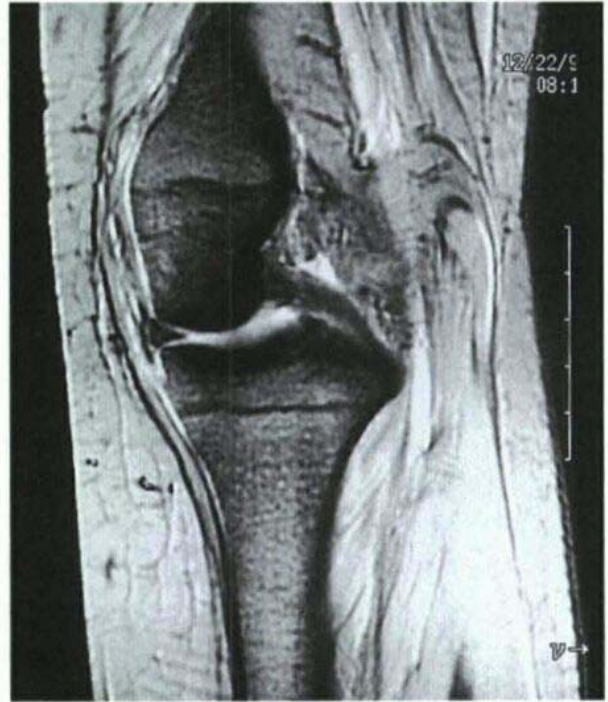
B



C



D



**Fig. 3-2** Magnetic resonance images of the knee in four planes. **A**, Sagittal. **B**, Coronal. **C**, Horizontal. **D**, Oblique, 45 degrees.

# External landmarks related to body structures at the same level

Body structures	External landmarks
<b>Cervical area (see Fig. 3-6)</b>	
C1	Mastoid tip
C2, C3	Gonion (angle of mandible)
C3, C4	Hyoid bone
C5	Thyroid cartilage
C7, T1	Vertebra prominens
<b>Thoracic area</b>	
T1	Approximately 2 in (5 cm) above level of jugular notch
T2, T3	Level of jugular notch
T4, T5	Level of sternal angle
T7	Level of inferior angles of scapulae
T9, T10	Level of xiphoid process
<b>Lumbar area</b>	
L2, L3	Inferior costal margin
L4, L5	Level of most superior aspect of iliac crests.
<b>Sacrum and pelvic area</b>	
S1, S2	Level of anterior superior iliac spines (ASIS)
Coccyx	Level of pubic symphysis and greater trochanters

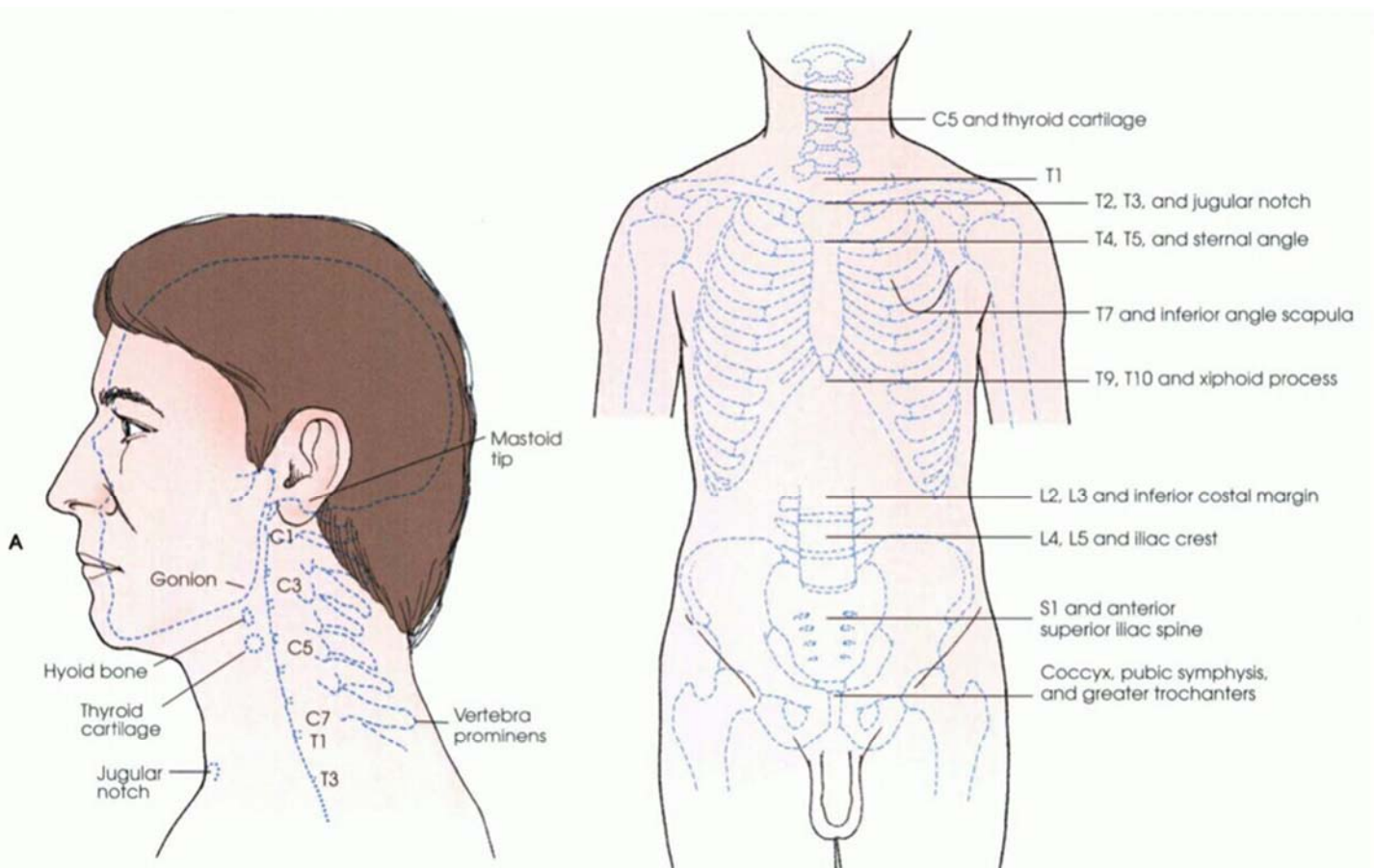


Fig. 3-7 Surface landmarks. **A**, Head and neck. **B**, Torso.

# Osteology

The adult human skeleton is composed of 206 primary bones. Ligaments unite the bones of the skeleton. Bones provide the following:

- Attachment for muscles
- Mechanical basis for movement
- Protection of internal organs
- A frame to support the body
- Storage for calcium, phosphorus, and other salts
- Production of red and white blood cells

The 206 bones of the body are divided into two main groups:

- Axial skeleton
- Appendicular skeleton

The *axial skeleton* supports and protects the head and trunk with 80 bones (Table 3-3). The *appendicular skeleton* allows the body to move in various positions and from place to place with its 126 bones (Table 3-4). Fig. 3-10 identifies these two skeletal areas.

**TABLE 3-3**

Axial skeleton: 80 bones

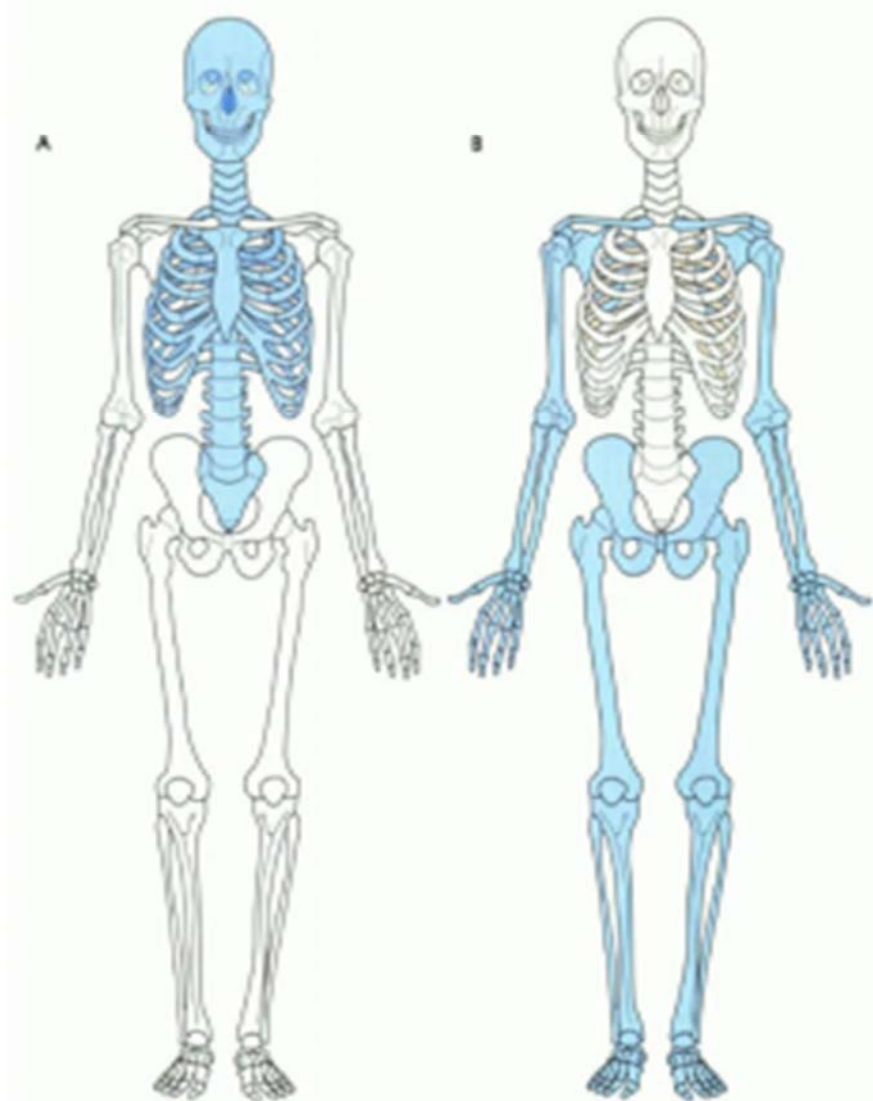
Area	Bones	Number
Skull	Cranial	8
	Facial	14
	Auditory ossicles*	6
Neck	Hyoid	1
Thorax	Sternum	1
	Ribs	24
Vertebral column	Cervical	7
	Thoracic	12
	Lumbar	5
	Sacrum	1
	Coccyx	1

\*Auditory ossicles are small bones in the ears. They are not considered official bones of the axial skeleton but are placed here for convenience.

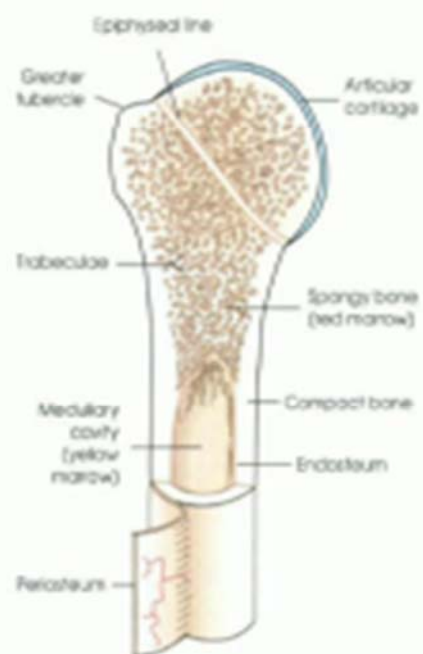
**TABLE 3-4**

Appendicular skeleton: 126 bones

Area	Bones	Number
Shoulder girdle	Clavicles	2
	Scapulae	2
Upper limbs	Humeri	2
	Ulnae	2
	Radii	2
	Carpals	16
	Metacarpals	10
Lower limbs	Phalanges	28
	Femora	2
	Tibias	2
	Fibulae	2
	Patellae	2
	Tarsals	14
	Metatarsals	10
	Phalanges	28
Pelvic girdle	Hip bones	2



**Fig. 3-10** Two main groups of bones. **A**, Axial skeleton. **B**, Appendicular skeleton.



**Fig. 3-11** General bone features and anatomic parts.



**Fig. 3-12** Radiograph of the distal femur and condyles showing the bony trabeculae within the entire bone.



## GENERAL BONE FEATURES :

All bones are composed of a strong, dense **outer part** called the **compact bone** that protects the bone and gives it strength for supporting the body , it is covered by :

**An Outer layer** of tough, fibrous connective tissue called the **periosteum** covers all bony surfaces except the articular surfaces, which are covered by the articular cartilage.

And **an inner layer** called the **endosteium** , that lining the medullary cavity .

The **inner part** of the bone is less dense ( softer ) called the **spongy bone ( the medulla )**

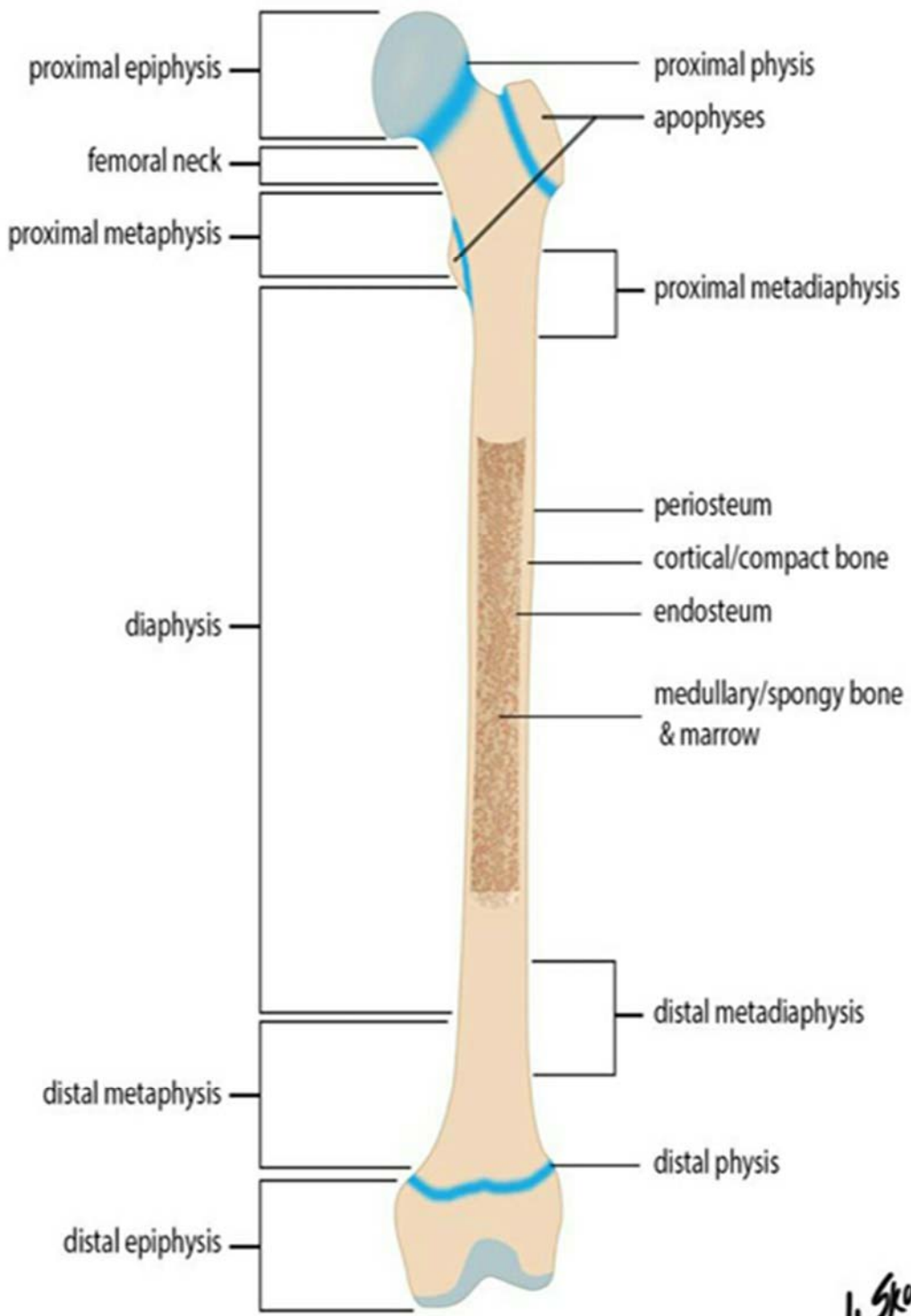
contains a speculated network of spaces called the **trabeculae**, that filled with red and yellow marrow

**Red marrow** produces red and white blood cells ,the red marrow concentrated at the ends of the bone and not in the medullary cavity

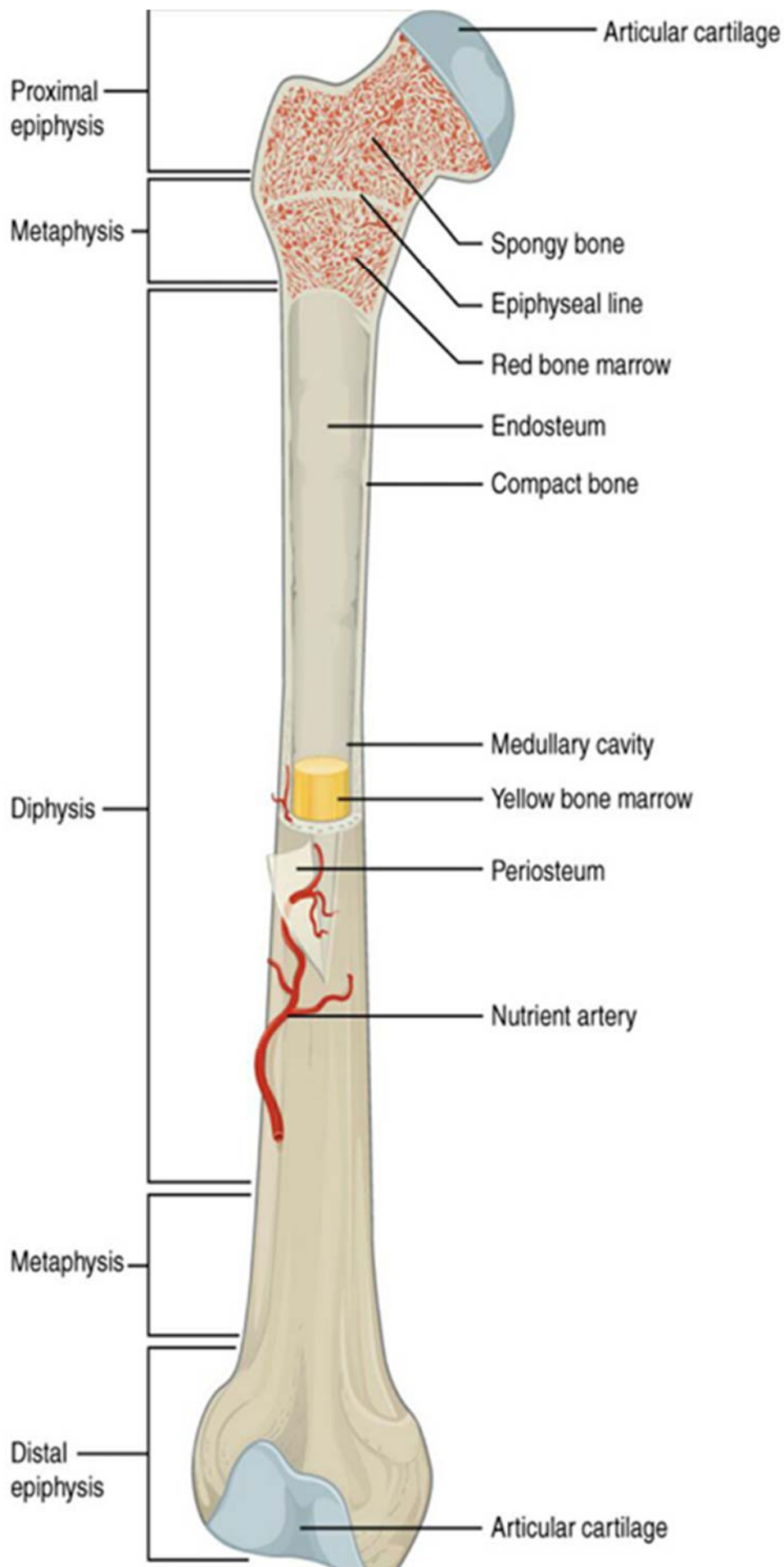
and **yellow marrow** stores adipose (fat) cells

Bones contain various knoblike projections called **tubercles and tuberosities**, which are covered by the periosteum ; Muscles, tendons, and ligaments attach to the periosteum at these projections.

Blood vessel and nerves enter and exit the bone through the periosteum.



*M. Skalski*



**Ossification** : is a process of formation and development of bones , it begins in the second month of fetal life.

## Primary Ossification

Begins before birth and forms the entire short bones , irregular bones and the shaft of the long bones ( diaphysis ).

## Secondary Ossification

Occurs after birth , a separate bone begins to form at each end of long bone called epiphysis .

**Epiphyseal plate (the physis )** is presented between the end of the bone ( the metaphysis ) and the epiphysis , this plate called ( **the growth plate**) which is responsible on growth of the bone and important in paediatric because it is a common site of fracture

This plate is **radiolucent** on x-ray , because it is cartilaginous in nature , after the growth is completed , the epiphysis and metaphysis will fuse together and only **epiphyseal line** seen which is **radioopaque** line.

Near the age of 21 , full ossification occurs .

## Classification of bones :

### Long bones :

found **only** in the limbs like the Femur and the Humerus in addition to the Phalanges of finger and toes ., the consist of cylindrical body and two rounded , enlarged ends

### Short bones :

are cancellous bones covered by thin **outer layer of compact bone** They are only found in the carpus and tarsus

## Flat bones :

they consist of **two tables of compact bone ( the diploe )** , surrounded by **inner and outer tables of compact bone**

Like the bones of cranium , sternum and scapula .

## Irregular bones :

have variety of shapes , like bones of the face , vertebrae and pelvis

## Sesamoid bones :

Very small , oval shaped , found inside and beside the tendons

**Their function is to protect tendons from excessive wear**

-The **largest** sesamoid bone in the body is the **patella** .

-2 small sesamoid located under the base of big toe .

- Os trigonum : posterior to the talus and Os peroneum behind the 5<sup>th</sup> metatarsal

They are like other bone can be fractured and inflamed .

## Accessory bones

Small superadded bones that are not usually presented in the body like fabella .

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## Vertebral column (Spine )

Consists of **33** vertebrae

7 cervical , 12 thoracic (dorsal ) , 5 lumbar , 5 sacral (fused/sacrum) and 4 coccygeal ( fused/ coccyx ).

In adult the cervical and lumbar spine are in extension posture called **Lordosis** .

## Typical vertebra

Has concave surface anteriorly and on both sides , and straight surface posteriorly .

Has a vertebral **body** anteriorly and a **neural arch** posteriorly .

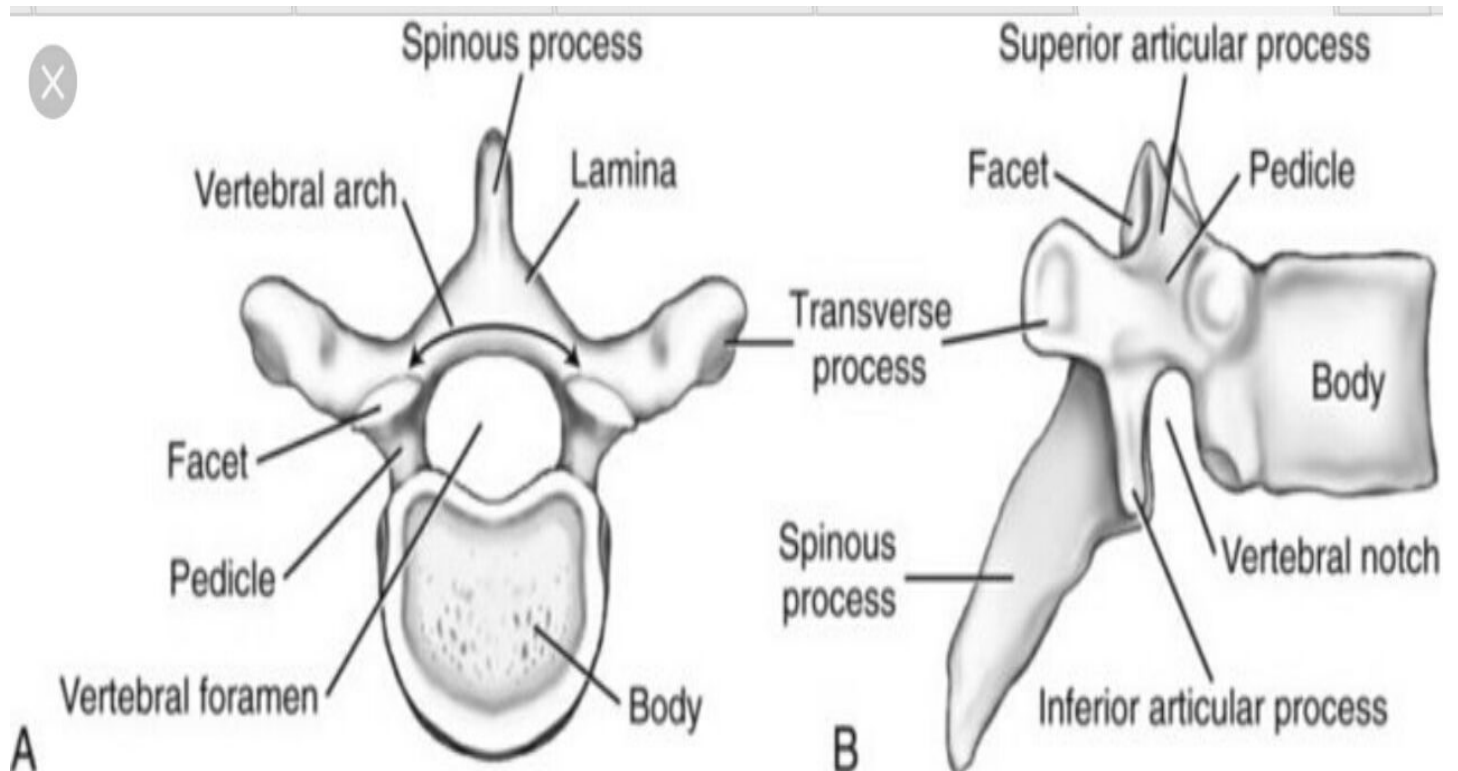
The neural arch has **pedicles** laterally and **laminae** posteriorly .

