

## Anatomy Lecture Notes Section 2: The Axial and Appendicular Skeleton

The Skeletal System has two Divisions – the Axial and Appendicular.

The distinction between the terms axial and appendicular can be made by describing **axial** as being the center-line or pivot-line through an object, and **appendicular** being described as something which is "hung on" to this central element. This type of description is apt for what we observe in the human skeleton.

**Axial Skeletal**



**Appendicular Skeletal**



The axial skeleton is composed of the bones in the skull, vertebral column and the ribcage of the chest.

The appendicular skeleton is composed the bones that attach (append) to your axial skeleton. The appendicular skeleton includes the bones of the pectoral girdle (shoulders, arms, hands) and pelvic girdle (pelvis, legs and feet). In other words, the bones of the appendicular skeleton are attached, therefore hanging off the axial skeleton.

The term appendicular comes from **appendicula**, which is the diminutive of appendix, both meaning 'small appendage'. Elsewhere in the body, for example, there is a structure called the **vermiform appendix** (often just called the appendix) which is hanging onto the colon like an appendage. There is also the appendix in a textbook, as a sort of attachment that is added onto the end of the book. As we will see, the appendicular skeleton is held onto the axial skeleton by girdles; the pectoral girdle for the upper limbs; and the pelvic girdle for the lower limbs. The garment called a girdle is an object that is wrapped around the body, from which articles are suspended, for example old fashioned garters from girdles. This is just one of many examples in anatomy where terms and functions from elsewhere in everyday life are used in anatomy.

It helps to know the vocabulary for bony landmarks that are commonly used for bones and work from there in locating other markings. In the skull in particular, processes are named for the bone they going toward, not the bone they are part of. These notes are to provide basic information about bone structures.

## The Axial Skeleton

Starting with the axial skeleton, the first area to focus on is of course the skull.

The **calvaria** is the dome or roof of the skull, also known as the “skullcap”. The calvaria is not a bone but an artificial section of the skull created by evenly cutting off the top part of the skull. The Latin *calvāria* means of the skull, from *calva* ‘scalp’ and from *calvus* ‘bald’. The calvaria is made up of the superior portions of the frontal bone, occipital bone, and parietal bones.



The format that follows will include brief descriptions of the sutures and bones of the skull.

### A. Sutures – immovable joints of the skull.

- A. Coronal Suture - between frontal and parietal bones.
- B. Lambdoidal Suture - between occipital and parietal bones.
- C. Sagittal Suture - between two parietal bones.
- D. Squamosal Suture - between temporal and parietal bones.
- E. Intermaxillary Suture – between the two halves of the maxillae bones.

Sutures of the skull are very useful landmarks because they create the boundary for where one bone ends and another begins, such that being familiar with key sutures enables easy identification of the different bones and specific processes.

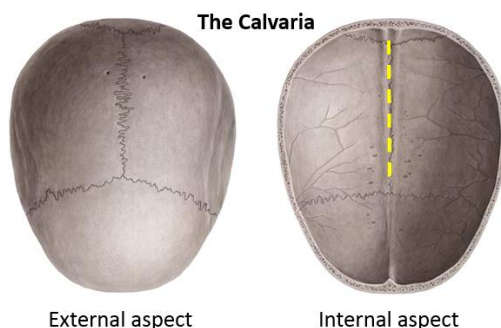
### B. Bones of the Skull: Cranial Bones

#### 1. Occipital Bone (1)

- a) Foramen magnum – means ‘hole big’, the large passageway is for the spinal cord to exit cranium.
- b) Occipital condyles – these articulate with atlas ( $c_1$ ), responsible for ‘yes’ gesture.
- c) External occipital crest - a midline ridge from external occipital protuberance to foramen magnum. Gives attachment to the nuchal ligament. It is also called the median nuchal line.
- d) External occipital protuberance – bony prominence for muscle attachment at the back of the head.
- e) Nuchal lines - inferior and superior – for muscle attachments for nape of neck.
- f) Jugular foramen – only seen when connected to temporal bone. Passageway for nerves and the exit of internal jugular vein from cranium.

#### 2) Parietal Bones (2)

- a. Groove for superior sagittal sinus – this is a shallow groove located on the internal aspect of the calvaria of the skull. A large vein of the head, called the **superior sagittal sinus**, sits in this groove.



In anatomy a word can have different meanings when used in the context of different systems in the body. The word **sinus** is a good example of this: A sinus in the skeletal system (bones) means a hollow cavity or chamber in bone; however a sinus in the cardiovascular system (heart and vessels) means a large vessel, usually a vein.