The pedicles are formed between the body and the transverse process , they are notched superiorly and inferiorly , so that the adjoining pedicles form intervertebral foramina that transmit the segmental nerves( there are 31 segmental spinal nerves) .

A **transverse process** forms at the junction of the pedicle with the lamina and extends laterally on each side .

A **spinous process** forms by the junction of the 2 laminae posteriorly.

From each lamina 2 articular processes containing facets project superiorly and inferiorly that articulate with the facets of the superior and inferior vertebrae .



So the spinal canal forms by the vertebral body anteriorly and the neural arch posteriorly

The spinal cord is located inside giving the spinal nerves .

## **Cervical spine**

Characterized by the presence of the **transverse foramen** within the transverse process that transmits the vertebral artery and vein and the sympathetic nerve.

All the cervical vertebrae have small bodies and large spinal canal because the spinal cord at this region is large

The spinous processes from C2 –C6 are bifid

The spinous process of C7 is not bifid and it is the **longest** spinal process ( **vertebra prominence**)

The largest spinous process is that of the C2 .

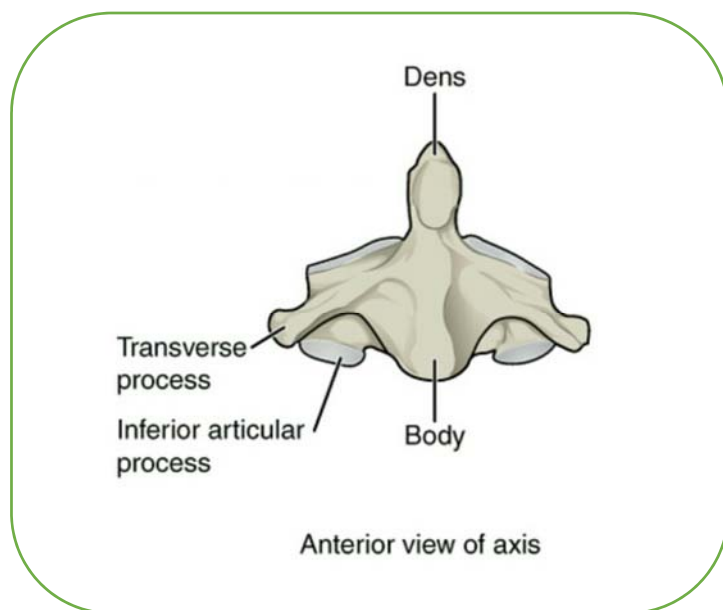
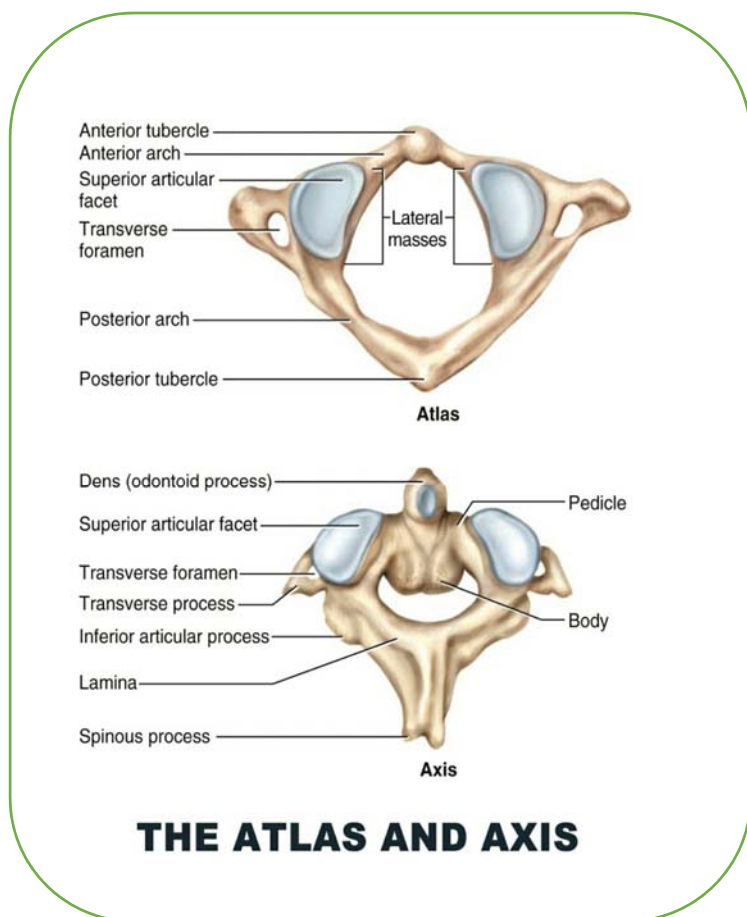
## Atlas – C1

It articulates superiorly with occipital condyles forming the atlanto-occipital joint and articulates inferiorly with the axis forming the atlanto-axial joint.

It has no vertebral body nor spinous process but anterior and posterior neural arches.

## Axis – C2

It has superior process ( odontoid process/ odontoid peg / dens ) which represents the head of atlas that is articulate with the anterior arch of atlas , it has **largest** spinous process



## Thoracic Spine

They have additional facets on each side to articulate with ribs .

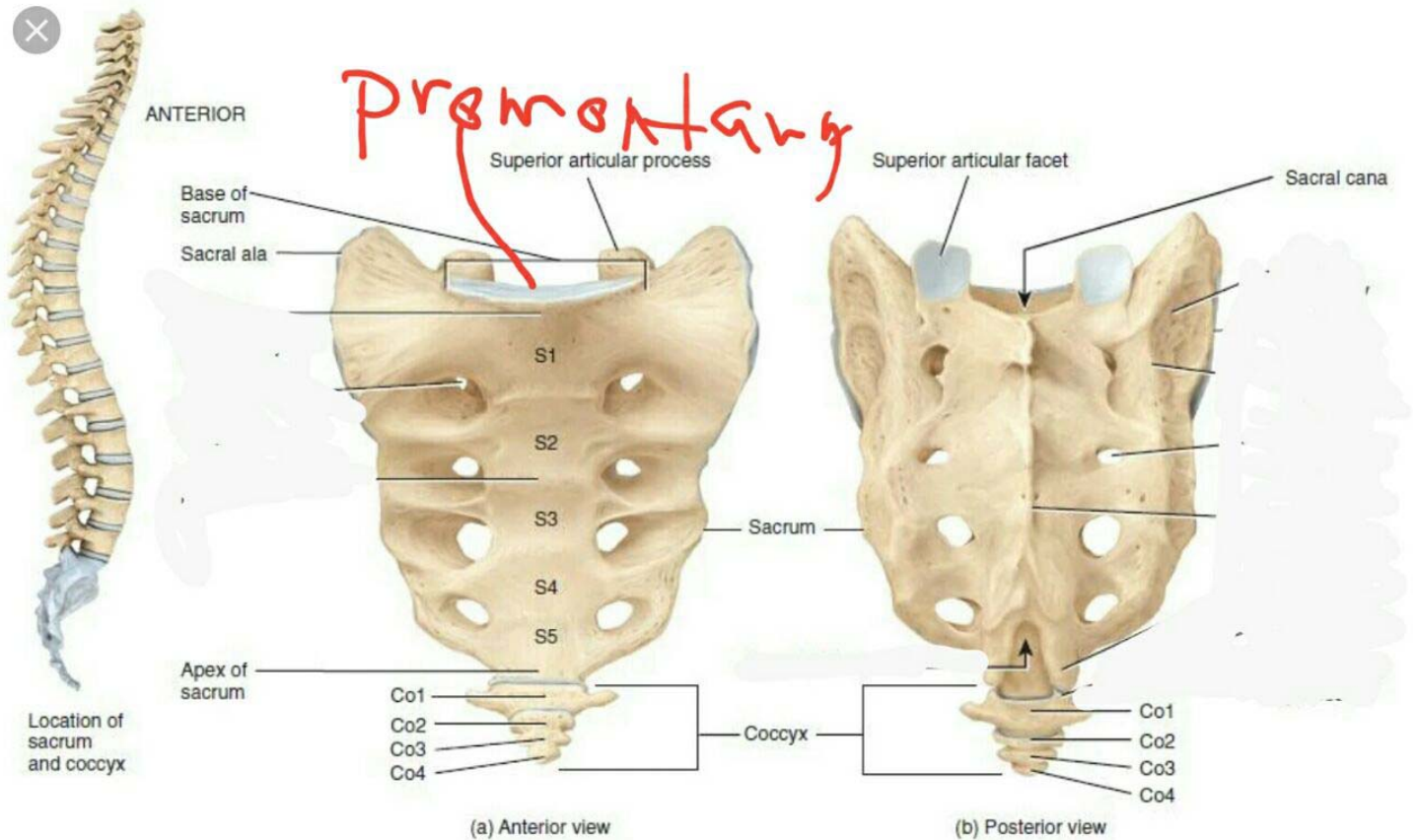
## Lumbar Spine

Characterized by large vertebral bodies and small spinal canal

## Sacral spine

The fused sacral vertebrae form a pyramidal shaped bone that have promontory superiorly to articulate with the L5 ( Lumbosacral joint ) and articulates at he lateral sides with the iliac bone to form the sacro iliac joint .

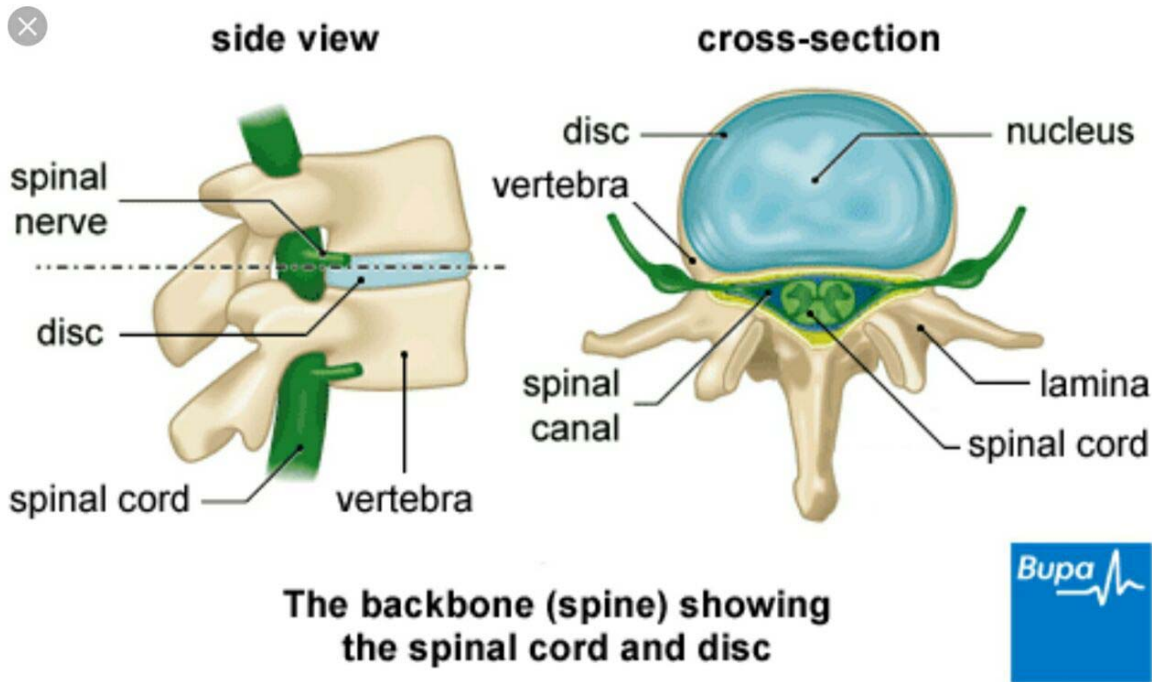
## Coccygeal spine (coccyx )



## Inter vertebral disc

It is a gelatinous material surrounded by fibrous ring , it is located between vertebrae





**Common Anatomical , Pathological terms and diseases that mentioned in x ray request :**

المصطلحات التشريحية والمرضية وبعض الامراض التي تذكر في ورقة الاشعة ( الريكويست )

**1 -Degenerative change of osteoarthritis ( O.A change )** is common at the weight bearing area like lumbar spine , mainly at L4-5 , which is seen as change in bone density( osteopenia ) and osteophyte formation and may associated with loss of joint space between vertebrae .

**2- Disc prolapse or disc herniation** , mainly at lower lumbar L5-S1 or lower cervical

When the fibrous ring is become weak and may torn and the gelatinous nucleus bulging out and press the spinal nerve ,

Which is shown as narrowing of the space between vertebrae or complete loss of joint space .

### **3 – Cervical rib**

An accessory rib forms unilateral or bilateral from the transverse process of C7 .

### **4 –coccyx area**

This area is important to be seen well in radiograph because it may be fractured or dislocated but not detected causing a chronic pain

Also it may be a source of pain when it is curved to inside more than usual .

**5 - Butterfly vertebra** : congenital loss of its typical shape and appears like butterfly .

**6 -Blocked vertebra** when 2 vertebrae are fused together congenitally and have one spinous process .

**7 - Spina Bifida** : is congenital failure of fusion of the spinous process that may be normal finding or associated with urine incontinence .

**8- Limbus vertebra** : is congenital unfused apophysis which is seen as small triangular bone at the anterior superior surface of the vertebra , resembling a small fracture .

**9- Vertebra Plana** is flattened vertebra in certain disease like leukemia and lymphoma.

**10- Bamboo stick spine** : seen in ankylosing spondylitis , it is due to calcification of ligaments around the vertebrae

**11 -Spondylosis** : is a defect in the posterior part ( neural arch ) of the vertebra at pars interarticularis with out slipping .

**12 -Spondylolisthesis** : is anterior or posterior slipping of vertebra due to defect in pars interarticularis .

## Spinal Cord

It extends from medulla oblongata at foremen magnum to conus medullaris distally at the level of **L1-L2**

It **31 pairs** of nerves which supplies whole the body by sensory and motor nerves

Like the brain ,it consists of grey and white matter and covered by meninges

It has a central canal for CSF

The subdural space called the **thecal sac** ( dural sac )

**The sub arachnoid space** is the part that shows the contrast in myelography either by injection ( lumbar puncture ) in conventional myelography or CT myelography or as fluid properties in T2 MRI .

The spinal column is surrounded by many ligaments ,the most known ligaments are **anterior and posterior longitudinal ligaments** , which may calcify in certain diseases like Ankylosing Spondylitis .

## Pelvis

It consists of Rt and Lt part , each part consist of 3 bones :

( Ischial (( Ischium )) , Iliac ((Ilium)) and pubic bones )

The **Ischium** has greater and lesser sciatic notch .

### The Ilium

is a flat curved bone ,its upper part called the **iliac wing** that has **iliac crest** superiorly.

On this crest

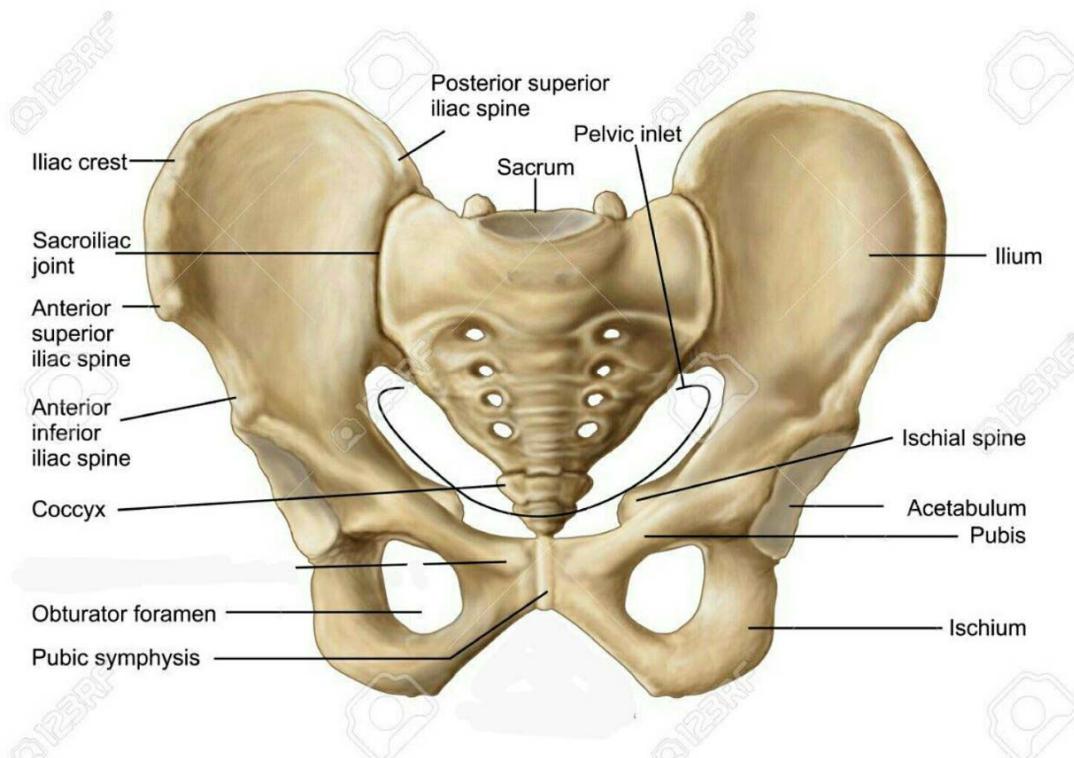
the **anterior superior** and **posterior superior** iliac spine are located

below them the **anterior inferior** and **posterior inferior** iliac spine , which are sites for muscular attachment .

They show avulsion fracture in certain types of trauma .

Each iliac bone articulate with Sacrum to form the **sacro-iliac joints** (SI joint) , which are important joints in radiology in many Rheumatological diseases like ( rheumatoid arthritis , ankylosing spondylitis and Psoriatic arthropathy )

where this joint may become **eroded ,widened then sclerosed and fused** . .



The **Pubic** bone consists of body and superior and inferior ramus , each pubic bone fuse with the other one at midline at **symphysis pubis** .

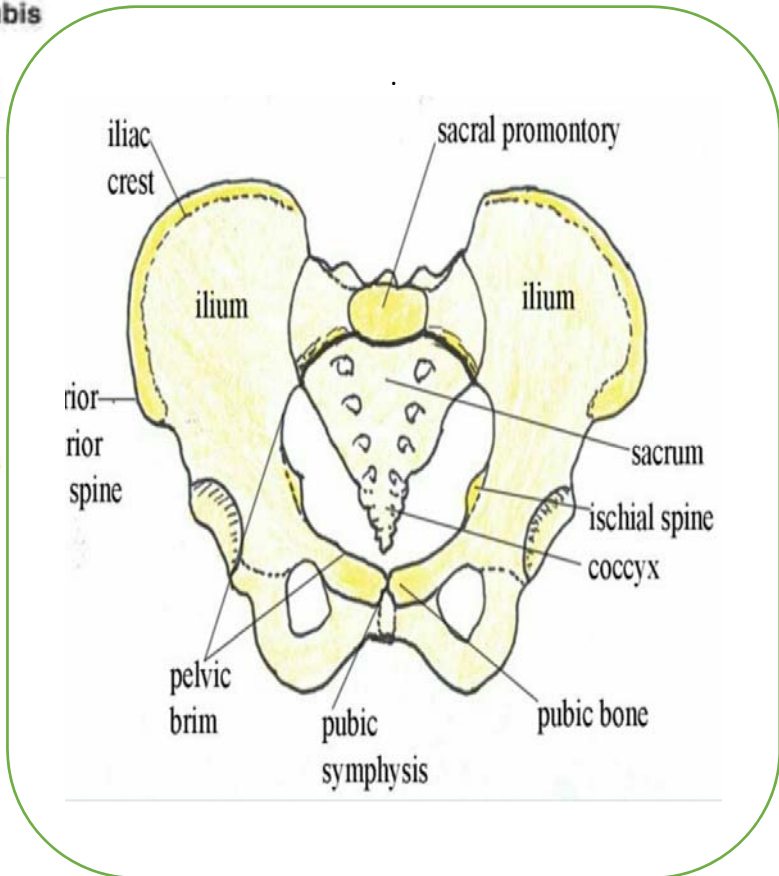
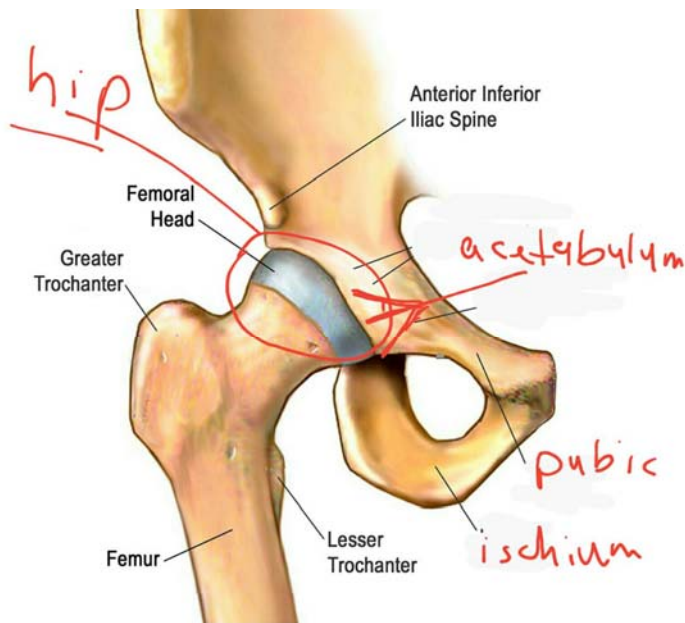
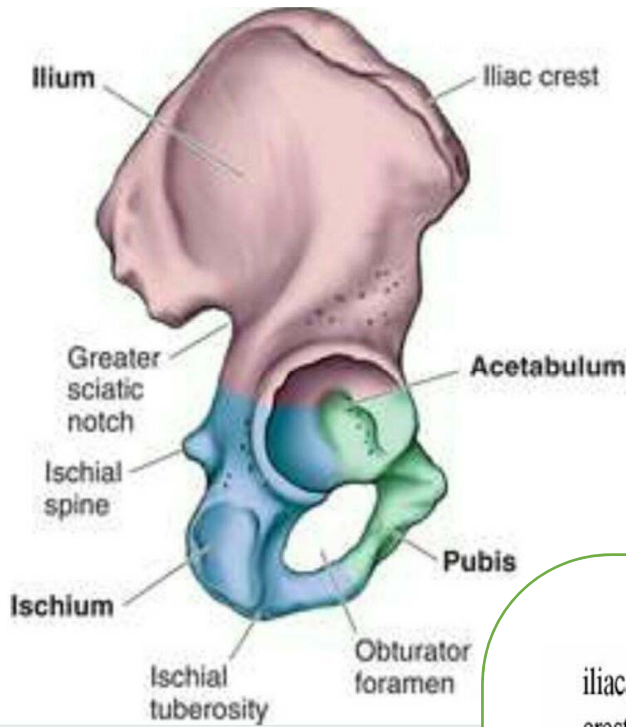
Ischium and pubic bones form the **obturator foramen** .

The 3 bones at each side articulate together to form the **acetabulum** , which is the room for the femoral head ( **the hip joint** )

The SI joint and the symphysis pubis are stable joints but slightly lax during labor.

The pelvis is a cavity, its entrance called pelvic inlet( pelvic brim ) and its lower opening called pelvic outlet .

The pelvic floor consists of muscles, the outer inferior surface is the perineum.

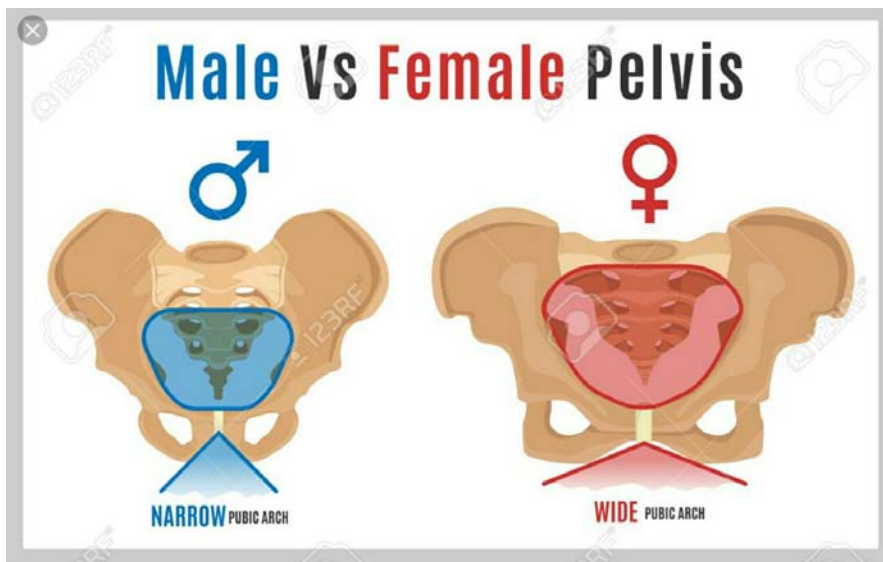


## The female pelvic inlet is

- 1 **wider** in diameter than in male and the angle between inferior pubic rami is wide
- 2 **oval or round shape**
- 3 **The pelvic cavity is shallow and short .**

## The male pelvic inlet is

- 1 **narrower** than in female and the angle between the inferior pubic rami is narrow
- 2 **triangular or heart-shaped**
- 3 **The pelvic cavity is deep and funnel –shaped.**



## Femur

Is the longest bone in the body ,

Its proximal(upper) end is called **head** , which articulate with the acetabulum , forming the Hip joint

The **neck** is joining the body (the shaft) in 120-140 angle .

2 trochanters adjacent to the neck at the **proximal metaphysis** ; the greater trochanter to outer surface and the lesser trochanter is to the inner surface .

The **distal metaphysis** is expanded into 2 condyles , the medial condyle is larger than the lateral condyle .

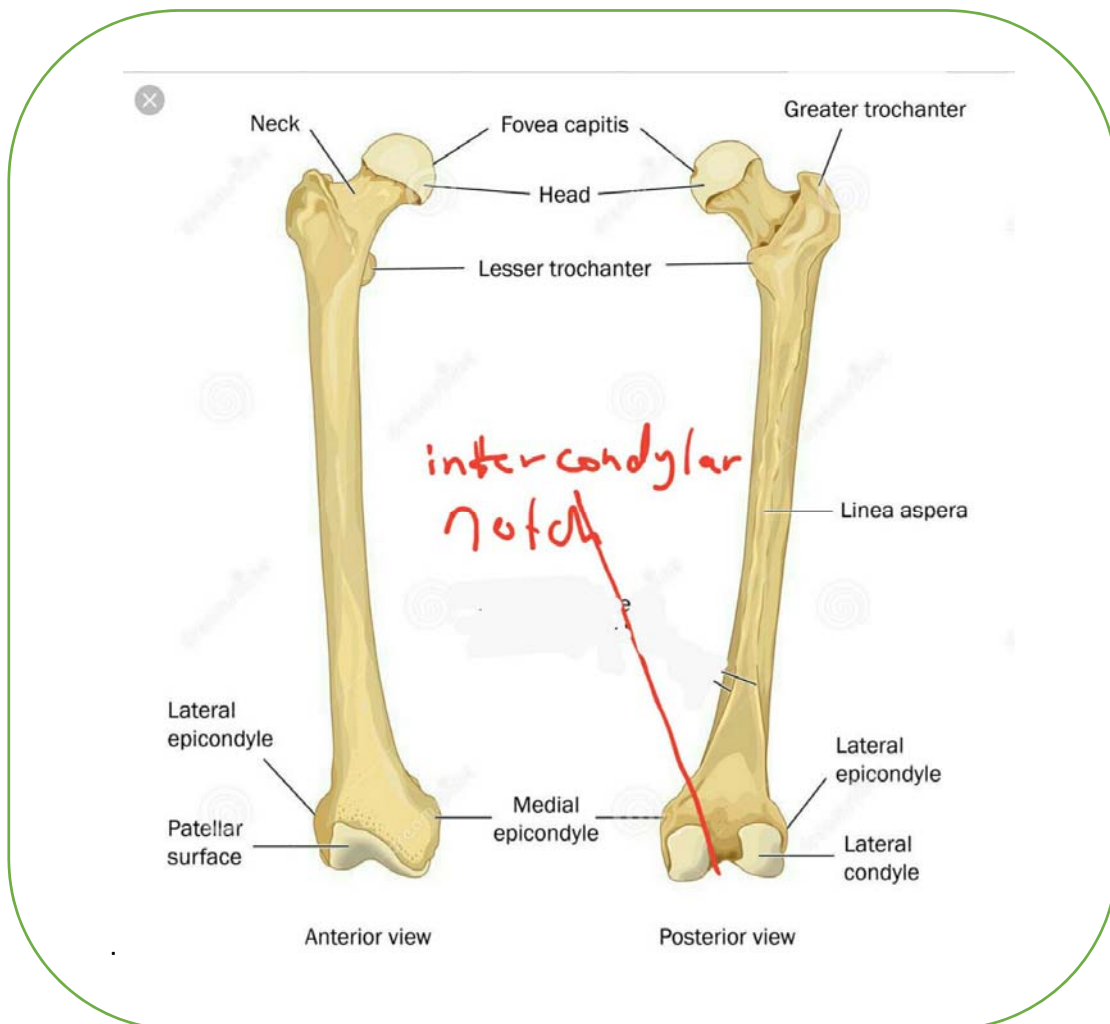
The anterior surface of the distal end is the **patellar surface** and the posterior surface is the **intercondylar notch**.

The main blood vessels and nerves lie on the medial aspect of the thigh .

The secondary ossification center of the femur

The head is appear after the 6<sup>th</sup> month of life .

The greater trochanter at 4<sup>th</sup>-5<sup>th</sup> y and the lesser trochanter at 8<sup>th</sup> -10<sup>th</sup> year .



## Knee joint

Is formed by articulation of the 2 femoral condyles with tibia and the deep surface of patella.

It is surrounded by a capsule , that is lined by synovium( synovial cavity ) , which contains oily fluid ( synovial fluid ) that nourishes the articular cartilage and decrease the friction between them . the synovial cavity communicates with **several bursa** , that contain synovial fluid , too .

The knee is supported by six main ligaments :

Medial and lateral mensci ( meniscus)      الاربطة الهلالية

Medial and lateral collateral ligaments      الاربطة الضامة

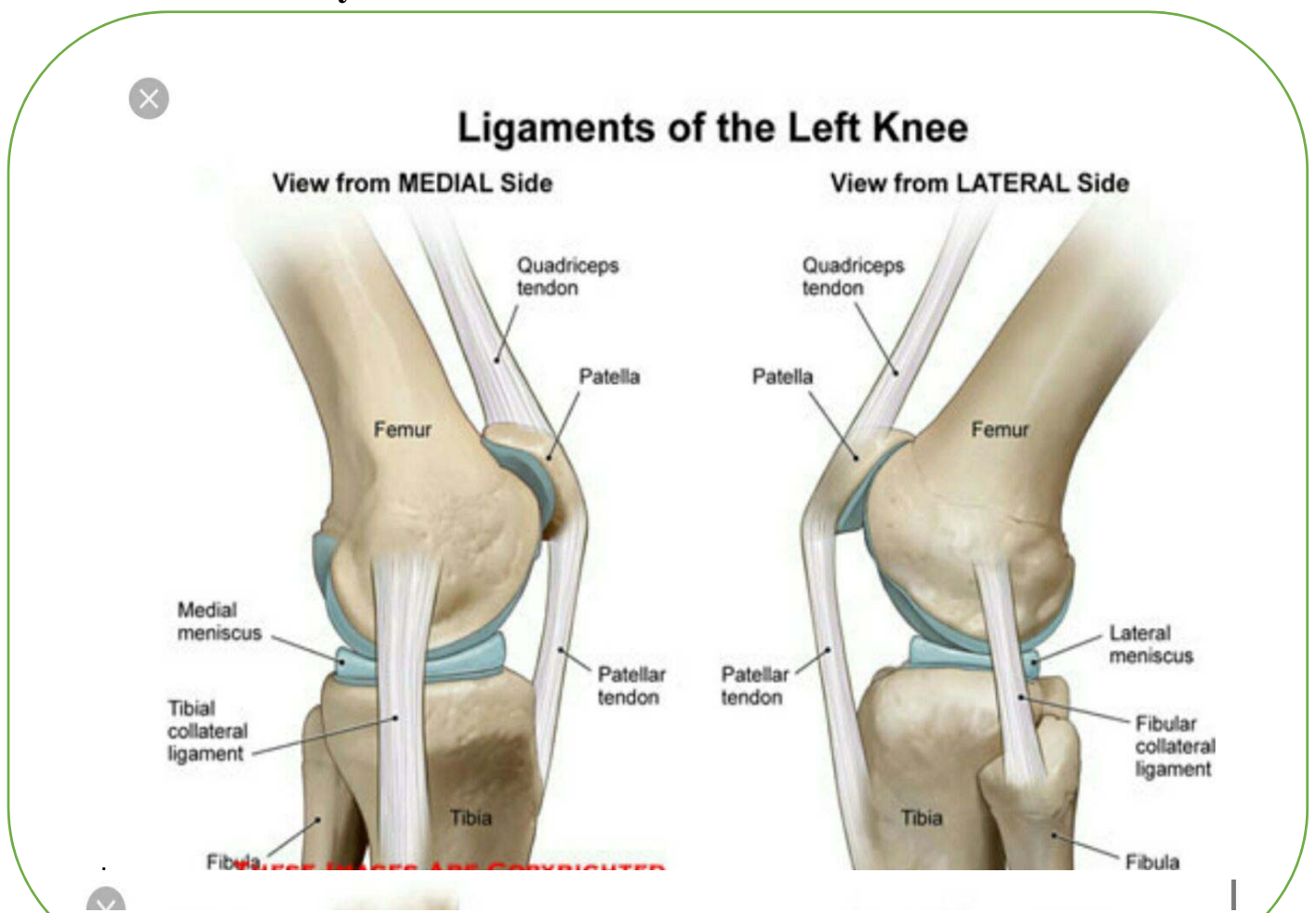
Anterior and posterior cruciate ligaments      الاربطة الصليبية

The patella located at the end of the **quadriceps tendon** at the upper end and attached to the **patellar tendon** at the lower end , under which the infrapatellar fat pad is located .

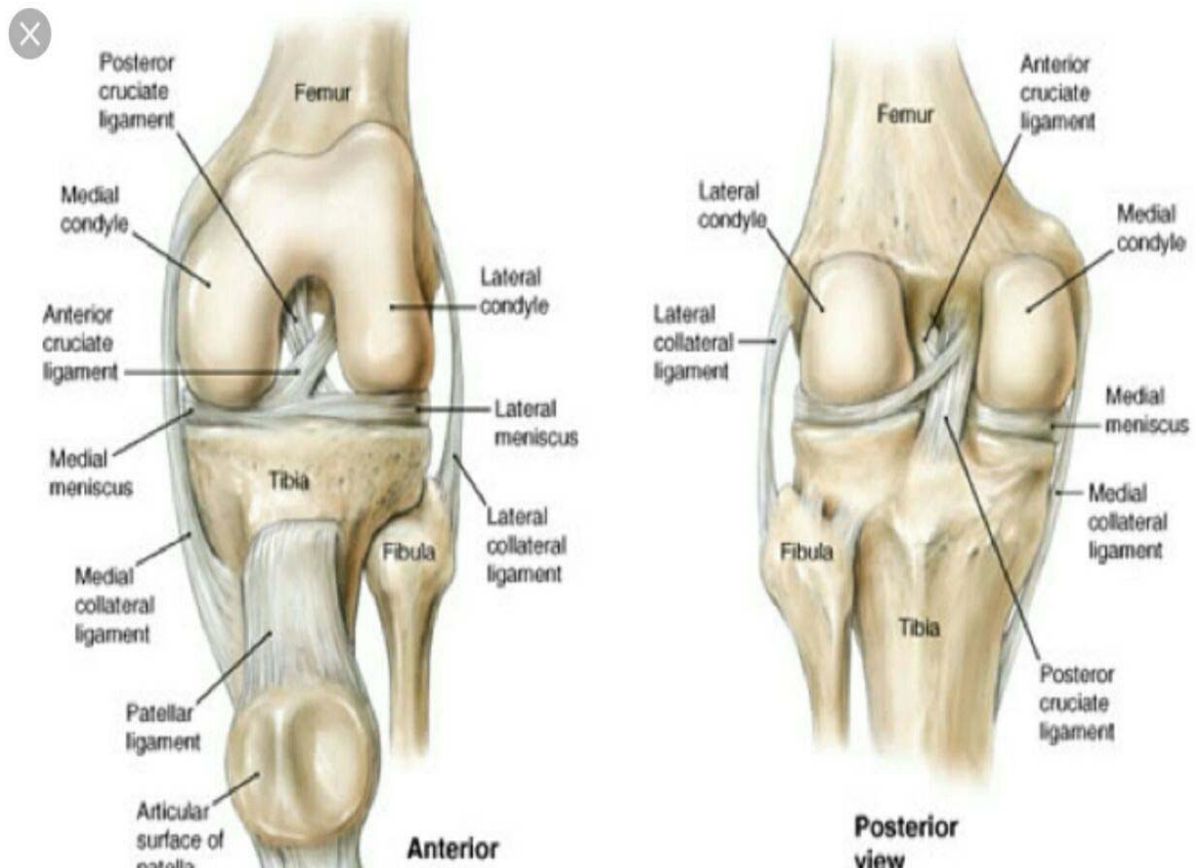
The patella-femoral compartment ( surface) is the 1<sup>st</sup> site for development of OA change .

The posterior aspect of the knee called the **popliteal fossa** , it consists of muscles , and contains popliteal artery and vein and tibial nerve .

A bursa in the popliteal fossa may collect synovial fluid and inflamed forming what is called **Baker cyst**.







## Pitfalls

- **Sesamoids**
  - Bones that form in a tendon as it passes over a joint. The patella is the largest.
- **Accessory ossicles**
  - These are accessory epiphyseal or apophyseal ossification centres that do not fuse with the parent bone

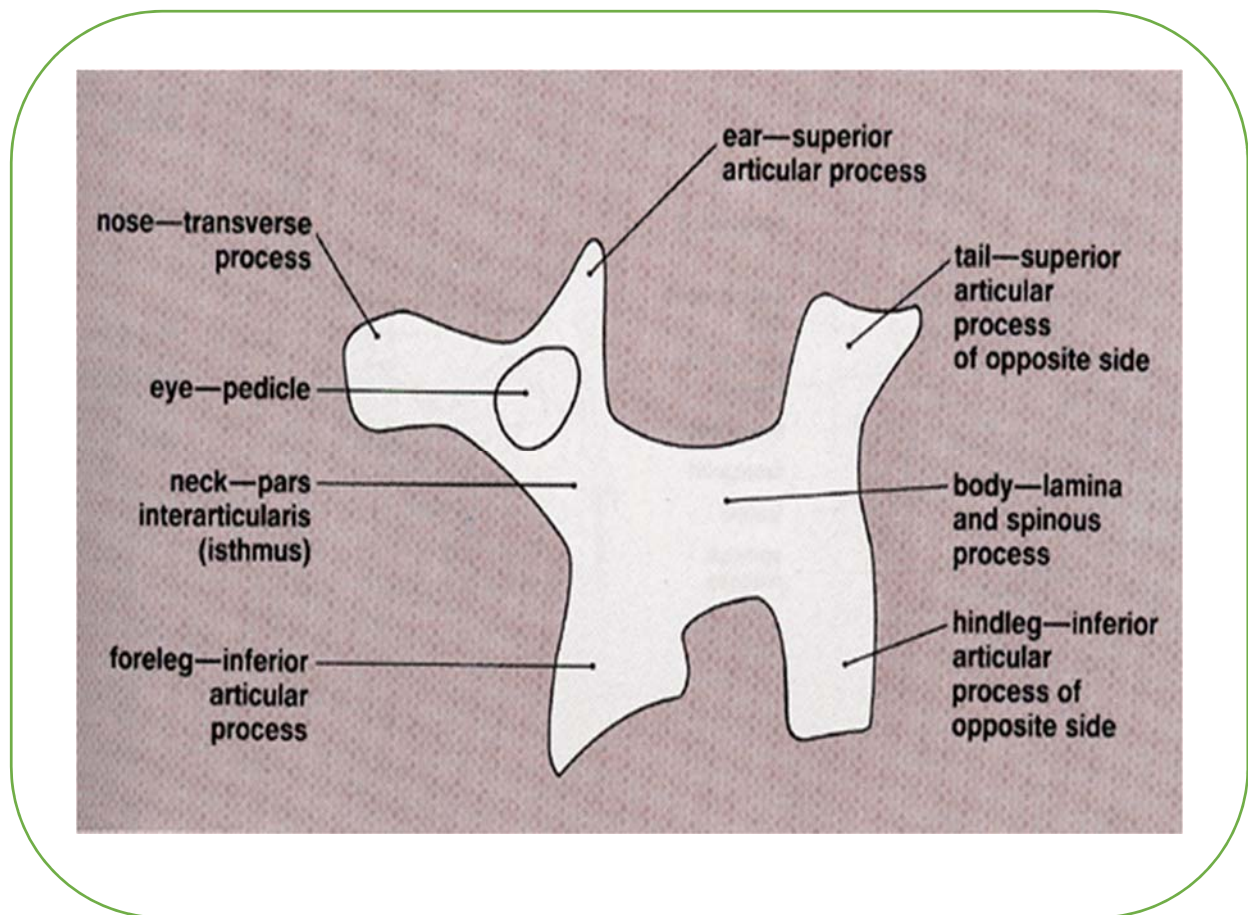
Unlike fractures these small bones are corticated and their edges are usually smooth

## Scottie dog sign (spine)

The **Scottie dog sign** refers to the normal appearance of the lumbar spine when seen on oblique radiographic projection. On oblique views, the posterior elements of the vertebra form the figure of a Scottie dog with:

- the **transverse process** being the nose
- the **pedicle** forming the eye
- the **inferior articular facet** being the front leg
- the **superior articular facet** representing the ear
- the **pars interarticularis** (the portion of the lamina that lies between the facets) equivalent to the neck of the dog.

If **spondylolysis** is present, the **pars interarticularis**, or the neck of the dog, will have a defect or break. It often looks as if the dog has a collar around the neck (or decapitation for those with a bloodier imagination).



# Tibia

At **upper end** is expanded to form : medial and lateral **tibial plateau** (**condyle**) as the articular surface with the femoral condyles.

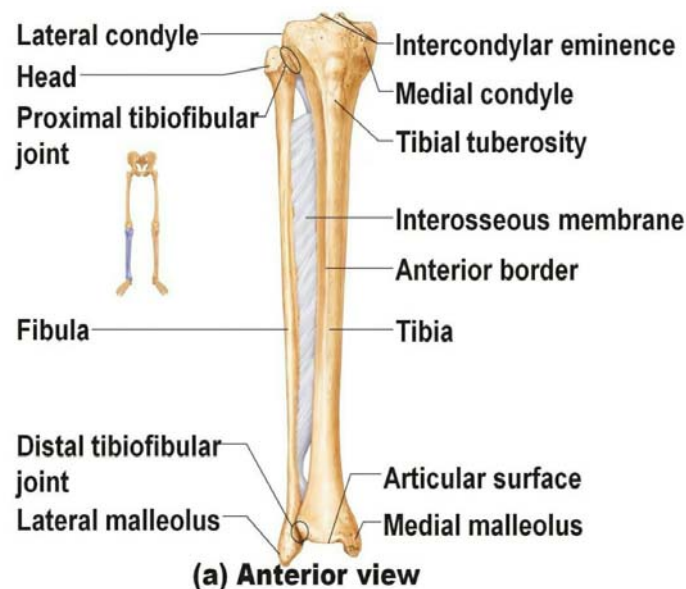
Between the condyles at the tibial surface there is a **tibial spine** which has medial and lateral projections ( **intercondylar eminence** ) .

At the anterior upper aspect of the shaft there is a **tibial tubercle**

The anteromedial surface of tibia is subcutaneous while the posterior surface is deep to muscles of the calf .

At the **distal end** it has the **medial malleolus** medially and the inferior **tibiofibular joint** laterally .

The inferior surface is flattened to articulate with the talus to form the Ankle joint .



Tagged: image of tibia bone, photo of tibia bone, picture of tibia and fibula bones, picture of tibia bone

## Fibula

It does not share in movement nor weight bearing .

It has 2 small joints with tibia ( the superior and inferior tibiofibular joints ).

It share in the formation of ankle joint by the articulation with the talus .

Its lower end expands to form **lateral malleolus** .

## Foot

Consists of :

**Tarsal** (7 bones ) :

Talus , Calcaneus ,Navicul ,Cuboid and 3 cuniform .

## Metatarsal

5 long bones .

## Phalanges

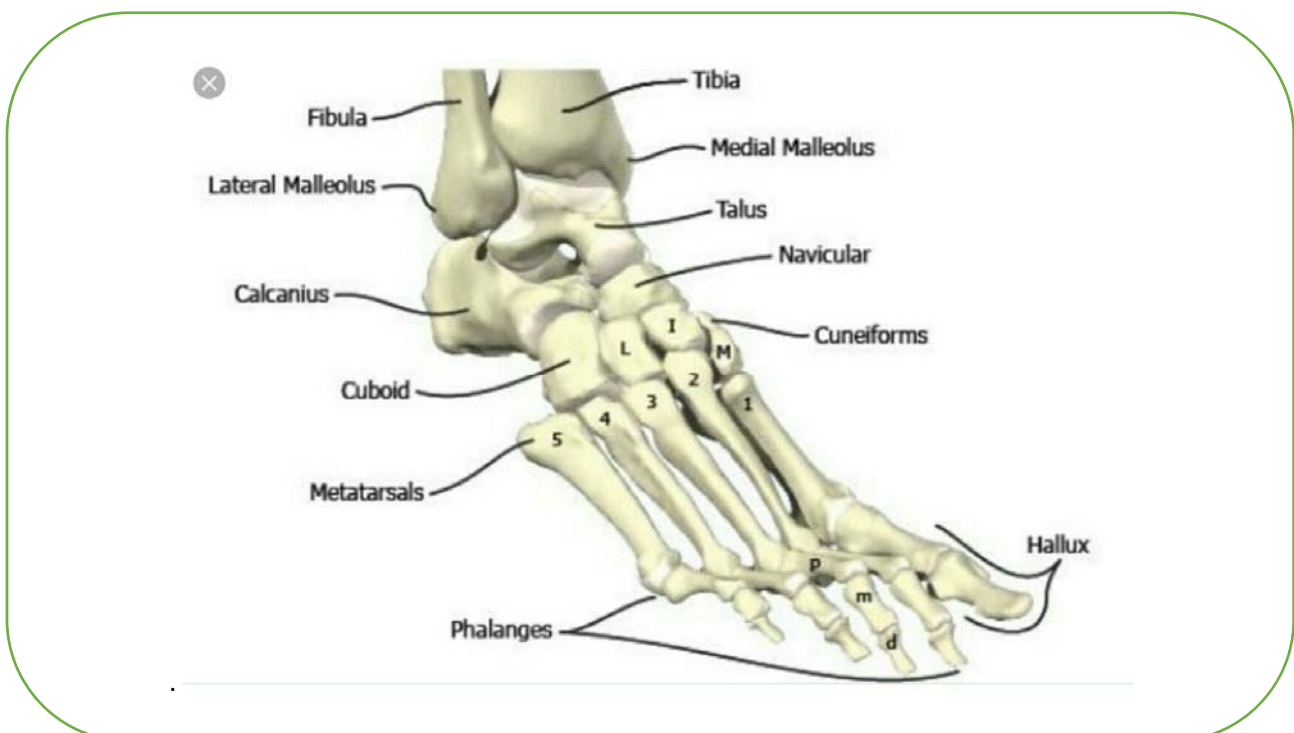
( proximal , middle and distal phalynx for each toe , except the big toe which have only proximal and distal phalynx )

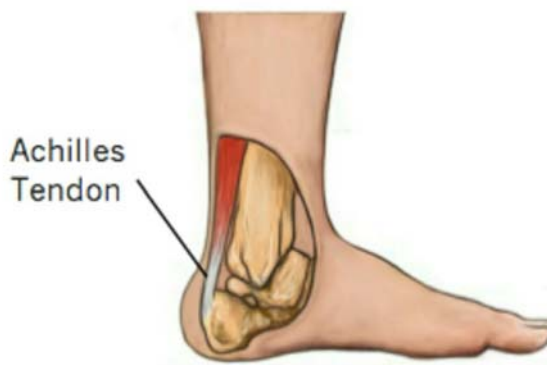
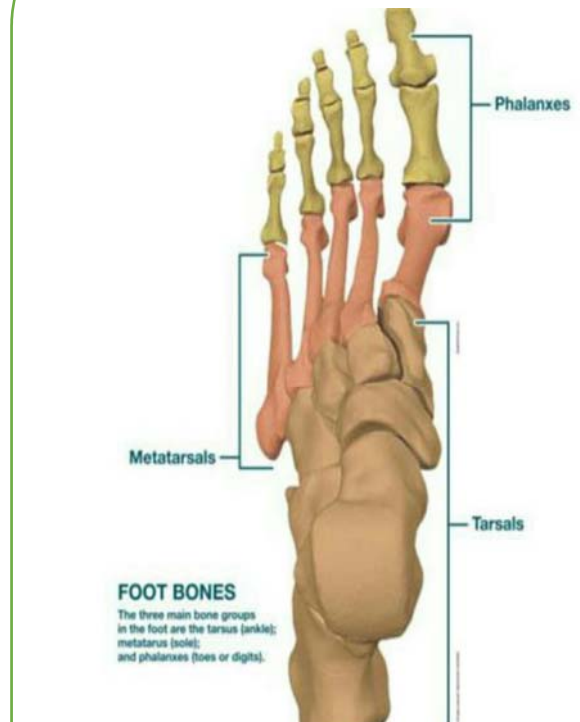
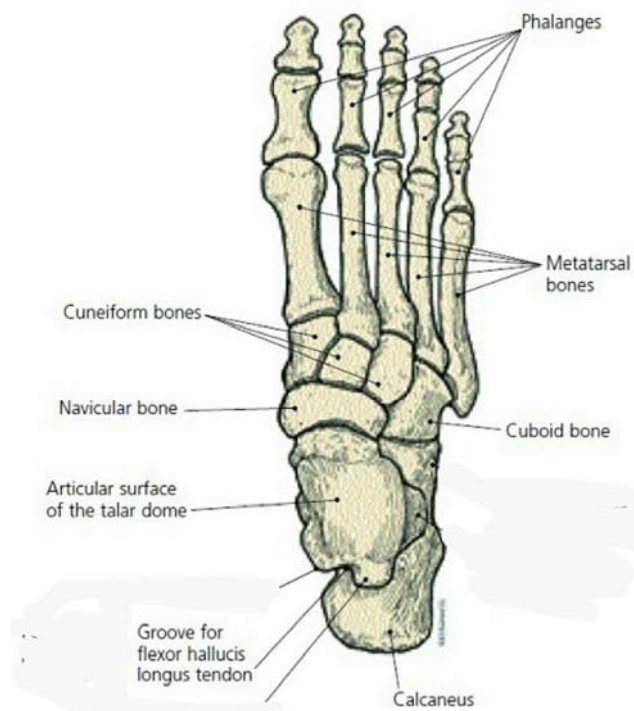
The big toe called **Hallux**.