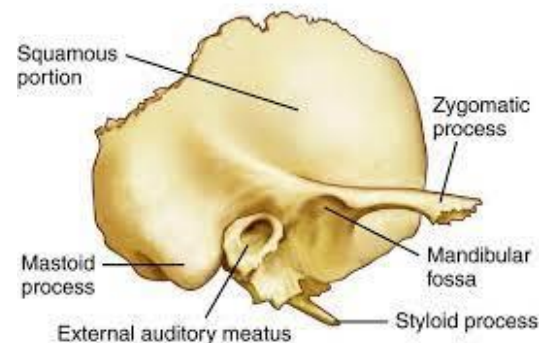
Looking at the internal aspect of the calvaria in the image (the one on the right), the dashed yellow line identifies the long deep groove running along the inner surface of the roof where the sagittal suture is located, sandwiched right in the middle of the two parietal bones.

### 3) Frontal Bone (1)

- Orbital surface – the frontal bone creates the roof of the orbital (eye socket).
- Supraorbital margins – creates the rim of the orbit.
- Supraorbital foramen and notch – these are different structures. Foramen is a hole, whereas a notch is a hole that has breached the margin and is no longer a hole, but a notch.
- Superciliary arch – a thickening prominence of the forehead just above the eyebrows.
- Lacrimal fossa – a shallow depression for lacrimal gland, on orbital surface.
- Zygomatic process – portion of this bone meeting the zygomatic bone of the cheek.
- Metopic suture - remnant of fusion between the two frontal bones of the fetal skull.
- Frontal sinus - the frontal bone is one of 4 skull bones that have a hollow sinus in them.

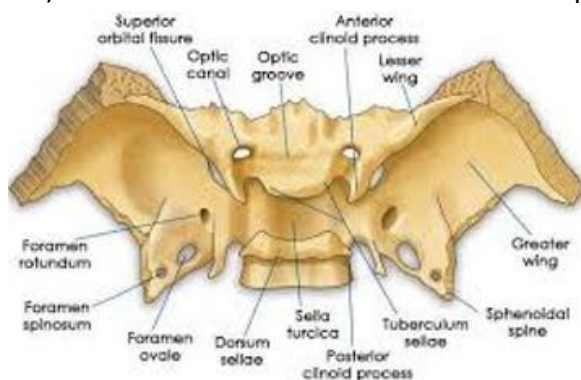
### 4) Temporal Bone (2)

- Squamous portion – the flat thin superior part of this bone, helps make the squamous suture.
- Petrous portion – meaning ‘rock’ or hard portion (like petroleum or petrified). This is found on the internal aspect of skull and separate the posterior.
- Mastoid process – rounded lump behind ear, ‘mastoid’ means breast-like.
- Zygomatic process - reaches toward zygomatic bone, contributes to the zygomatic arch.
- Mandibular fossa – the shallow depression that hold the articulation surface with the mandible.
- External auditory canal – outer entrance to tympanic membrane (ear drum).
- Internal auditory canal – internal passageway within the petrous portion.
- Styloid process - sharp pointy process, stylus means needle.
- Carotid canal – passageway for entry of the internal carotid artery to cranium.
- Jugular foramen (only seen when temporal bone is joined with occipital). This very large passage way is for the passage of internal jugular vein, in addition to the passage of the glossopharyngeal, vagus, and accessory nerves.



### 5) Sphenoid Bone (1)

- Greater wings – the largest flared out portion of this bone.
- Lesser wings – the smaller upper portion.
- Sella turcica – creates a fossa which the pituitary gland sits in. Sella means saddle, turcica means Turkish, so this is a Turkish saddle for the pituitary gland to ride on.
- Optic foramen (canal) - passage for optic nerve bringing in sensory information from the eye.
- Superior orbital fissure – a large jagged opening at the top of the orbital (eye socket).
- Foramen rotundum – has a round shape, for passage of maxillary nerve.