The talus articulate with the tibia and fibula to form the anke joint

The calcaneus ( **calcaneum forms the heal** ) ,

**Achilles tendon** attached to the posterior surface of **calcaneum** , it is the **thickest tendon** in the body .





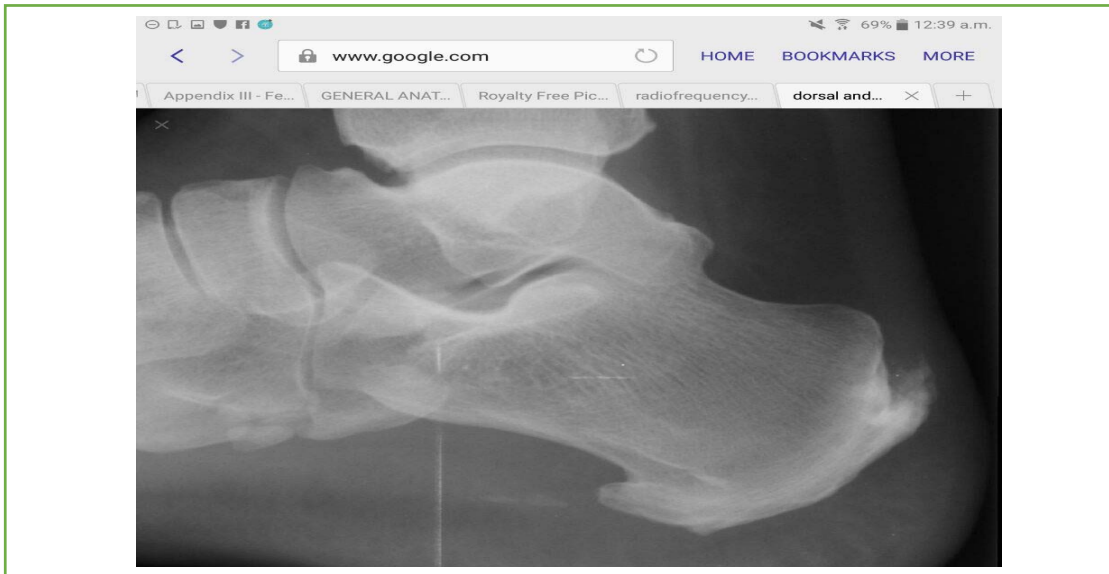
The lower surface of the foot called the **plantar surface**

Which is arched normally .

When this arch is loss , the foot is called **Flat Foot**

Common Abnormality in daily practice in foot radiograph is **calcaneal spur** which is a projection either at the planter aspect or dorsal aspect of calcaneum or both aspects ,Unilateral or bilateral

The pain of the Foot is not from the spur itself but from the fasciitis caused by this spur .



## **Gout**

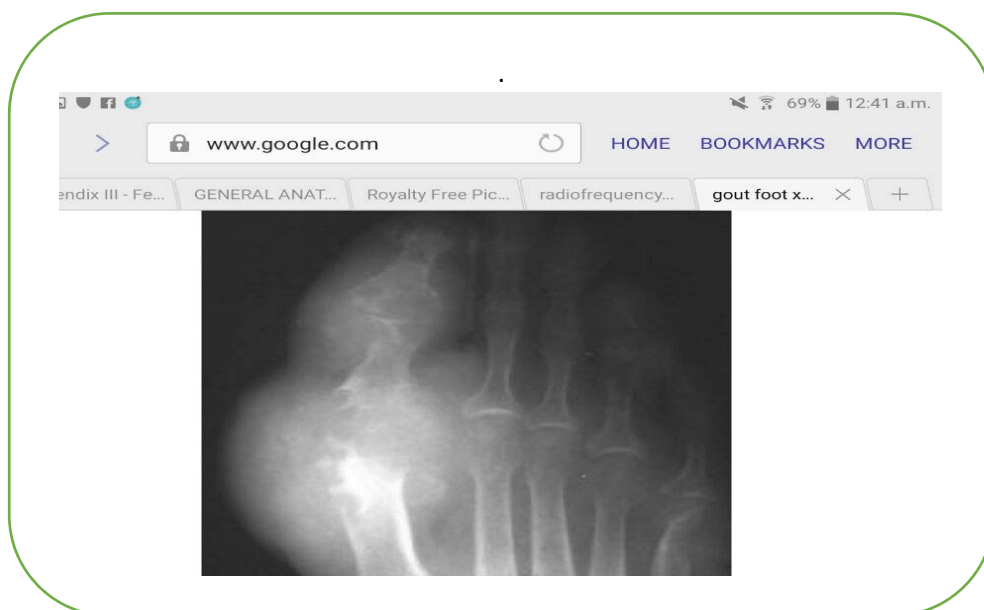
**(Increase Uric acid)**

Mainly affect juxta articular area ( beside the articular surface)

When affect the foot , it is mainly occurs at the big toe .

It cause erosion of the bony then destruction

It is associated with soft tissue swelling.



# The Hip Joint in Infant

Usually the femur is seen without epiphysis within the 1<sup>st</sup> 6 month of life ( because the femoral head is cartilagenous in this period so it is radiolucent ).

The femoral capital epiphysis ( proximal epiphysis ) begins to erupted ( epiphysis appearance ) in the 6<sup>th</sup> month of life .

The acetabulum (as a room ) is still not developed yet in this period.

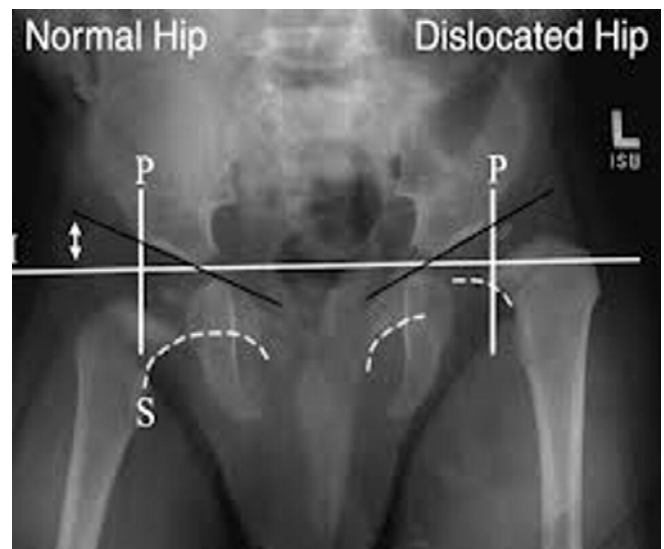
The 2/3 of the femoral head should be medial to the lateral aspect of acetabulum ( perkin line ) .

Another line is drawn from the inferomedial surface of the femoral neck to the superior border of obturator foramen , should be a continuous curve ,semi-circle ( not interrupted ) , this is called (Shenton line).

## Developmental Dysplasia of Hip : DDH

It is an abnormal development and formation of the hip joint in the 1<sup>st</sup> year of life  
It had thought to be congenital ( CDH ) but indeed it is a developmental process causing abnormal ( asymmetrical ) or delayed eruption of the femoral capital epiphysis with displaced femur laterally ( dislocated ) and as a consequence results in a shallow acetabulum ( dysplasia ).

It could be unilateral or bilateral .



## Perthes disease

It affect femoral capital epiphysis in children the epiphysis is flattened , fragmented , dense (sclerotic ) and result in mushroom deformity of it



## Osteosclerosis

Abnormal increase in bone density due to different conditions or diseases, it could be acquired ( due to hypervitaminosis D or hereditary ( like osteopetrosis and osteopoikylis)





## Osteopetrosis

It is a hereditary disease leads to thick bon with increase density . , the bone although appears thick but is more liable for fracture .

## Osteopoikelosis

It is a hereditary numerous white densities of same sizes spread throughout the bone , usually it is asymptomatic .

Some times it is difficult to differentiate from bone metastasis



## Bone island

Is a **white density** focus of **compact bone** located within the cancellous bone , it is found incidentally , and sometimes difficult to be diffentiate from sclerotic metastasis.



## Transitional lumbosacral vertebra

- **Sacralization and lumbarization** are congenital anomalies of the fifth lumbar (L5) and first two sacral (S1 and S2) segments.
- The anomalous segments are frequently referred to as transitional vertebrae.
- **Lumbarization** occurs due to non-fusion of the first two sacral segments allowing the lumbar spine to have what appear to be six segments

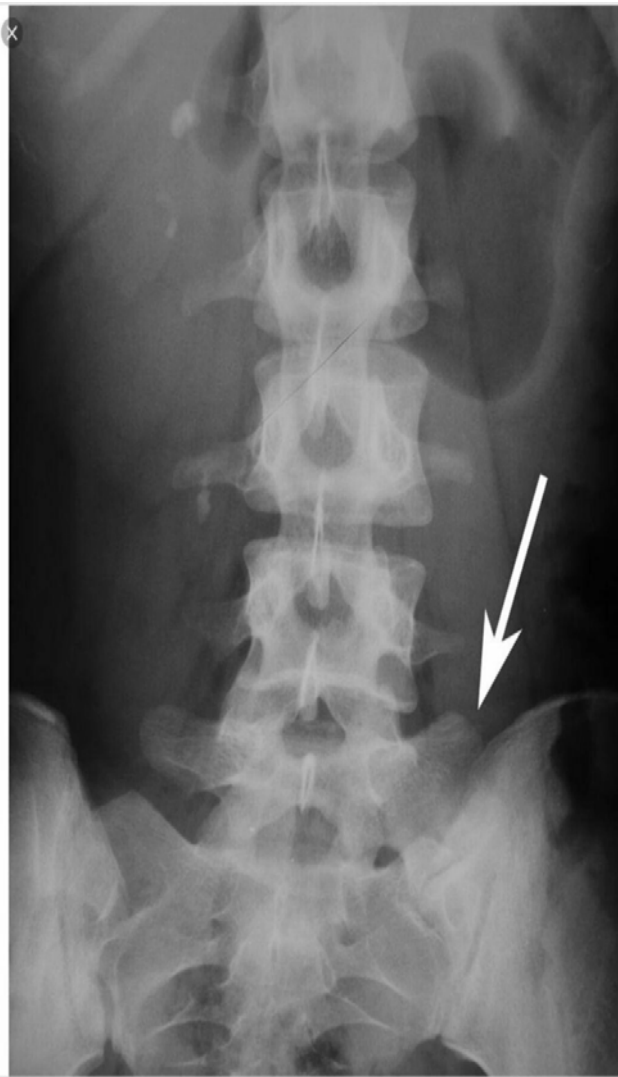
The sacrum appears to have only 4 segments rather than its normal 5

- **Sacralization** occurs when one or both transverse processes of L5 fuse with the first sacral segment (or rarely, the ilium)

This may be unilateral or, more frequently, bilateral

- Many people with transitional vertebrae are asymptomatic .
- the presence or absence of a transitional vertebra is important if a surgical intervention is needed .





## **Congenital Dysplasia of bones**

### **Achondroplasia**

**It is a congenital abnormal bone ossification , it is a most common skeletal dysplasia result in dwarfism**

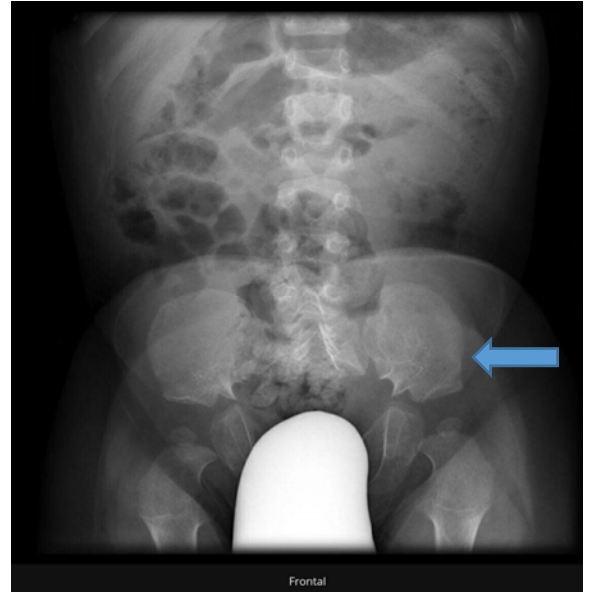
### **Radiologically**

**The bones are short and wide**

**the forehead is prominent**

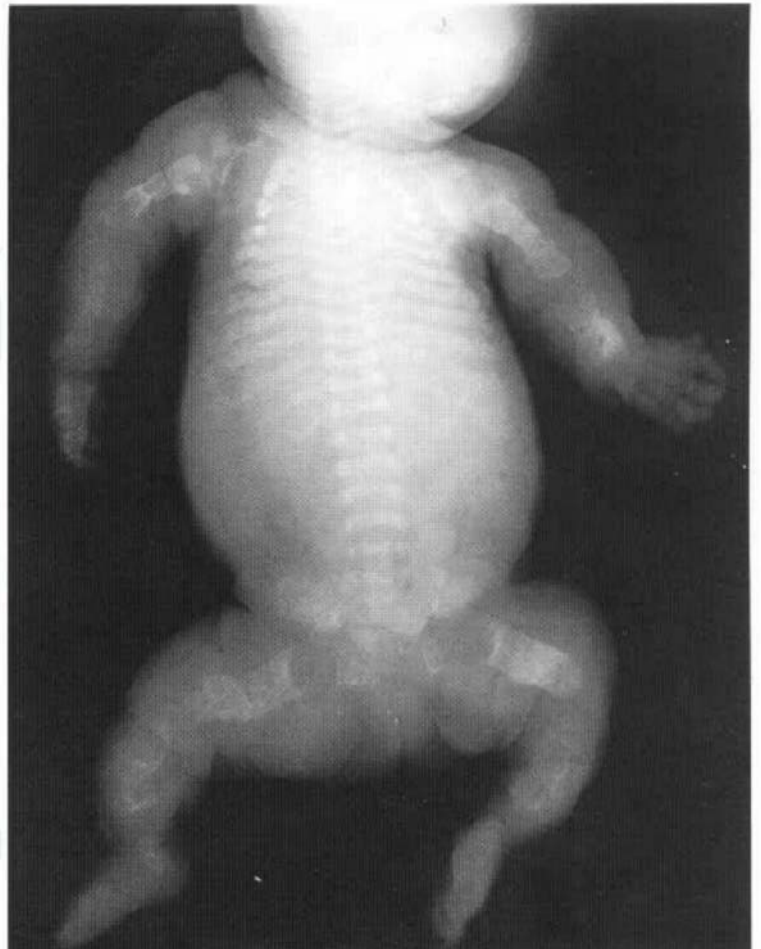
**the iliac bone is squared**

**with excessive lordosis of sacroiliac area .**



## **Osteogenesis imperfecta**

**Is rare severe type of bone dysplasia**



## **Exostosis**

**(bone spur)** is the formation of new bone on the surface of a bone, it is a benign process



## **Hemophilia**

Is a pathological process , a type of bleeding disorder , exclusively affects males

**Hemophilic arthropathy** occurs due to repeated hemoarthrosis mainly affect the knee and elbow .

### **Radiologically in the knee :**

- **Osteopenia .**
- **Widened intercondylar notch .**
- **Bulbous femoral condyles .**
- **Enlarged epiphysis .**



# Cervical rib

Is accessory rib arising from the [seventh cervical vertebra](#). They occur in ~0.5% of the population, **usually bilateral**, but often **asymmetric**<sup>2</sup>, and are more common in females.

Although cervical ribs are **usually asymptomatic**, they are the most important [anatomic rib variant](#) clinically, because they can cause [thoracic outlet syndrome](#) by compression of the [brachial plexus](#) or subclavian [artery](#) / [vein](#).

On imaging, cervical ribs can be distinguished because their transverse processes ( of C7 ) are directed **inferolaterally**, whereas those of the adjacent [thoracic spine](#) are directed [anterolaterally](#).



# Vitamin D deficiency

It is called **osteomalacia in adult** and called **Rickets in pediatrics**.

**(Rickets affect immature skeleton)**



## Radiological features :

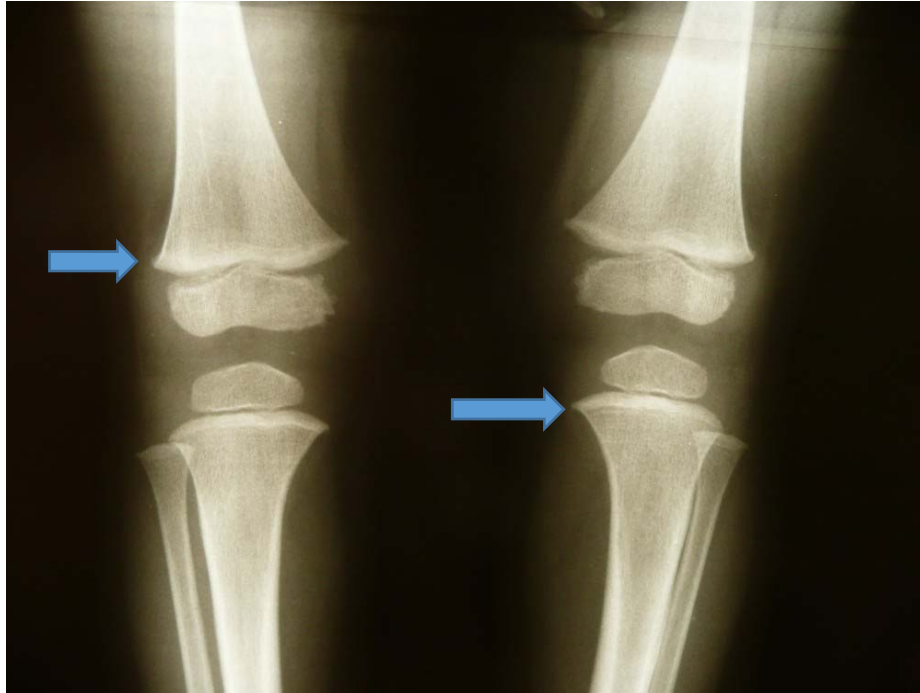
- **Cupping and fraying** of metaphysis
- **Poorly mineralized** epiphyseal centers with **delayed** appearance
- **Irregular widened epiphyseal growth plates** (increased osteoid)
- **Periosteal reaction** may be present
- **Deformities** : **Bowing** of long bones , frontal **bossing** and **fractures**



**Rickets of the knees demonstrates bowing of the femurs, metaphyseal cupping and fraying, coarsening of the trabecular pattern, increase in distance between end of shaft and epiphyseal center, poorly ossified epiphyseal centers.**



**In case of treated rickets or hypervitaminosis D , there will be dense band at the metaphyseal end**



## **Upper limb bones**

### **Hand**

Phalanges , metacarpals and carpals

#### **Phalanges :**

They are **14 in no.** , 3 phalanges in each fingers but 2 phalanges in the thumb .

#### **Metatarsal bones :**

They are **5 long bones** , their base articulate with **carpals** forming C.M.J and their heads articulate with **phalanges** forming M.P.J.



## Carpal bones :

They are 8 **irregular type bone** in 2 rows :

### Proximal row :

Scaphoid , lunate triquetral and pisiform

### Distal row :

Trapezium , trapezoid , capitate and hamate .

The **proximal row articulate with** the **lower end of radius** forming the wrist joint .

The **distal row articulate with** the **bases of metacarpals**.



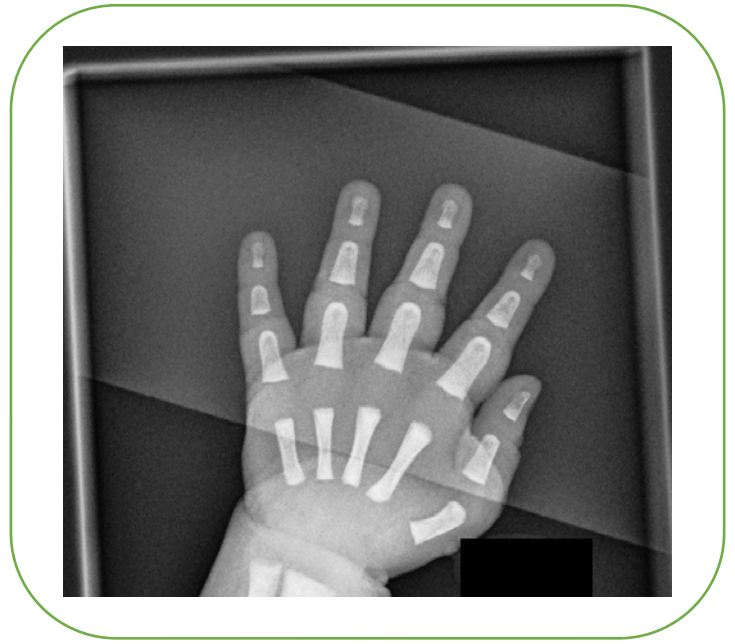
## Bone age of the Hand

The 2<sup>ry</sup> ossification centers of the **phalanges and the metacarpals** appear in the 2<sup>nd</sup> \_ 3<sup>rd</sup> year of life and fused at age of 18 year . **(3/18)**

There are 2 ossification center for each bone ( on the upper end and on the lower end ) ,

**Carpal bones age :**

- **capitate:** 3 months
- **hamate:** 3 months
- **triquetrum:** 3 years
- **Lunate:** 4 years
- **scaphoid:** 6 years
- **trapezium:** 6 years
- **trapezoid:** 6 years
- **pisiform:** 11 years



At birth



3 months age



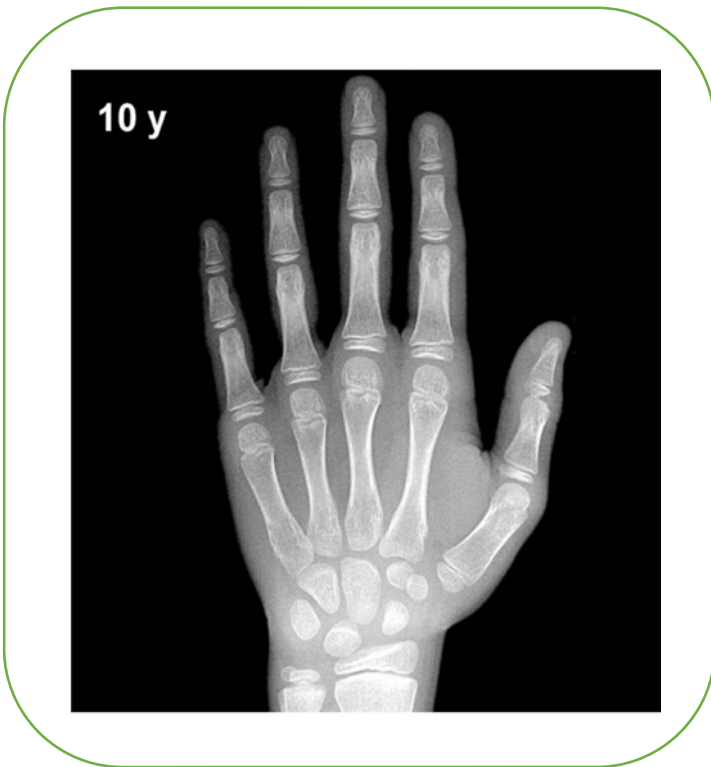
Above 2 y



4 y age



8 y age



10 y



Above 11-13 y

**The carpal bones are important in determining the child age**  
**Some times the bone age is less than chronical age**

**Example : child with 8 y age but has not erupted scaphoid , so that his bone age is less than 6 y .**

## **Forearm :**

### **Radius :**

The radius is one of the two long bones presents in the forearm. It is **located laterally** in the **supinated** anatomic position. It has a **smaller proximal end** and **a larger distal end** (opposite to the ulna).

The proximal radius comprises :the radial head and the radial neck, notch and tuberosity.

The radial shaft is thicker than the ulna and becomes more thicker distally.

### **Articulations :**

#### **Proximal:**

**radial head with capitellum** of the humerus (**elbow flexion and extension**)

**radial head with proximal ulna** (site of supination and pronation)

#### **distal :**

**distal radius facet with scaphoid and lunate fossae** separated by a small ridge

**distal radioulnar** (site of **supination and pronation**)

### **Ulna:**

It has a narrow lower end with a small bony projection called ulnar styloid ( styloid process of ulna).

**The lower end does not share in formation of the wrist joint**

The upper end is curved forming the olecranon process which articulate with capitellum forming the elbow joint .

2ry ossification center of the forearm

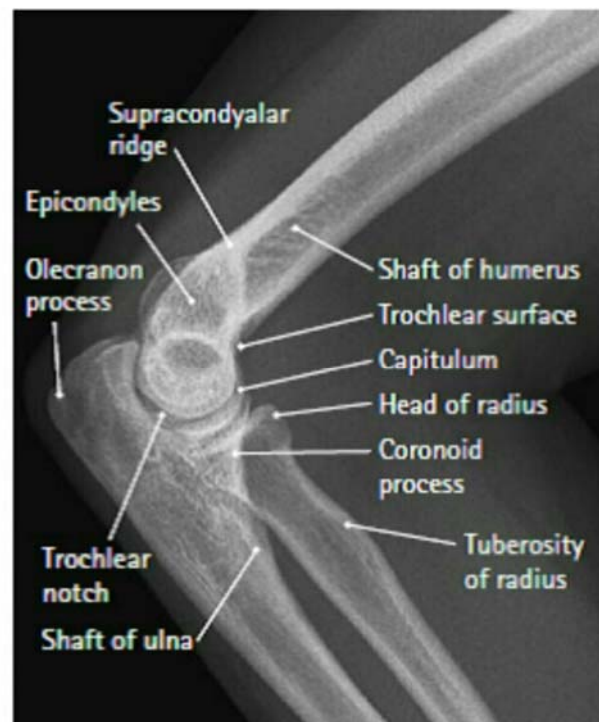
**Lower end of radius** appears at 1 year and fused at 20 year (1/20)

Upper end of radius (**radial head**) appear at 4 year and fused at 18 year (4/18)

Upper end of ulna (**olecranon process**) appears at 11 y and fused at 16 y (11/16)

## Elbow joint

Formed by articulation of capetellum of distal humerus with olecranon process of ulna .



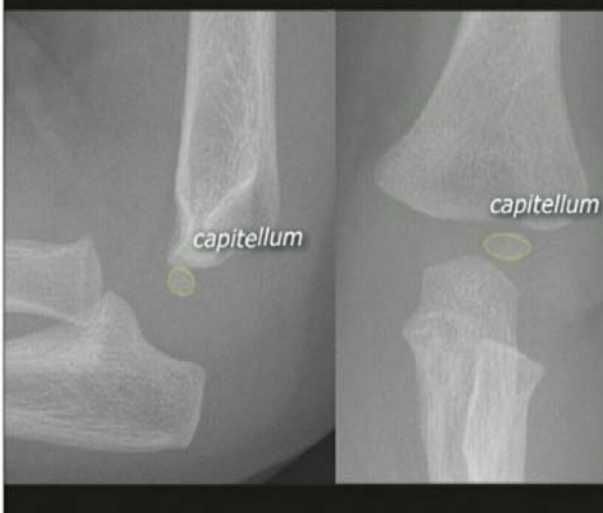
## Elbow 2ry Ossification centers :

### CRI TOE

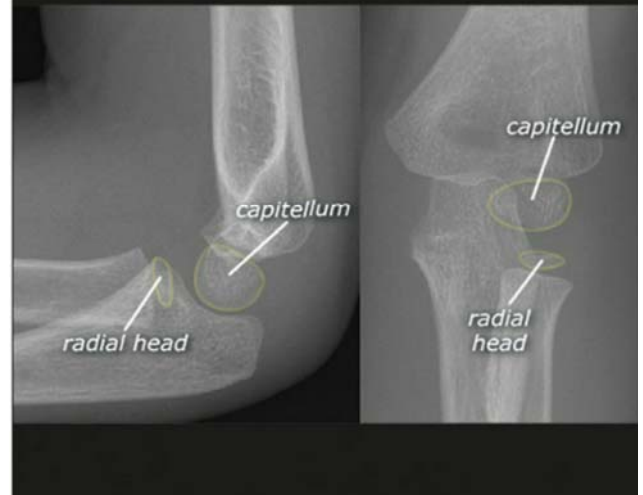
<b>Ossification center</b>	<b>Years at ossification (appear on xray)</b>
Capitellum	1
Radius	3
Internal (medial) epicondyle	5
Trochlea	7
Olecranon	9
External (lateral) epicondyle	11

(1) +/- one year, varies between boys and girls

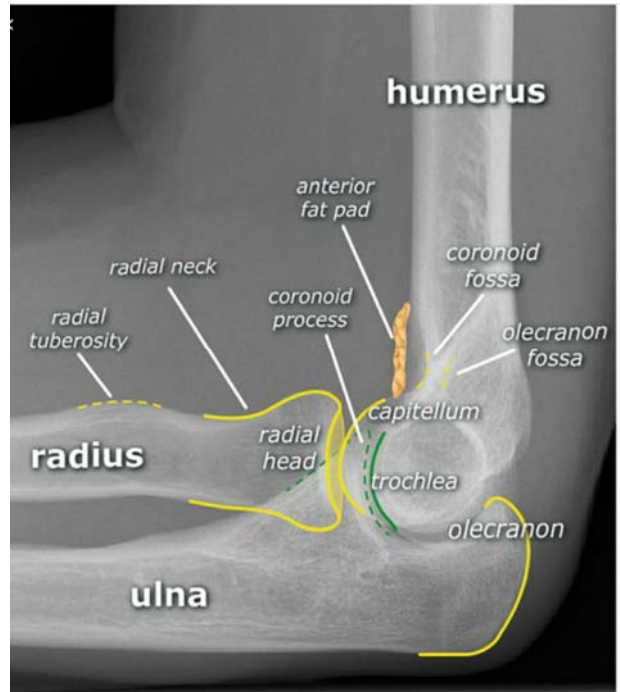
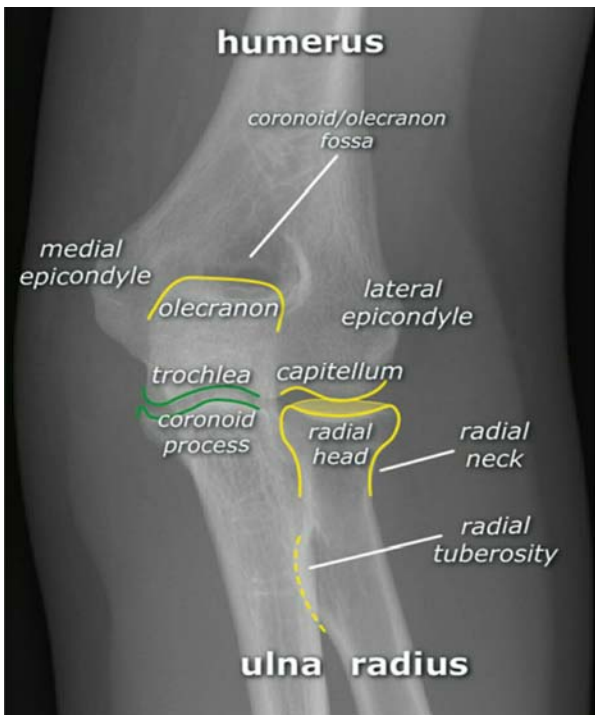
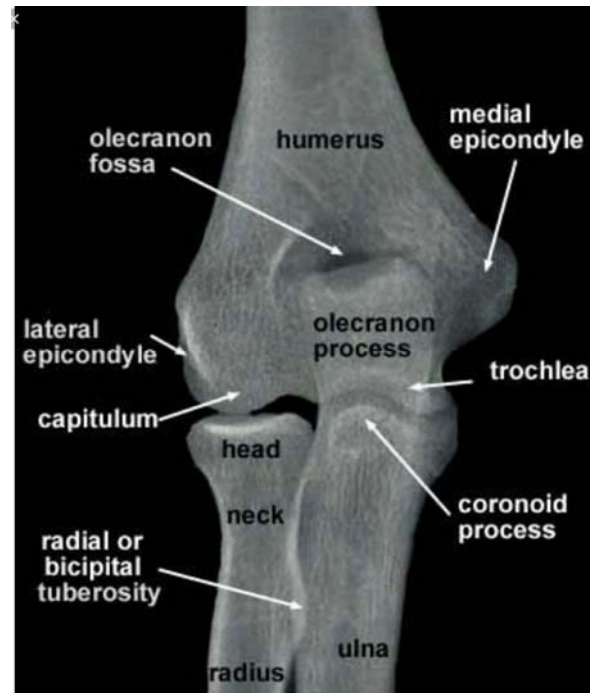
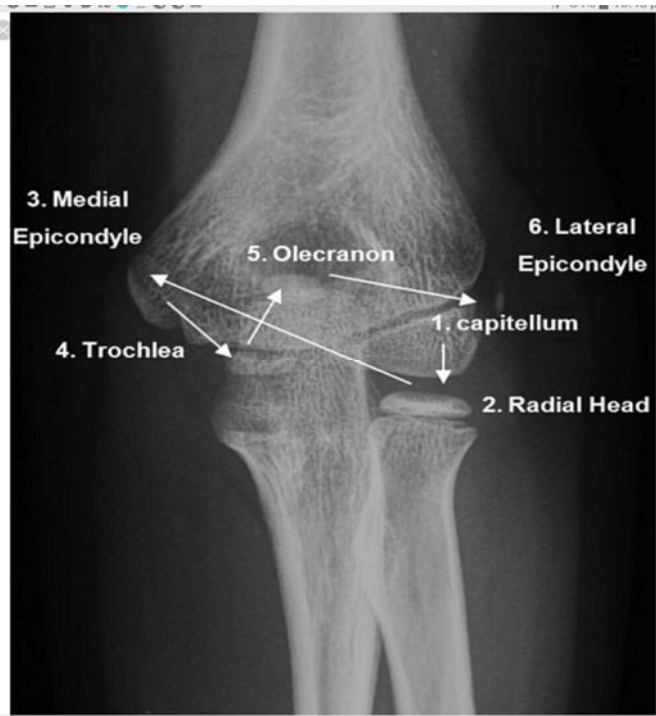
**1 year**



**4 years**









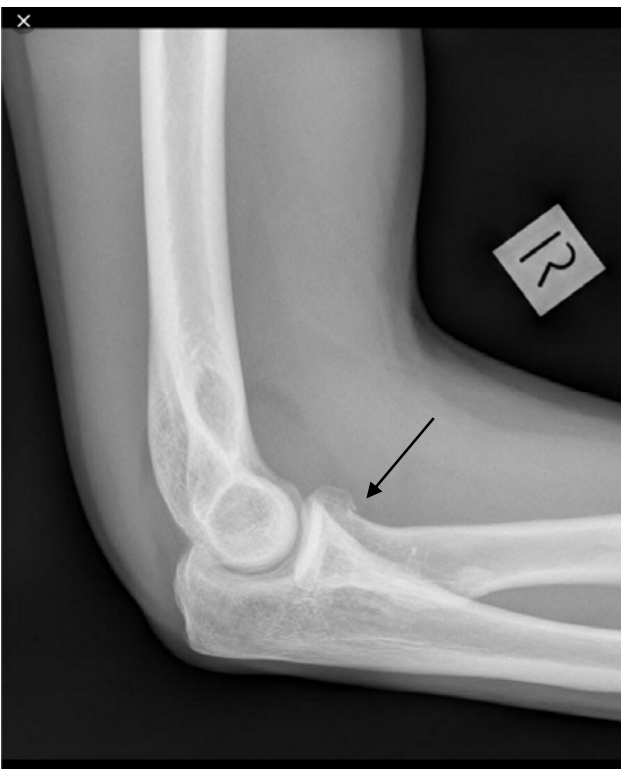
[www.radiologytutorials.com](http://www.radiologytutorials.com)

Emergency Radiology - Upper extremities (Medial epicondyle avulsion - adult - Radionranhv )



[radiopaedia.org](http://radiopaedia.org)

Lateral condyle fracture | Radiology Case | Radiopaedia.org



[radiopaedia.org](http://radiopaedia.org)

Olecranon fracture | Image | Radiopaedia.org



[www.orthobullets.com](http://www.orthobullets.com)

Olecranon Fractures - Pediatric - Pediatrics - Orthobullets



1. There is enormous soft tissue swelling, which indicates that the elbow has been dislocated (blue arrows). So the next question is where is the medial epicondyle?
2. The medial epicondyle is seen entrapped within the joint (red arrows).
3. Notice that there is only minor joint effusion (asterisk). The medial epicondyle is an extra-articular structure and avulsion will not produce joint effusion. The small amount of joint effusion is probably the result of the prior dislocation.

Continue with the MRI.

# Humerus

Its upper end is the head which is semi circular in shape , it **articulates with the glenoid cavity** of the scapula to form the shoulder joint

It has a **greater and lesser trochanter** , they join the humerus at the (anatomical neck )

Under these tubercles is the surgical neck which is the site most liable for fracture

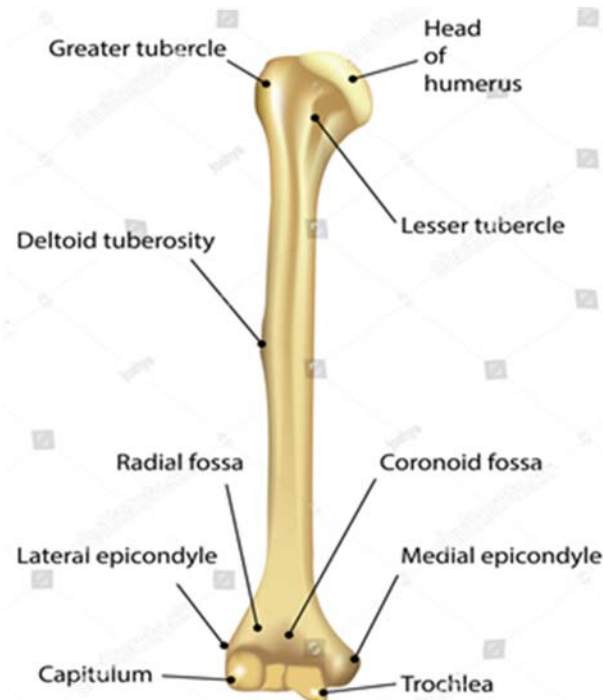
The body of the humerus called the shaft it is surrounded by biceps muscle internally and triceps muscle externally

The condyle of the humerus articulates with the radius and ulna. It is composed of the trochlea, capitulum, and medial and lateral epicondyles.

2ry ossification centers of the **humerus** :

The head appears **after birth** as 3 unfused bones

These bones fused together at **16 y** and fused with the metaphysis at **18 y**



# Clavicle

- It is a curved bone
- Its **medial end articulates with** manubrium of the sternum , forming sternoclavicular
- Its **lateral end articulates with** acromion forming the acromioclavicular joint .
  
- The clavicle is liable to fracture because it is directly under the skin
- Its medial half is convex anteriorly
- Its lateral half is convex posteriorly
- The clavicle protects the underlying blood vessels and nerves and protect the apex of the lung .
- It is the 1<sup>st</sup> bone to appear in the intra uterine(fetal )life in the 5<sup>th</sup> week

The 2ry ossification center appear at the medial and lateral end at 18 y and fused at 25 y.

(18/25)



# Scapula

It is a triangular shape bone

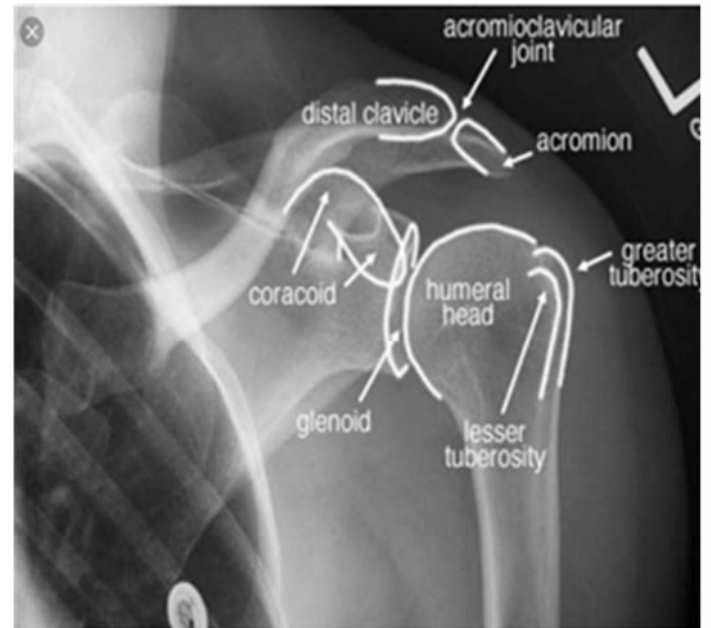
It has superior angle and lower angle

Glenoid cavity is posteriorly located  
which is a part of the shoulder joint

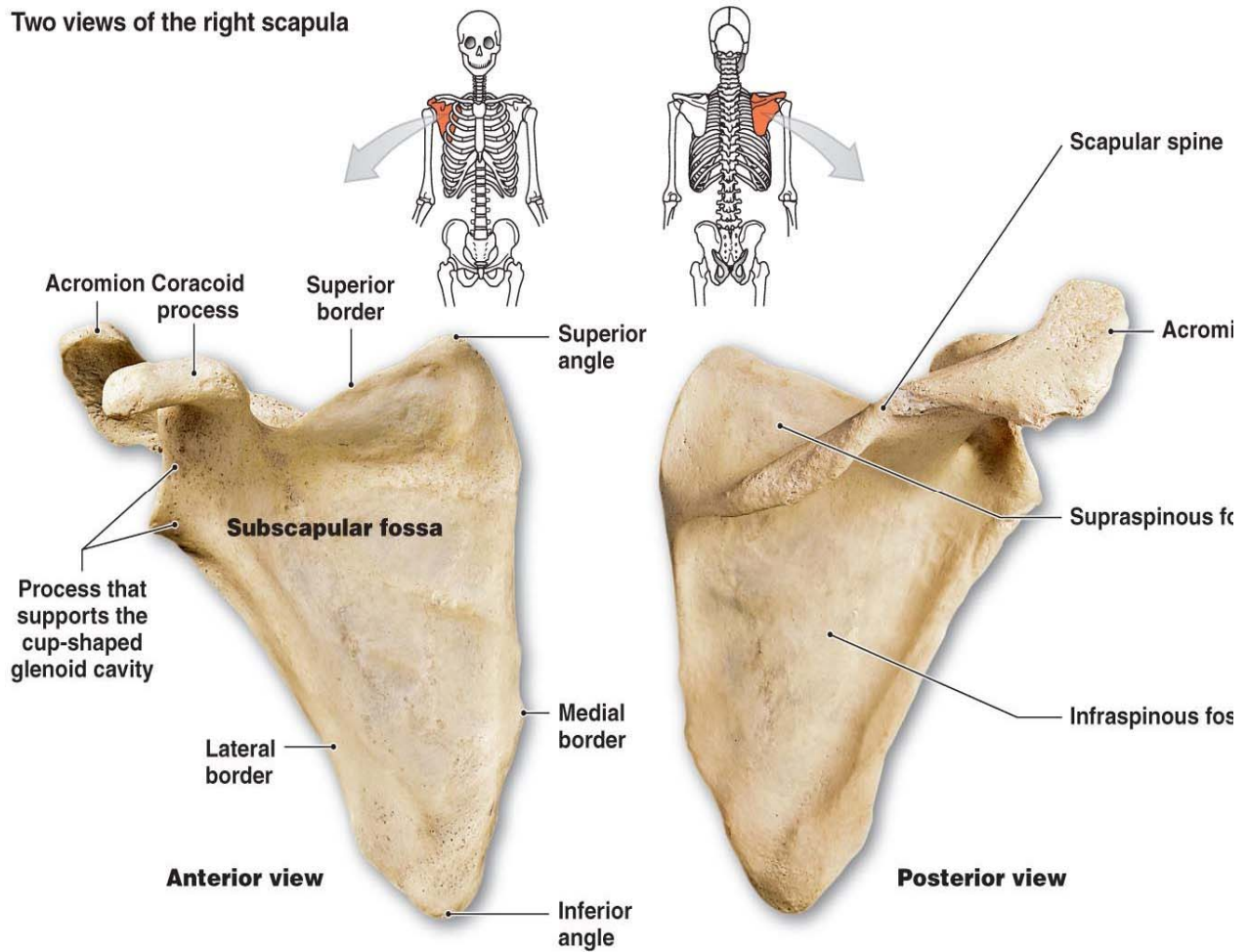
**3 borders** : medial , lateral and superior .

Coracoid process and spinous process

Acromion forms the roof of the shoulder joint



Two views of the right scapula



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## Rotator cuff muscles

They are group of muscles and their tendons , they stabilize the shoulder joint

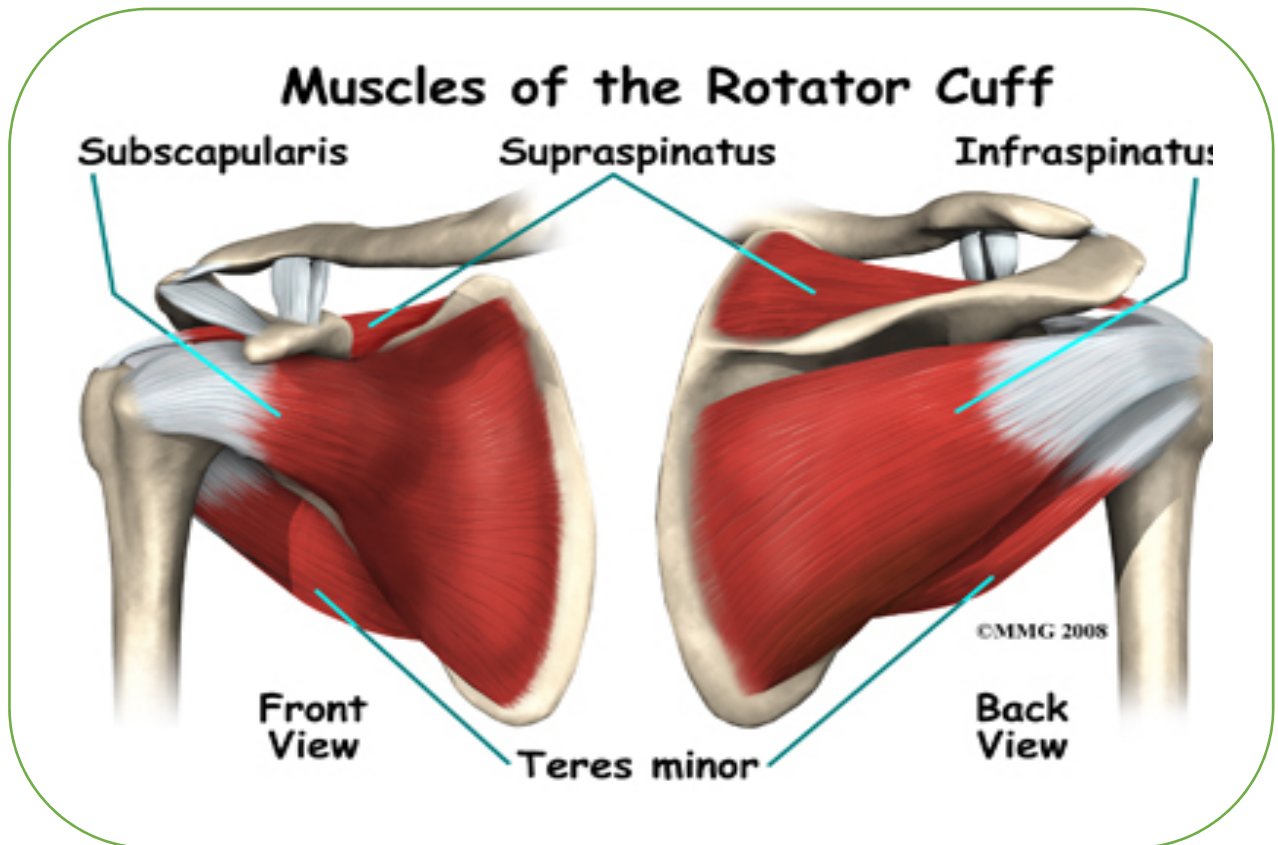
They are

- supra spinatus ( the most important )
- The infra spinatus
- Subscapularis
- teres minor

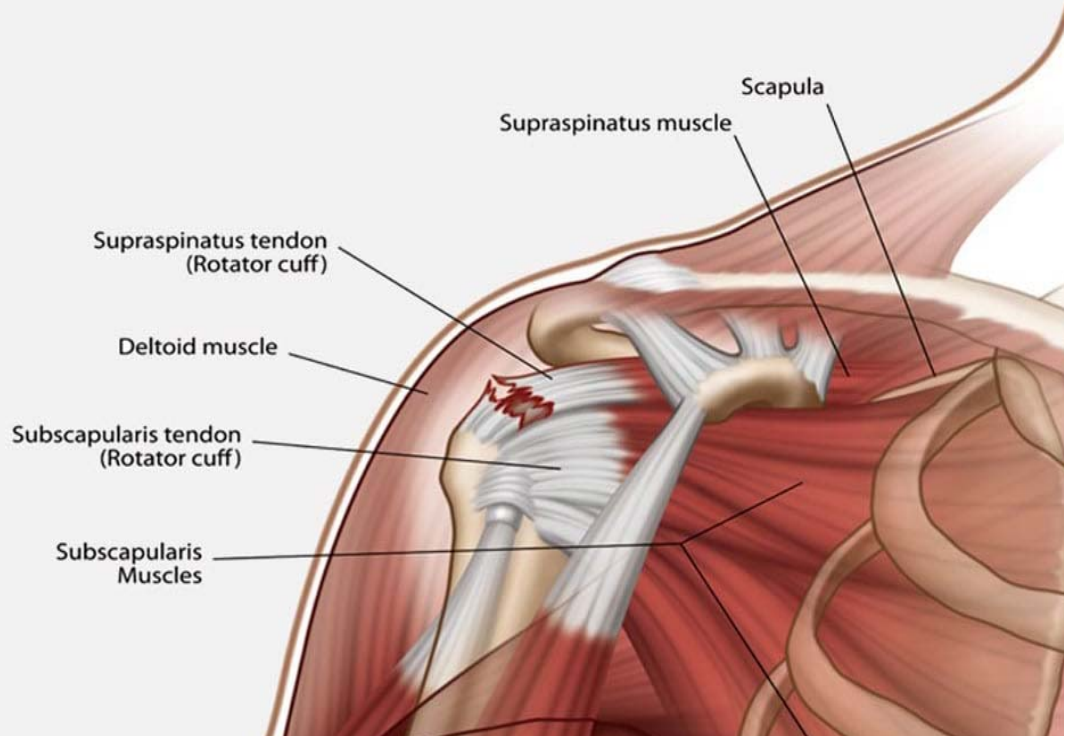
The shoulder joint is liable to degenerative change and tears of the rotator cuff muscles that are the cause of pain in most cases of shoulder pain , that is usually not appear on x – ray , a part from sometimes calcification appear at the tendon of supre spinatus

The US may diagnosed many condition of shoulder pathology

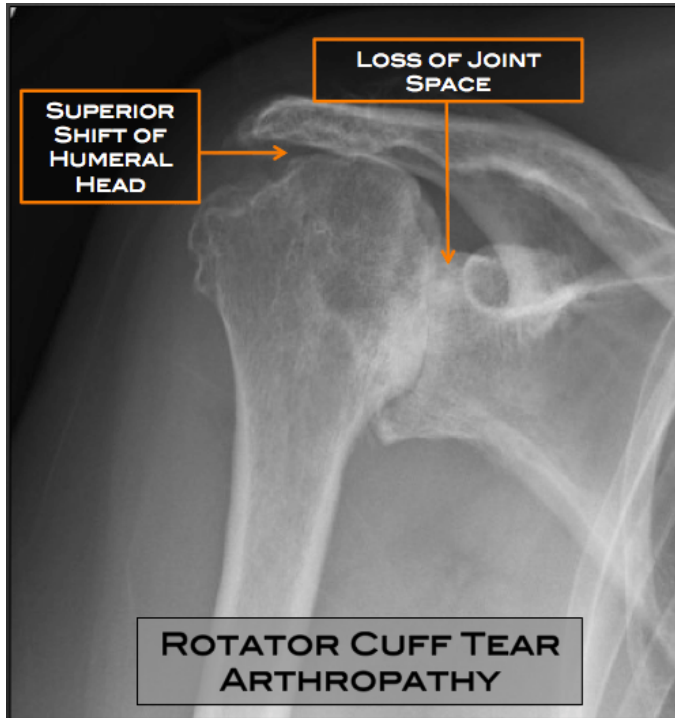
The MRI is diagnostic of choice for shoulder diseases



## ROTATOR CUFF TEAR







## Shoulder dislocation (Gleno –humoral joint dislocation )

### Anterior shoulder dislocation

the commonest type of dislocation and usually results from forced abduction, external rotation and extension

It represents 95 % of dislocation types

It is common to occur in young population

#### Radiological types

- subcoracoid: most common
- subglenoid
- subclavicular



[radiopaedia.org](http://radiopaedia.org)

Anterior shoulder dislocation | Image | Radiopaedia.org

## Posterior shoulder dislocation

It represents 4% of shoulder dislocation , it is difficult to be diagnosed on AP view

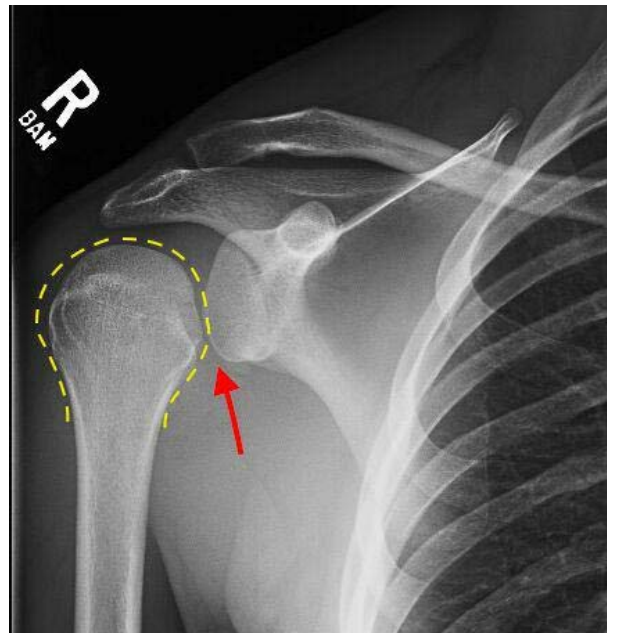
- Causes : convulsion state and electric shock

Humeral head is fixed in internal rotation no matter how forearm is turned – “lightbulb sign”

- Both anterior and posterior dislocation may be associated with fracture



Posterior dislocation



Posterior dislocation

# The skull

rests on the superior aspect of the vertebral column, . It formed by **2 tables of compact bone** : (the outer table ( **periosteum**) and inner table ( **endosteum**) ) and **spongy bone** ( **the diploe** ) between the 2 tables .

It consists of **22 bone** and divided into 2 main parts :

the **cranium ( 8 bone)** and the **Facial bones ( 14 bone)** . ( except the mandible which is not a part of the skull ).

**The cranial bones(cranium)** are further divided into:

1\_ **The Calvarium ( the vault)** ( the skull cap) →

Frontal , Rt parietal , Lt parietal and occipital .

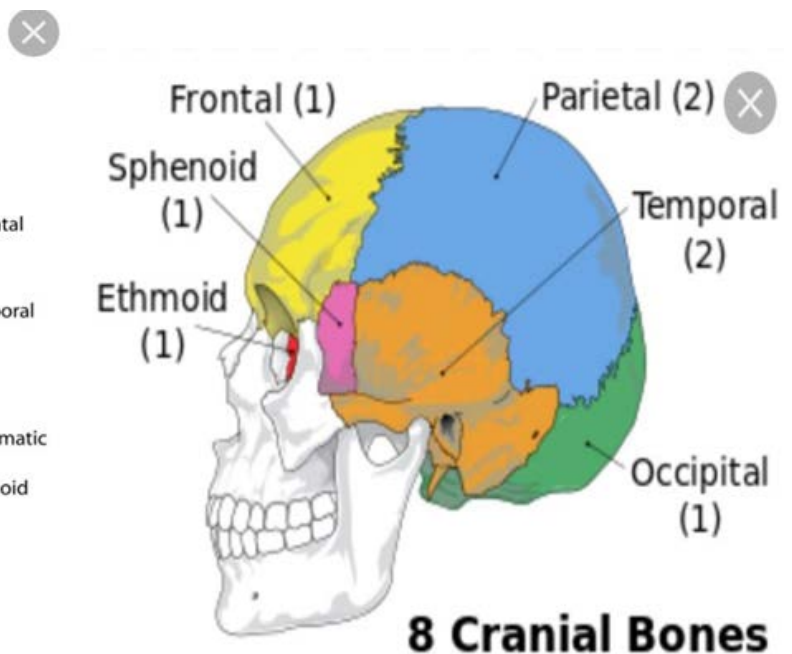
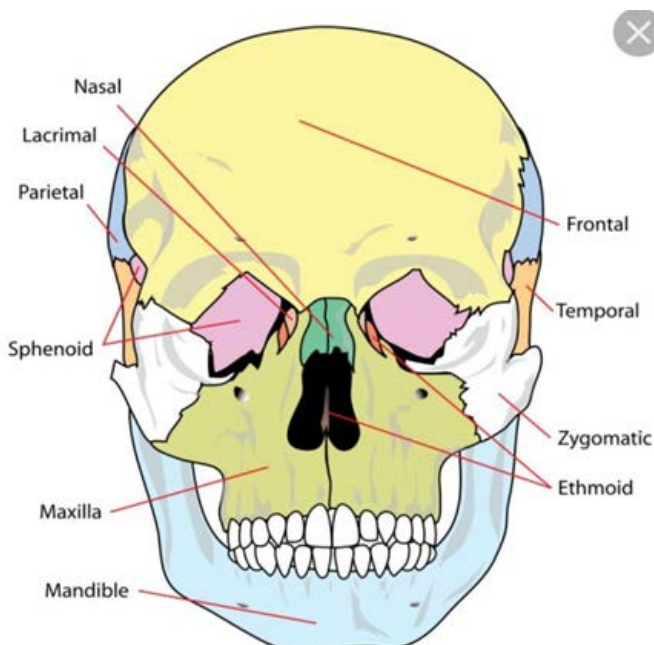
2\_ **The Base (the floor)** →

Sphenoid , Ethmoid , Rt Temporal and Lt Temporal .

**The Facial bones** →

2 Nasal , 2 Lacrimal , , 2 Inferior Conchae , 2 Palatine, 1 Vomer ,

2 Maxillary , 2 Zygomatic and 1 Mandible.



The bones of the cranium and face ( except the mandible ) are joined by **fibrous joints** called **sutures**.

**1 The Coronal suture** is found between the frontal and parietal bones.

**2 The sagittal suture** is located on the top of the head between the two parietal bones and behind the coronal suture.

**3 The Squamosal sutures** is between the temporal bones and the parietal bones .

**4 The Lambdoid suture** is between the occipital bone and the parietal bones .

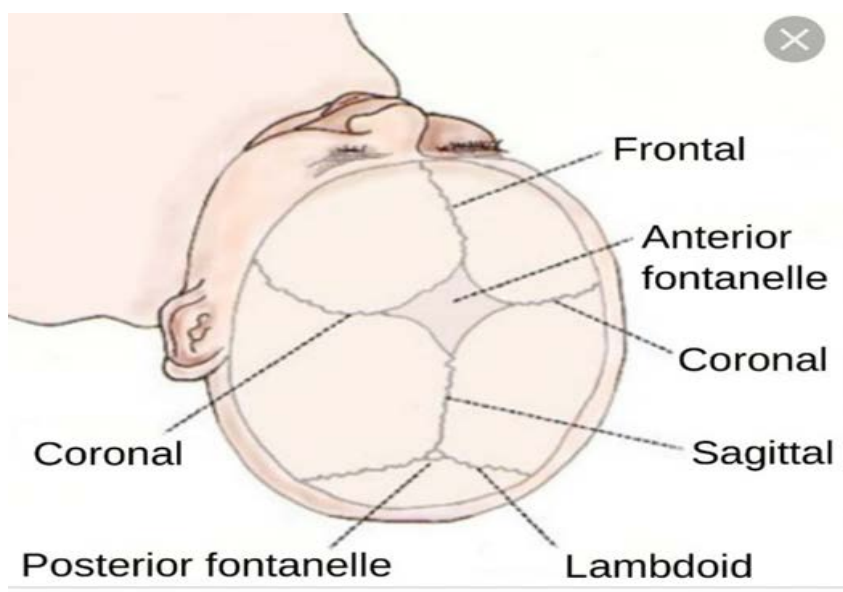
**The infant`s cranium** contains **6 areas** of incomplete ossification ( soft spots ) called **Fontanel**.

They have an importance in medical imaging where they considered windows for Ultrasound examination of the infant`s brain and have a clinical importance to indicate some medical diseases ( hydrocephalus , dehydration .... etc)

The 2 largest fontanels are located at mid sagittal plane ;

**The Anterior Fontanel** : is located at the junction of the two parietal bones and the one frontal bone . at the point called **Bregma** . It is closed at the 2<sup>nd</sup> year of life .

**The Posterior Fontanel** : is located at the junction of the the two parietal bone and the one occipital bone . at the point called **Lambda** . It is closed at the 2<sup>nd</sup> month of life .



## The neonatal skull :

At birth the **diploic space** is not developed

The **sinuses** is not aerated

The **vascular marking** is not presented

The **fontanel**s are opened

The **sutures** are more prominent that is fused in the 2<sup>nd</sup> decade of life

## Surfaces of the skull

Consist of the following bones :

### Superior surface :

Frontal , 2 parietal and occipital bones

### Anterior surface :

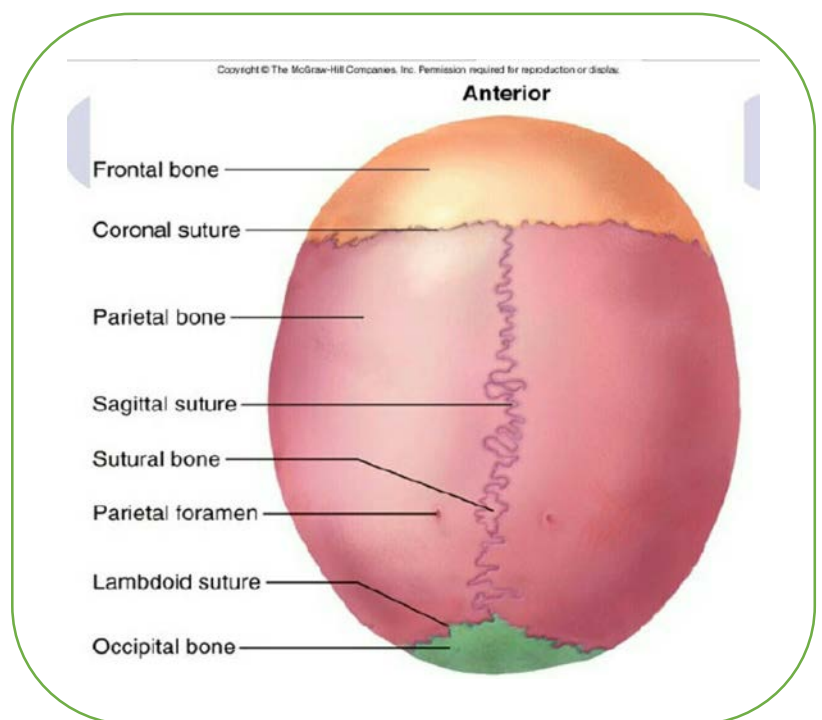
Frontal , nasals , zygomatics , maxillae , Mandible bones and orbital cavities and nasal septum

### Lateral surface :

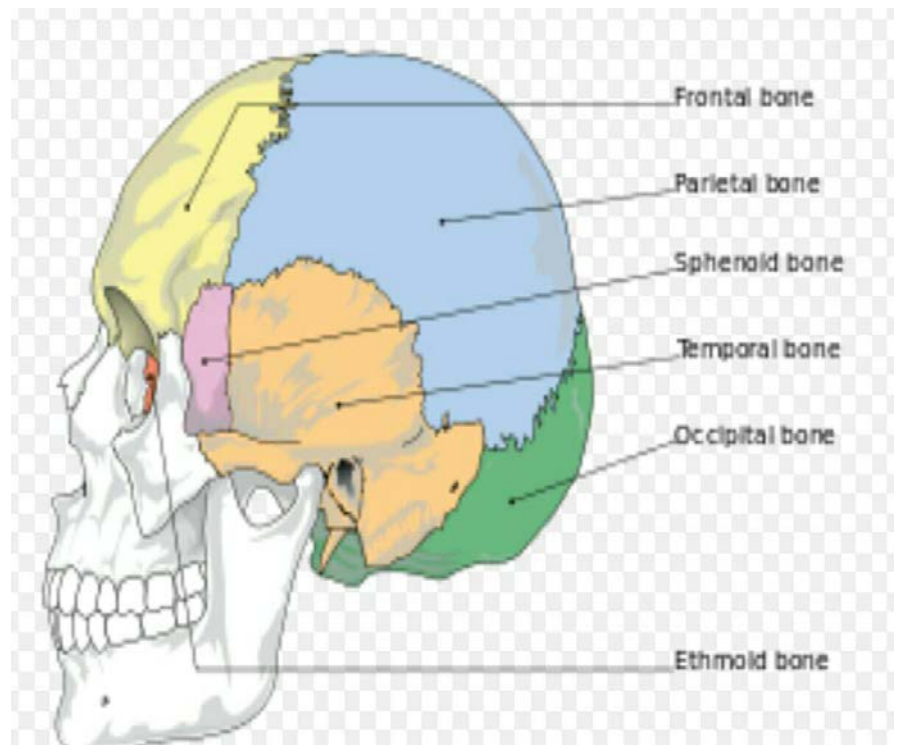
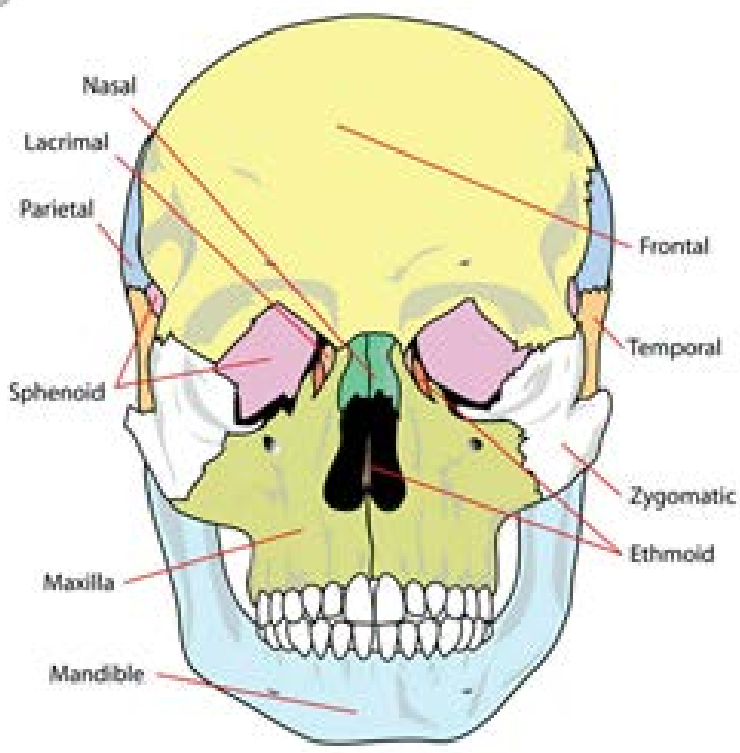
Frontal , nasal, parietal ,temporal ,zygomatic , squamous temporal , mandible bones and EAM

### Intefrior surface :

Irregular bony surface , contains multiple ,different sizes **foramina** , the largest one is the **foramen magnum** .



20



## The Frontal Bone :

Has : a **vertical plate** which forms the forehead and Horizontal plate which forms most of the anterior cranial fossa and the orbital plate (roof of the orbit).

The **Glabella** : located between the 2 eye brows

The **Nasion** : is the site of articulation of the frontal bones with the nasal bones.

## The Ethmoid Bone :

Located between the orbits , it has

**Vertical plane** which forms part of the nasal septum.

**Horizontal plane** ( cribriform plate ) , which has multiple opening for passing of the olfactory nerve and forms part of the anterior cranial fossa .

**Labyrinths** : which are 2 portions that contain the ethmoidal sinuses .

## Parietal Bones :

That form the side of the skull and the posterior portion of the cranial roof (vault ) .

## Sphenoid Bone :

A wedge –shaped bone resembles **a bat** with **extended wings** .

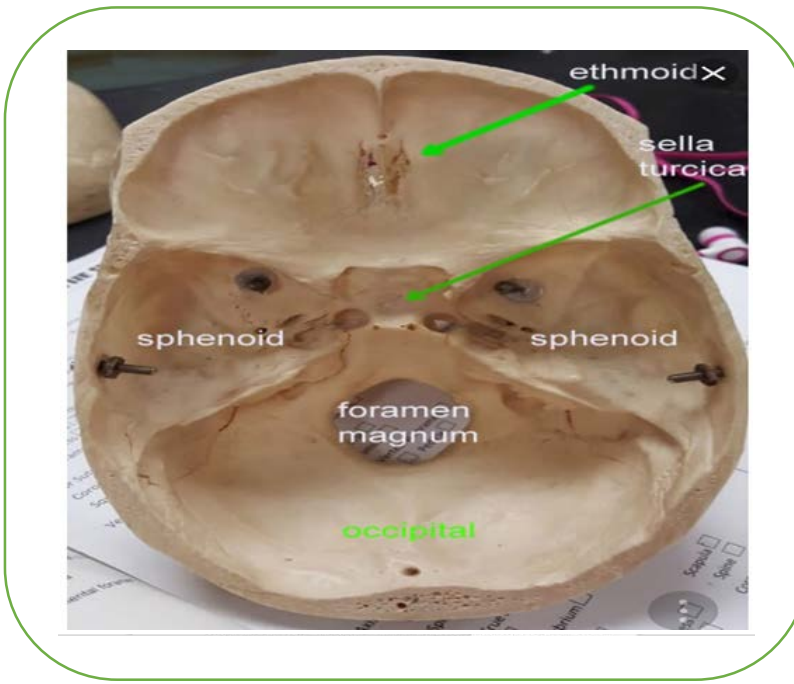
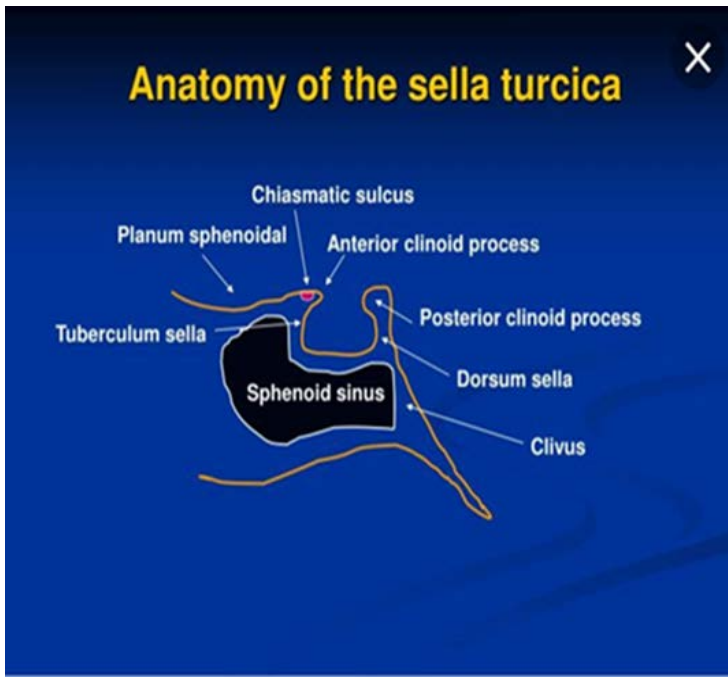
Located at the **base** of the cranium , consists of :

**Body , 2 lesser wings ,2 greater wings and 2 inferior projections** called **pterygoid processes**

.

The anterior surface of the body is the bony part of the posterior surface of the nasal cavity .

The body contains **2 sphenoid sinuses** inside and has superior impression called **Sella turcica** at mid sagittal plane



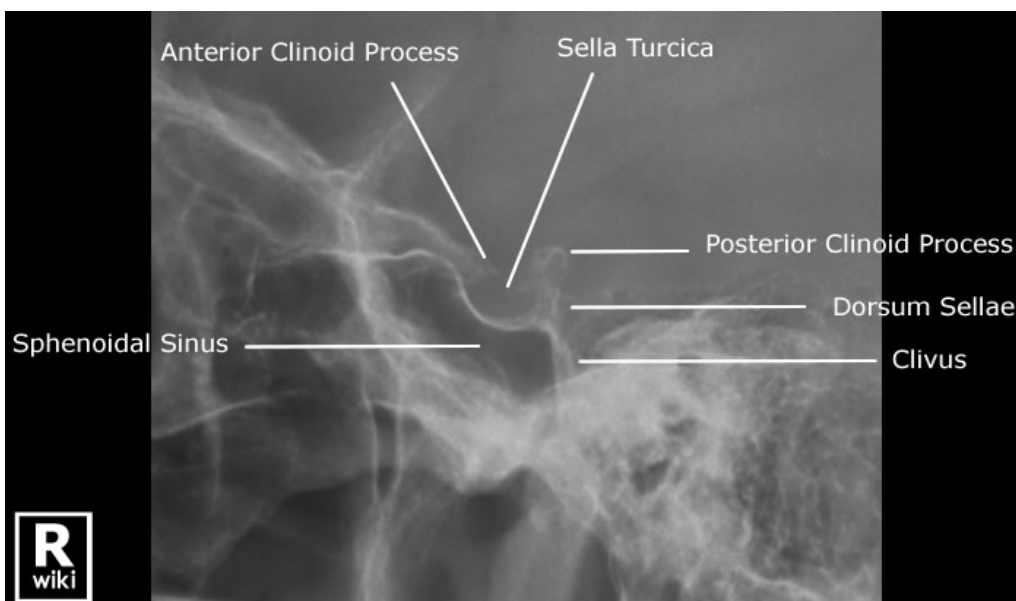
### Sella Turcica

It is located about **2 cm anterior** and **2 cm above** the level of **external auditory meatus** , it contains the **pituitary gland**

It is bounded by :

**Anteriorly** : the **tuberculum sellae** and the **anterior clinoid processes**

**Posteriorly** : the **dorsum sellae** and the **posterior clinoid processes** , the dorsum sellae is continues as a slope posteriorly and inferiorly to join the base of the occipital bone and form the **Clivus** , which support the pons .



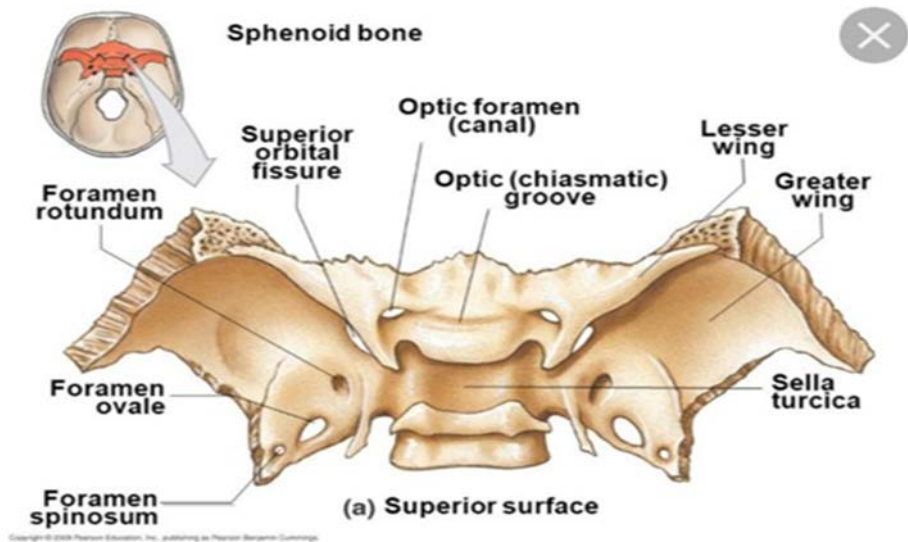


The **lesser wings** form the posterior portion of the anterior cranial fossa.

The **greater wings** form a part of the middle cranial fossa, the posterior walls of the orbits.

The **foramina rotundum, ovale, and spinosum** are paired and are situated in the greater wings.

They transmit nerves and blood vessels.



### The occipital bone:

is located at the **posteroinferior** part of the cranium. It forms the **greater part** of the posterior cranial fossa. It has :

The **foramen magnum** : the largest opening in the skull base through which the inferior medulla oblongata exits the cranial cavity and joins the spinal cord.

**Two occipital condyles**: one on each side of the foramen magnum and the basilar portion. These condyles articulate with the C1 ( the Atlas ) ,form the atlanto occipital joint .

On the external surface of the occipital bone is a prominent process termed the **external occipital protuberance. or inion.** that corresponds in position with the **internal occipital protuberance.**

### The Temporal bone:

It is **irregular in shape**, located between the greater wings of the sphenoid bone and the occipital bone, it **contains the middle and inner ear** , it consists of:

1- a **squamous portion** forming a part of the side wall of the cranium ,

The lower part contains **the mandibular fossa** that articulate with the condyle of the mandible to form the temporo mandibular joint (**TM joint**) .

2- a **tympanic portion** that contains the **EAM and the styloid process**.

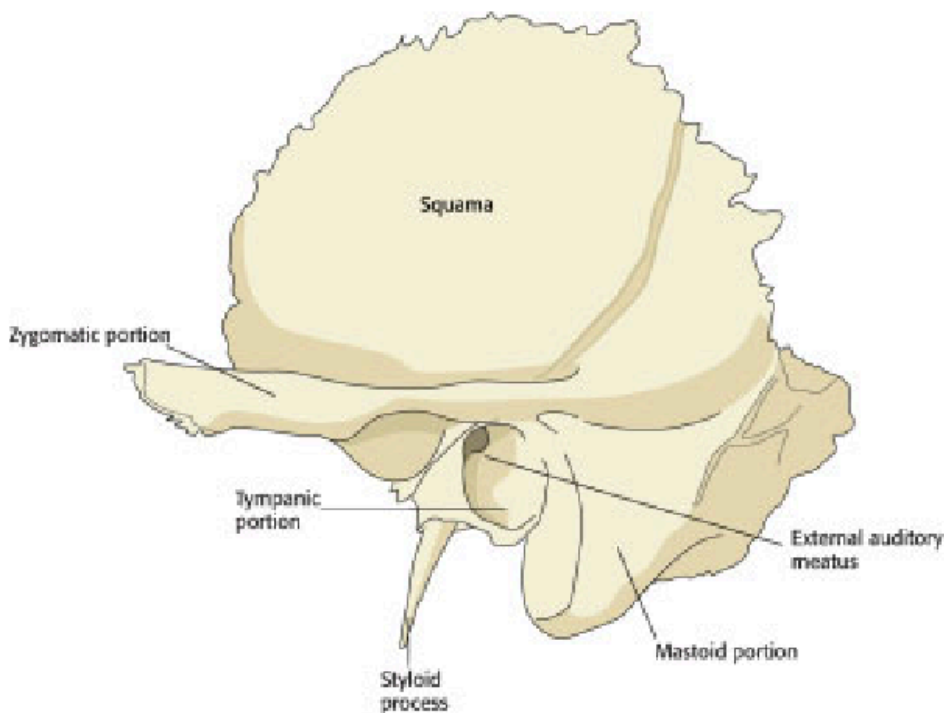
3- a **petromastoid portion** (**the mastoid and petrous portions**)

**A ) The mastoid** portion, which forms the inferior, posterior part of the temporal bone which is prolonged into the conical shape mastoid process which contains air-filled spaces called **mastoid antrum** .

It varies in size, depending on its **pneumatization** . , it communicates with the tympanic cavity.

The pneumatization disappears and replaced by fluid in case of inflammation of mastoid ( mastoiditis ) the bone may become sclerosed , which is usually associated with inflammation of the middle ear ( otitis media ) , and called otomastoiditis .

It may be completely absent in some persons.

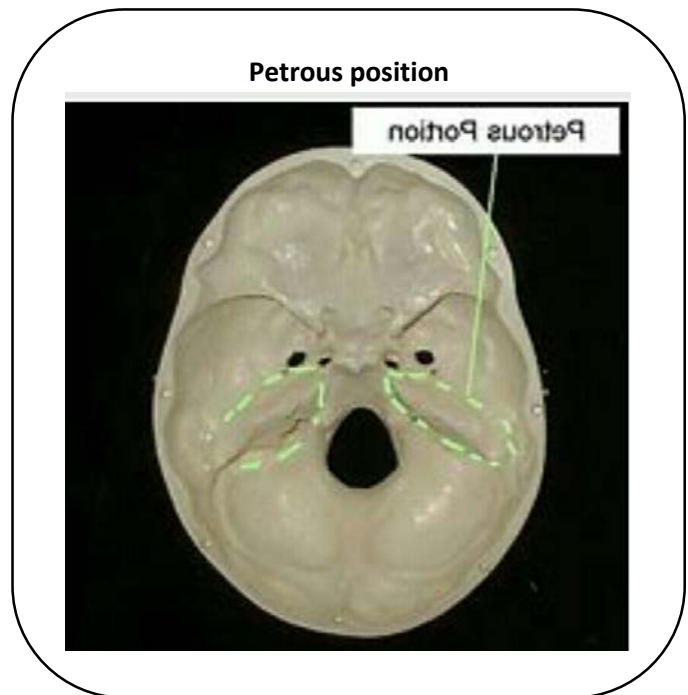
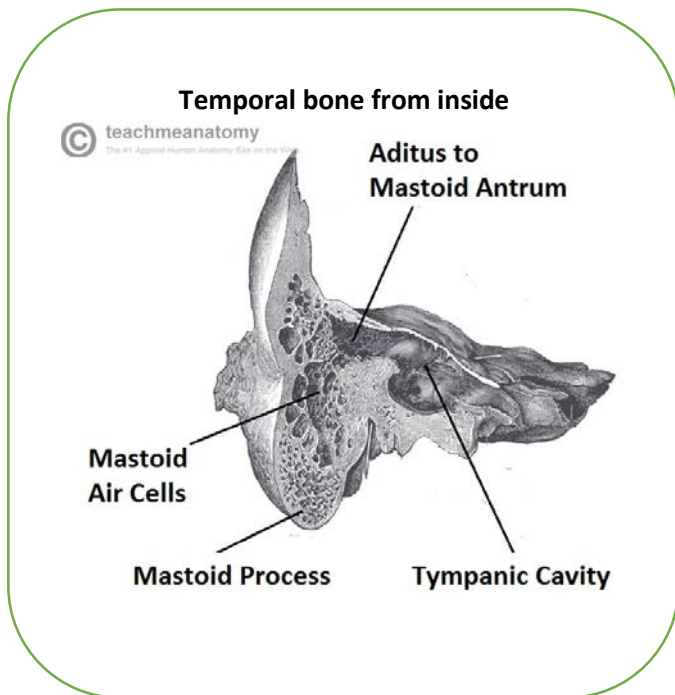


**Figure 2** Diagram of the left temporal bone from a lateral

**B) The petrous** portion, often called the **petrous pyramid** , the **densest bone in the cranium**. contains **the organs of hearing and balance**.

The upper border of the petrous portion is commonly referred to as the **petrous ridge**. The top of the ridge lies approximately at the level of an external landmark called the top of ear attachment (TEA).

The temporal bone articulates with the parietal, occipital, and sphenoid bones .



## Ear :

The **external ear** consists of :

- 1- The **auricle** , which has a deep central depression .

The **tragus** , projects posteriorly over the entrance of the ear.

- 2-The **EAM** : which is 2.5 cm in length, it ends at the tympanic membrane of the middle ear.

The **middle ear**: is the part of sound transmission, consists of

- 1- The **tympanic membrane** (or eardrum).
- 2- The **tympanic cavity** : an irregularly shaped, air-containing compartment .
- 3- The **Auditory ossicles** : three small bones ( **malleus , incus and stapes** ) located inside the tympanic cavity .

The middle ear communicates with the **mastoid antrum** and communicates with the nasopharynx through the **Eustachian tube**, by which air pressure is equalized in the middle ear.

**The Internal ear:** it is the essential part for hearing and equilibrium , consists of membranous structure contained within a bony labyrinth .

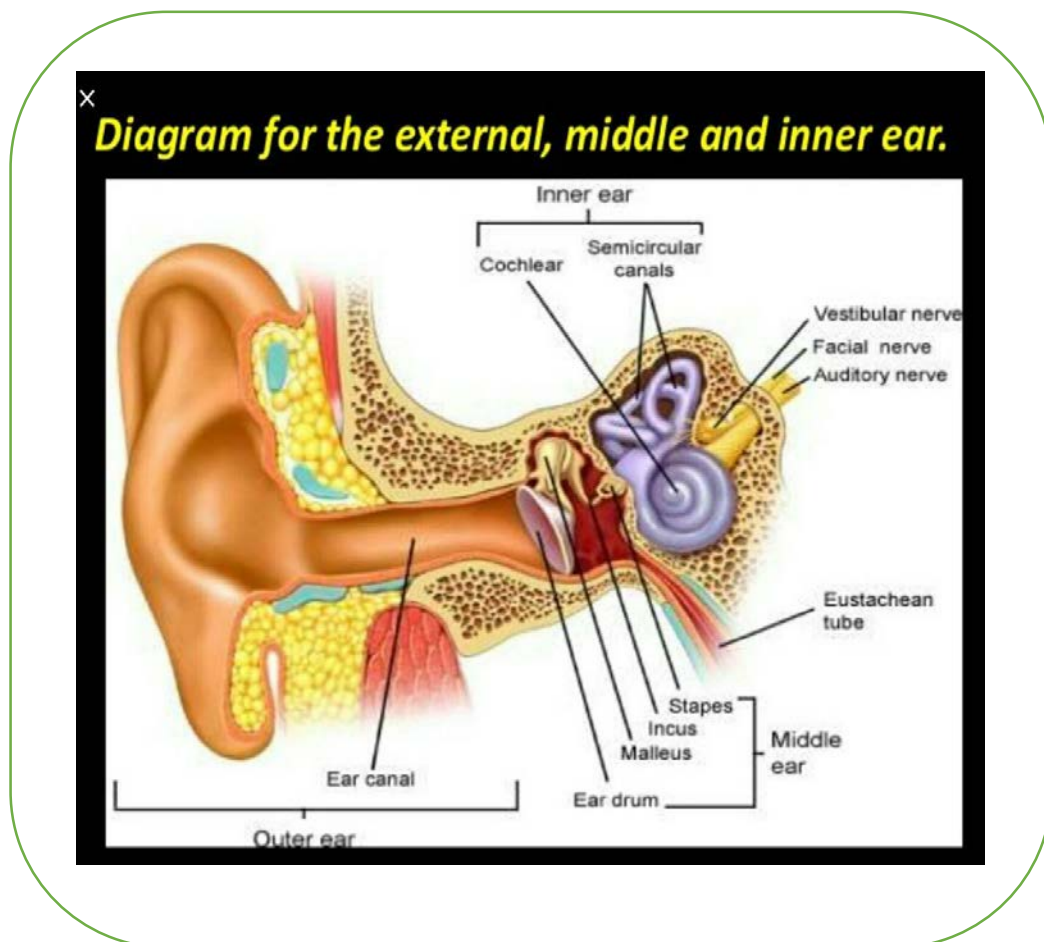
The bony labyrinth consists of three parts:

(1) The **cochlea**( organ of **hearing** ) : a spiral coiled, tubular part, which communicates with the middle ear through the membranous covering of the **round window** .

(2) The **vestibule** : a small, ovoid central compartment behind the cochlea, which communicates with the middle ear by way of the **oval window**.

(3)The **semicircular canals** : three canals , forming with the vestibule the organ of equilibrium.

The **IAM** : is a bony canal about 1 cm in length , for passing the facial nerve( 7<sup>th</sup> N) and the vestibulocochlear nerve( 8<sup>th</sup> N) from posterior fossa to the inner ear .



## Base of skull:-

has three fossae through which the brain is situated and they contain foramina for entering and exiting of the blood vessels and nerve to the skull .

### 1. Anterior cranial fossa,

The bone which formed this fossa are

**Ethmoid bone**  
(cribriform plate)

**Frontal bone**  
(Orbital plate)

**Sphenoid bone**  
(lesser wing)

### 2. Middle cranial fossa, it contains pituitary gland

The bone which formed this fossa are

**Sphenoid**  
(body & great wing)

**Temporal bone**

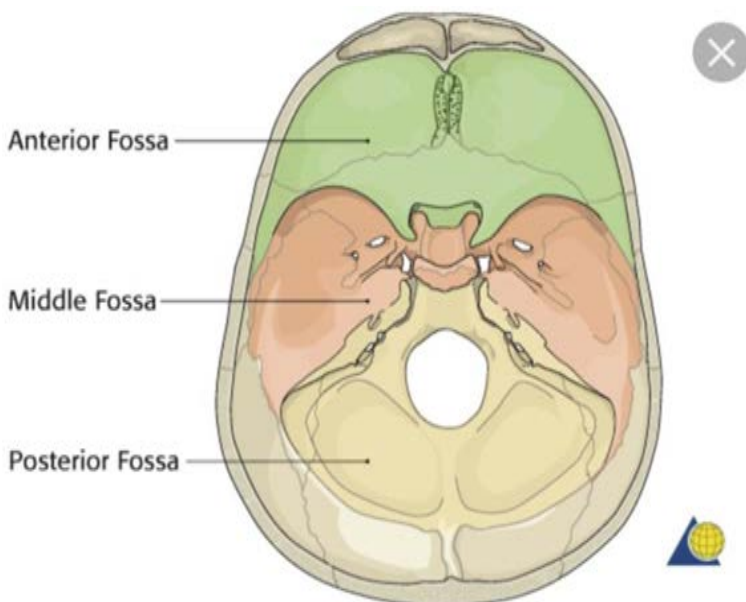
### 3. Posterior cranial fossa,

The bone which formed this fossa.

**Occipital**

**Sphenoid**  
(body)

**Temporal bone**

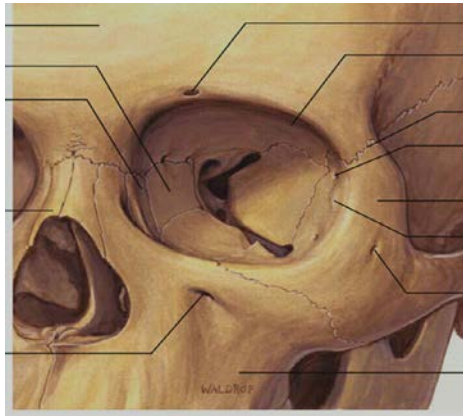
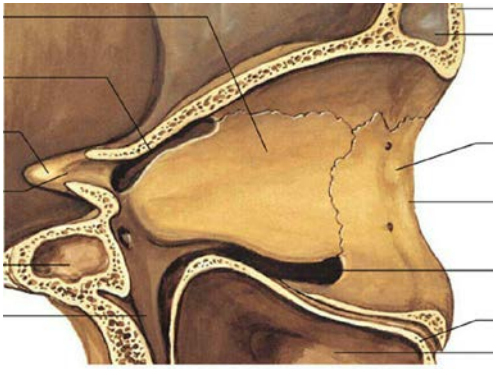


## Orbit :

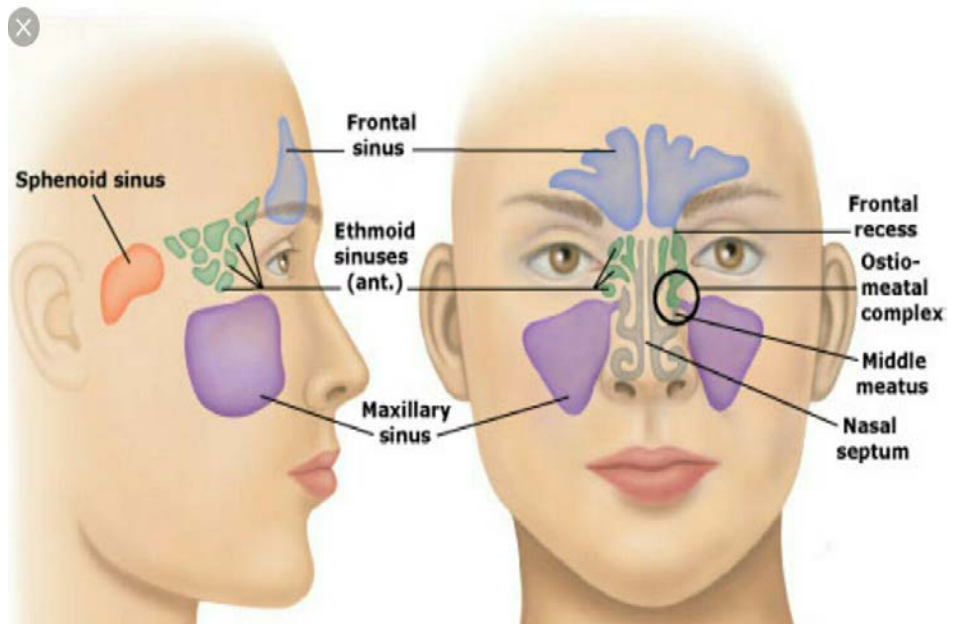
Is a **quadriangular pyramid** , it contains :**the Globe** , **the lacrimal gland** and **the extra ocular muscles**

It has anterior circular margin( **orbital rim** ) and posterior confluence ( **orbital apex** ) , there are **3 openings** ( **the optic canal** , **the superior** and **inferior orbital fissures** ) for transmission of nerves and vessels from the intra cranial compartment to the orbit .

It consist of **7 bones** ( **3 cranial** and **4 facial** ) .



## Paranasal Sinuses :



They are **4 paired** , **air filled** spaces located within the skull that surround the nasal cavity , situated in the frontal, ethmoidal, and sphenoidal bones of the cranium and the maxillary bones of the face

They are called the para nasal sinuses because of their formation from the nasal mucosa and their communication with the nasal cavity.

They serve for **lightening** the weight of the skull and considered **shock absorber** also they humidify the air inside .

They develop by **pneumatization process** as an outgrowth from the nasal cavity , all of them drain into the nasal cavity.

They should **contain only air** , the radiographer should avoid over penetration or under penetration because it may mislead the pathology .

**The maxillary sinuses** which are the largest sinuses and first sinuses to appear on x- ray since a few week after birth and continue to develop till the permanent teeth is completely erupted .

Its floor is below the nasal cavity and its opening is superior

Its floor is below the nasal cavity and its opening is superior

**The frontal sinuses** : they are not visible on x-ray at birth and appears by the age of 2 years. Asymmetry is common and one or both may fail to develop.

**The ethmoid sinuses:** are located within the labyrinths of the ethmoid bone between the 2 orbits , and develop at the same rate as the frontal sinuses.

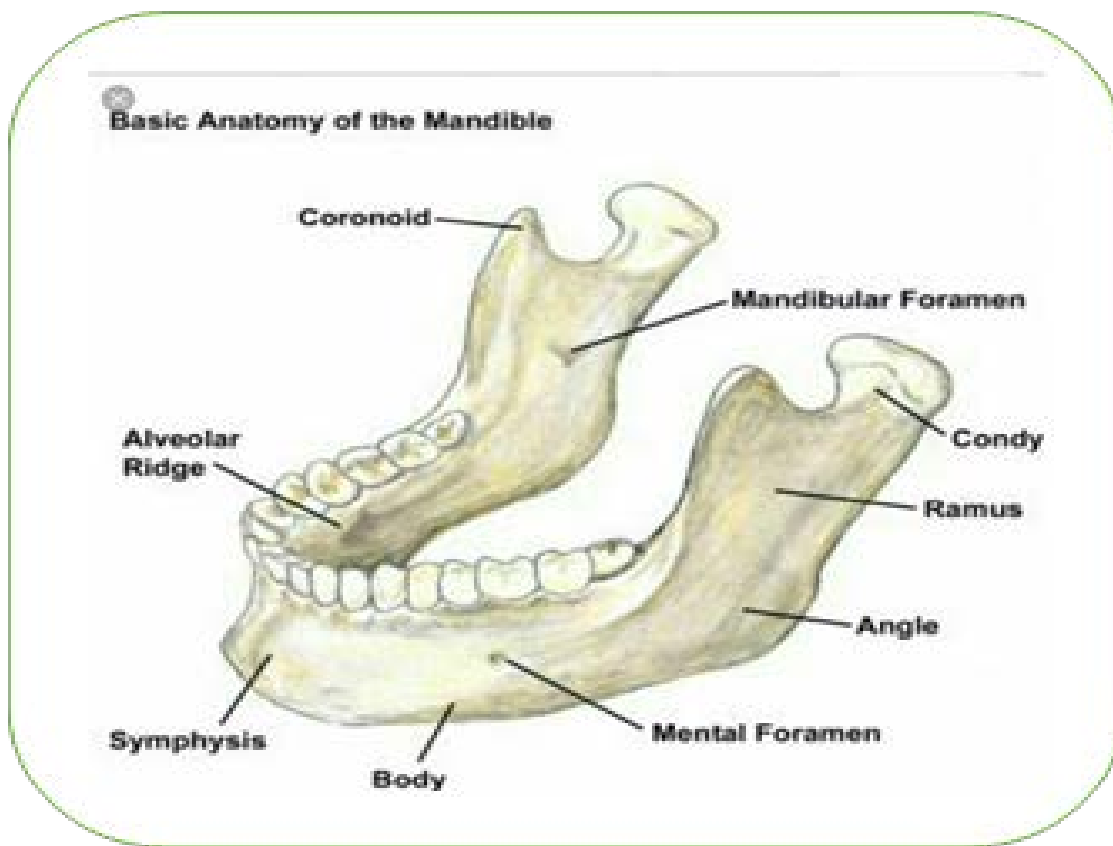
**The sphenoid sinuses** : are located inside the head of the sphenoid bone , their pneumatization begin at the age of 3 years , their floor is the roof of the nasal cavity .

## **MANDIBLE**

The largest and densest bone of the face

consists of a horizontal portion( **the body**) and two vertical portions( **the rami**) which unite with the body at the **angle of the mandible**( **gonion**).

The **symphysis** is the most anterior and central part of the mandible where the left and right halves of the mandible have fused.



The superior border of the body consists of spongy bone, called the **alveolar portion**, which supports the roots of the teeth.

Below the second premolar tooth, is a small opening on each side for the transmission of nerves and blood vessels called **mental foramina**.

The rami project superiorly at an obtuse **angle ( 110-120)** to the body of the mandible. Each ramus has **2 processes** at its upper end , one **coronoid** and one **condylar** ,which are separated by a concave area called the **mandibular notch**

The condylar process articulates with the mandibular fossa of the temporal bone the **TMJ**

## Hyoid Bone

a small , **U-shaped** structure **at the base of the tongue**, where it is held in position by the stylohyoid ligaments extending from the styloid processes of the temporal bones.

Is the only bone in the body that **does not articulate** with any other bone. serves as an **attachment** for certain muscles of the larynx and tongue.



## **Nervous system**

**Central Nervous System (CNS)** : consists of the **brain and the spinal cord** which are located in the skull and the spinal canal respectively .

**Peripheral Nervous System(PNS )** : consists of :

### **a- Cranial nerves :**

**12 pairs** of nerves from the brain and exit the skull through different foramina to innervate the head , face and neck .

### **b- Spinal nerves:**

**31 pairs** of nerves arise from the spinal cord and exit the spinal canal to innervate the whole body by sensory and motor nerves.

### **c-Autonomic nervous system :**

#### **1- sympathetic nervous system**

#### **2-para sympathetic nervous system**

both innervate the internal organs like the heart , the intestine and the respiratory system and **regulate** the pulse ,the temperature , the intestinal movement and the hormone secretion.

## **Brain**

Consists of :

**Forebrain ( cerebrum ):** Rt and Lt cerebral hemisphere , each hemisphere consist of :

( Frontal ,parietal ,temporal and occipital lobe)

It has an irregular outer surface ( **cortex** ) consists of gyri ( the grey matter ) and sulci in between .

And more deep ( inside ) complex tracts of fibers called white matter

In addition to the basal ganglia , the thalamus ,hypothalamus and pituitary gland .

The lateral ventricle forms a cavity within each hemisphere .

The most important sulci are:

The central sulcus and the lateral sulcus ( **Sylvian fissure** ).

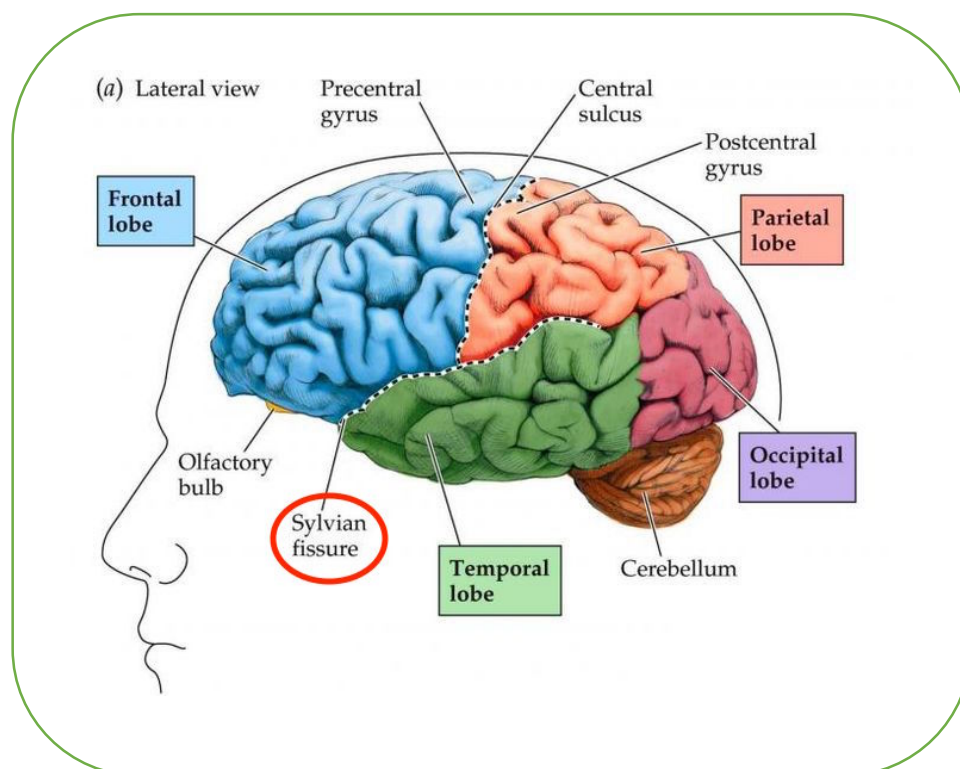
The largest part of the white matter is called **Corpus callosum** ,which is located centrally between the 2 hemispheres .

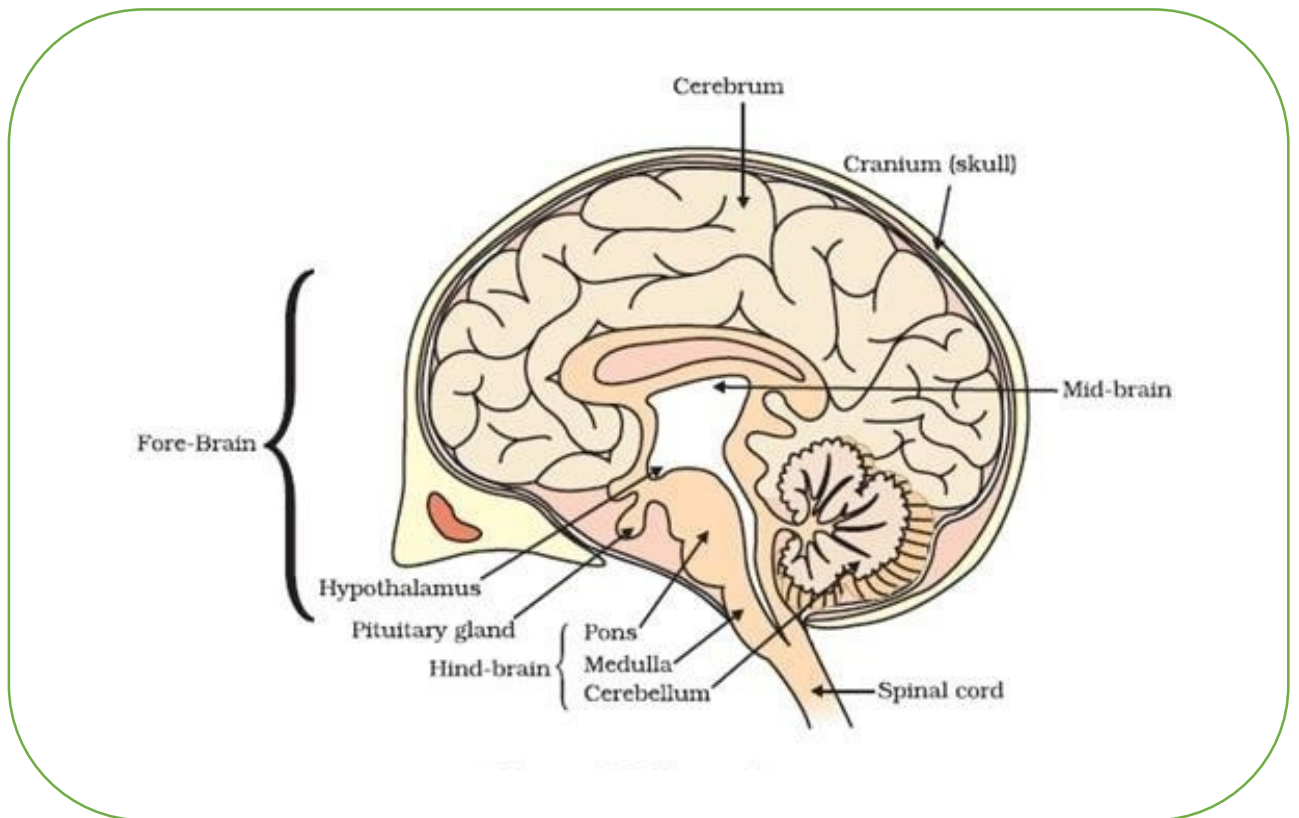
Each lobe of the brain is responsible on certain activity : for example :

The visual activity is located in the occipital cortex

The Intellectual activity is located in the frontal cortex

The Emotion is within the frontal and temporal lobe





## Mid Brain

Consists of : 2 cerebral peduncles ( crus cerebri ) and interpeduncular fossa

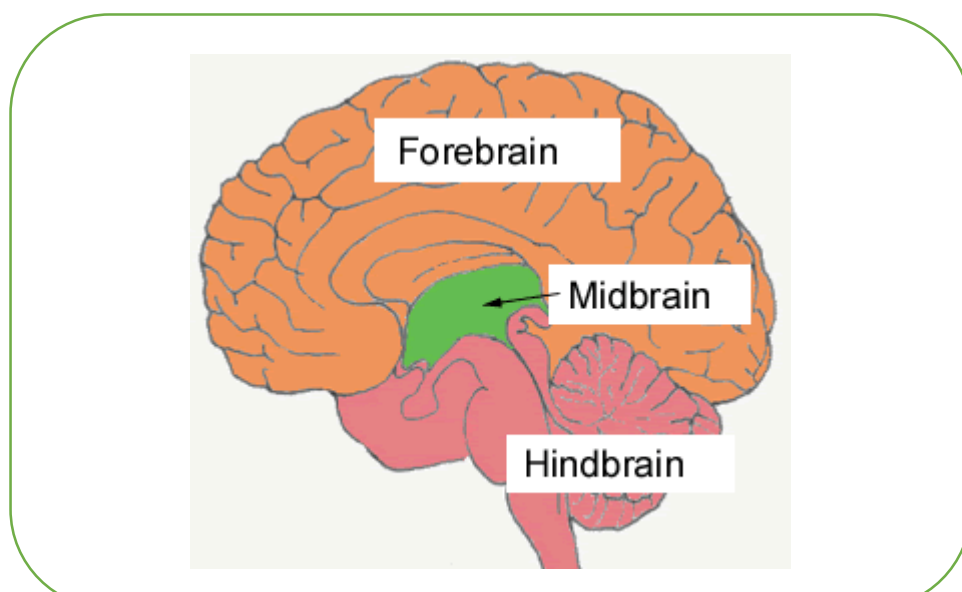
It connects the brain to the pons .

It gives 2 cranial nerves : the 3<sup>rd</sup> and the 4<sup>th</sup> .

## Hind Brain

Consists of :

Pons , Medulla oblongata and Cerebellum .

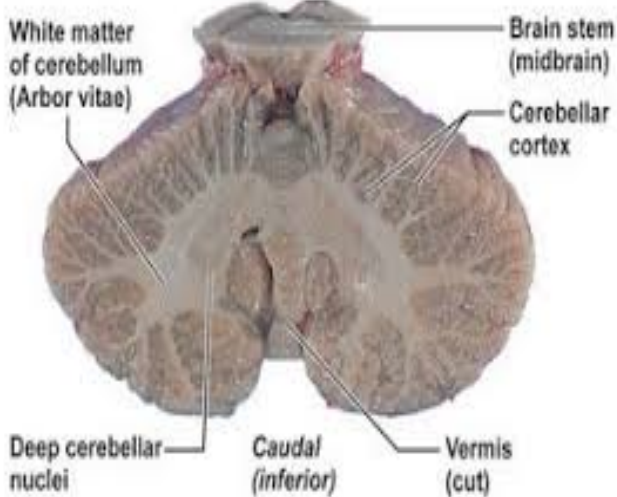


## Cerebellum

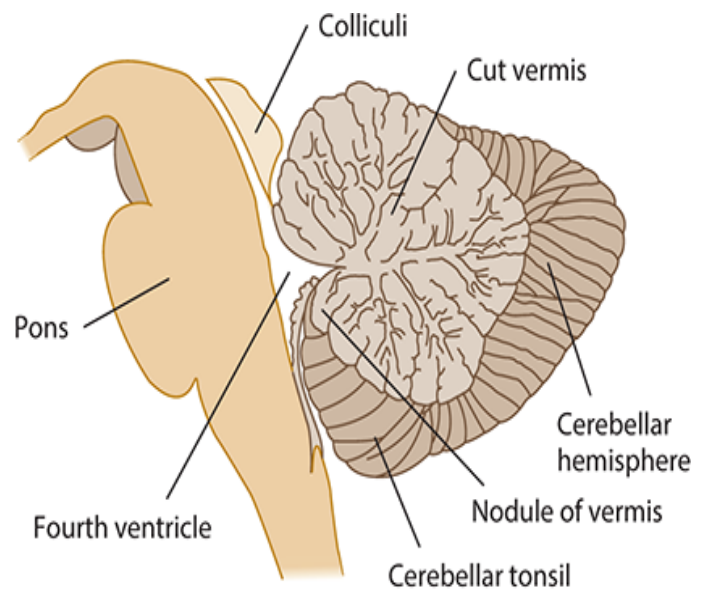
It consists of 2 hemispheres and is located in the posterior cranial fossa, it has a narrow midline portion called **Vermis**

It is located inferior to the cerebrum and posterior to the Pons and Medulla oblongata separated from them by the 4<sup>th</sup> ventricle.

**Brain Stem** : consist of mid brain , pons and medulla .

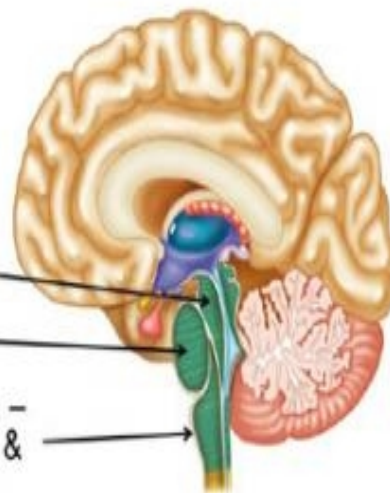


(d) Coronal section, posterior view



## Brain Stem

- Attaches to the spinal cord
- Parts of the brain stem
  - Midbrain
  - Pons
  - Medulla oblongata – controls breathing & heart rate



## Meninges

There are covering membranes to the brain and the spinal cord , these are from outside to inside :

### Dura matter:

Is the thickest layer that lining the cranium from inside , its outer surface is the endosteum of the skull .

The inner surface has several inward projections

- **Falx cerebri** which is located in median sagittal plane between the 2 hemispheres and attached anteriorly to the crista galli in the anterior cranial fossa.
- **Falx cerebelli** between the cerebellar hemispheres.
- **Diaphragma sellae** : a horizontal fold of the dura that covers the pituitary gland.
- **Tentorium cerebelli** : a horizontal fold of the dura separate the cerebrum from cerebellum .

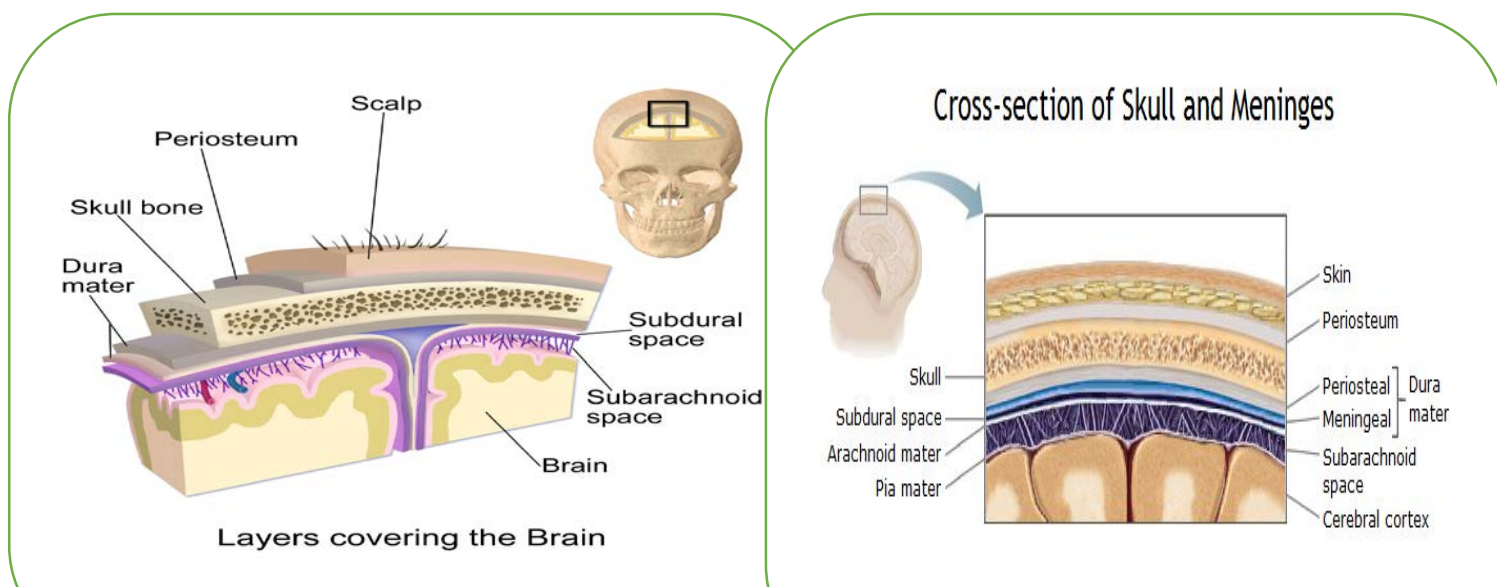
### Arachnoid matter:

A thin membrane under the dura ,impermeable to CSF , it contains the arachnoid villi that are responsible for CSF absorption .

### Pia Matter:

A thin membrane adheres to the brain and spinal cord .

Between the Pia and Arachnoid matter is **subarachnoid space** , through which the CSF circulate around the brain and the spinal cord .



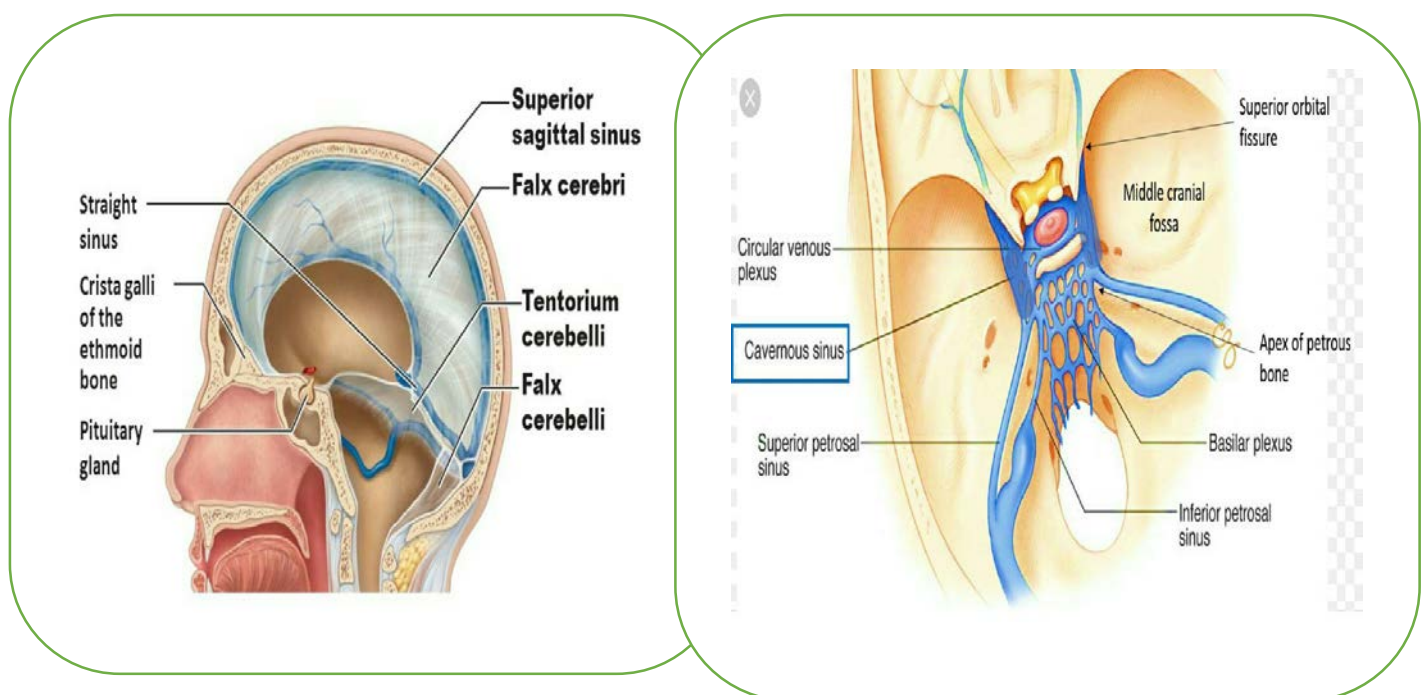
## Venous drainage of the brain

Via venous sinuses which are large veins within the folds of the Dura

Like : superior sagittal sinus which ends in the internal occipital protuberance by union with other sinuses

And Cavernous sinuses which are on each side of pituitary gland and sphenoidal body .

They drain into Internal jugular veins via the **jugular foramen** in the petrous temporal bone .



## Arterial supply of the brain

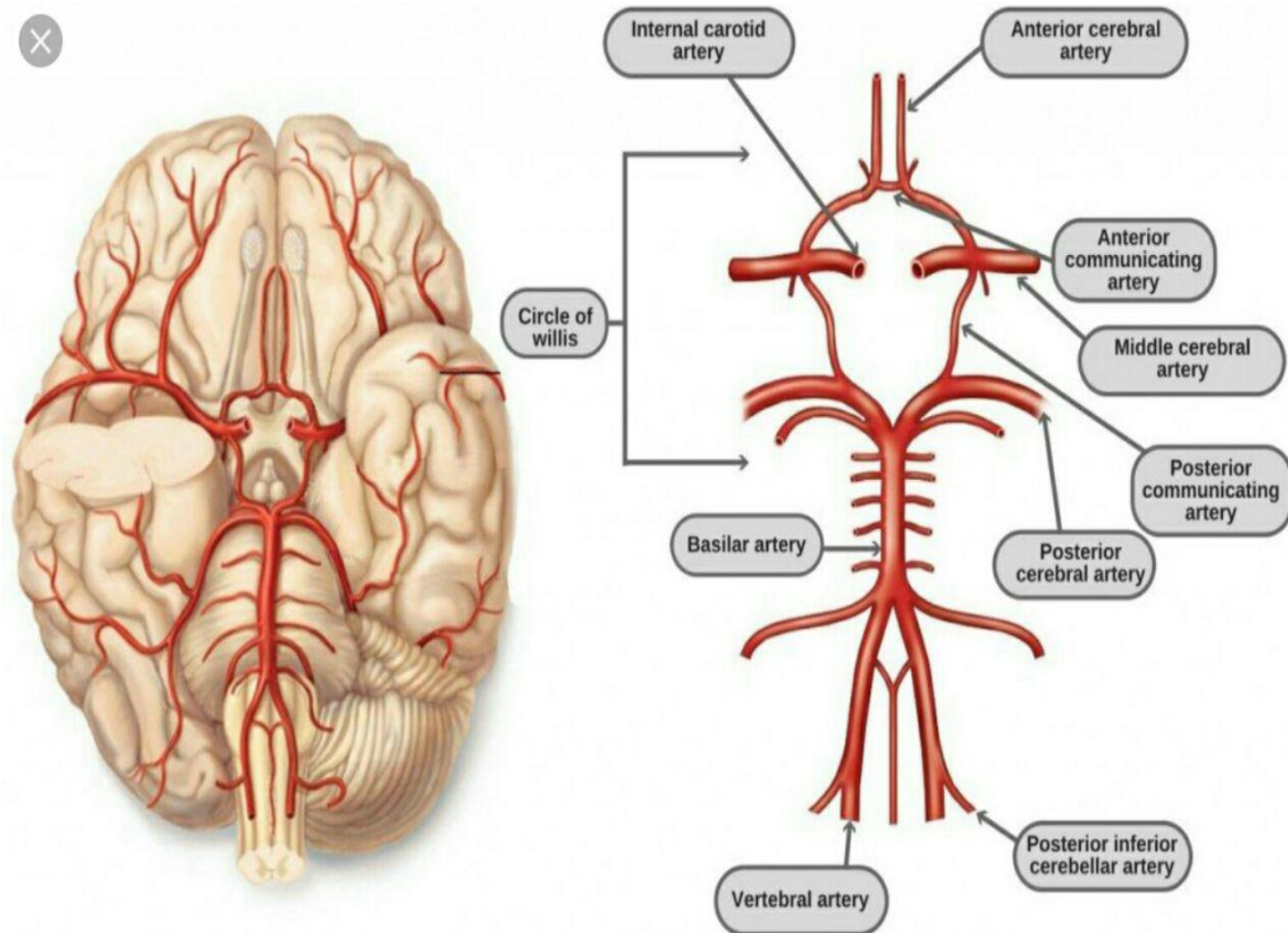
Via branches from the **Internal carotid artery** which enter the cranium through the carotid canal in the petrous temporal bone.

These are (2 anterior and 2 middle cerebral arteries)

And the **Basilar artery** which is formed by union of the 2 vertebral artery

It gives branches to the cerebellum and brain stem and ends by giving 2 branches ( posterior cerebral arteries )

The anterior , middle and posterior cerebral arteries form the **Circle of Wills** at the base of the brain .



## Ventricular system and Cisterns of the Brain

These are **fluid-filled** spaces within the brain

The lateral ventricle that located within each hemisphere ( consists of body and horns )

The 3<sup>rd</sup> and 4<sup>th</sup> ventricles which are midline continuation with the central canal of the spinal cord .

The ventricular system is also continuous with the subarachnoid space via foramina in the 4<sup>th</sup> ventricle

Some areas of the subarachnoid space are deep that are called

**Cisterns** , which contain CSF , particularly located at the base of the brain , like cisterna magna and suprasellar cistern .

## CSF Production and Flow

It is produced by choroid plexus inside the ventricles , and absorbed into the venous blood by arachnoid villi

It circulate in the ventricular system into the cisterns , some of which flows down ward around the spinal cord and some flows upward around the surface of the brain.