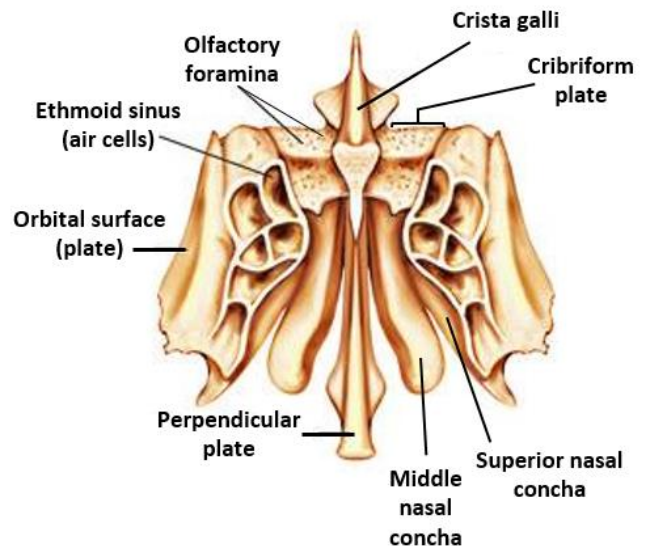


- Foramen ovale – an ovale shape, for passage of mandibular nerve.
- Foramen spinosum – has a spiny small shape, for passage of middle meningeal vessels.
- Sphenoidal sinus – the body of the sphenoid bone is a hollowed sinus cavity.
- Pterygoid processes – from the Greek word pteryg-meaning “wing”, and -oid meaning “like”, as in a pterodactyl, the so called winged dinosaur. The two pterygoid processes have a lateral and medial plate and

are for the attachment of the pterygoid muscles which are involved in the lateral movement of the mandible when chewing and grinding food.

### 6) Ethmoid Bone (1)

- Crista galli – site of attachment for the cranial meninges. Means crest of the chicken.
- Cribriform plate - opening for passage of the many branches of the olfactory nerve.
- Olfactory foramina – these are many holes on the cribriform plate for the olfactory nerve branches.
- Perpendicular plate – long structure going down to the vomer to form the bony nasal septum.
- Superior nasal conchae – the top shell structure of ethmoid.
- Middle nasal conchae – the bottom shell structure of ethmoid.
- Ethmoidal sinuses (air cells) – these are the sinuses of the ethmoid bone.



## B. Bones of the Skull: Facial Bones

1) Nasal Bones (2) – these form the bony bridge of nose.

### 2) Maxillae Bones (2)

- Frontal process – process that reaches up towards and articulating with the frontal bone.
- Infraorbital foramen – hole just below the orbit.
- Zygomatic process - reaches toward zygomatic bone.
- Palatal process – creates the first 2/3 of the hard pallet (roof) of mouth. Horizontal orientation.
- Alveolar process - these are the ridges around the sockets for the teeth.
- Incisive fossa – immediately posterior to central incisors, leads to the incisive foramen or canal.
- Intermaxillary suture - -immovable joint connecting the 2 maxillary bones.
- Maxillary sinus – very large, cavernous chamber in this bone, inferior to the eyes.

### 3) Mandible Bone (1)

- Body – this structure is the bulk of this bone.
- Angle – is a term meaning ‘corner’, it’s where it changes direction and goes up from the body.
- Ramus – is a term meaning branch. This is the part that goes up to temporal bone after the angle.
- Mandibular condyles, or condylar processes – the articulating surface, sitting in the mandibular fossa of the temporal bone creating the temporal mandibular joint, or the TMJ.
- Coronoid process – coronoid means ‘crown-like’, this is the high sharp point opposite the condyles.
- Mental foramen – nutrient foramen on the chin region.
- Mental protuberance – bony protrusion of the chin, ‘mental’ means chin.
- Mandibular notch – that dip or downward arch between condylar and coronoid process.
- Mandibular foramen – on the internal aspect of the rami of the mandible.
- Alveolar process – these are the ridges around the sockets for the teeth.

**4) Zygomatic Bones (2)** – the ‘union’ cheek bone of the face.

**5) Palatine Bones (2)** – contributes to posterior 1/3 portion of hard palate. A small section of this bone is one of the 7 bones that contributes to the orbit of the eye.

**6) Lacrimal Bones (2)** – a bone that helps to create the orbit of the eye. Within this bone is the lacrimal canal, which drains tears from the eyes into the nasal cavity.

**7) Vomer Bone (1)** – this bone creates the inferior portion of bony nasal septum.

**8) Inferior Nasal Conchae (2)** – a turbinate bone in the nasal cavity, to slow passage of air.

**Hyoid Bone (1)** – this is the only bone in body that does not directly articulate with any other bone.

**Auditory ossicles** – these are the smallest bones in the human body. They are located in the middle ear and receive the transduction of sound waves from the tympanic membrane (ear drum). (three pairs) – Malleus (2), Incus (2) and Stapes (2)

**Sinuses:** In the skeletal system a sinus is a hollow cavity or chamber in bone that is lined with a mucous membrane, producing mucus that drains into the nasal cavity.

There are 4 **paranasal sinuses** (para means next to), all of them open into the nasal cavity. All of them are lined with a mucous membrane because they are directly (although not easily) connected to the external environment.

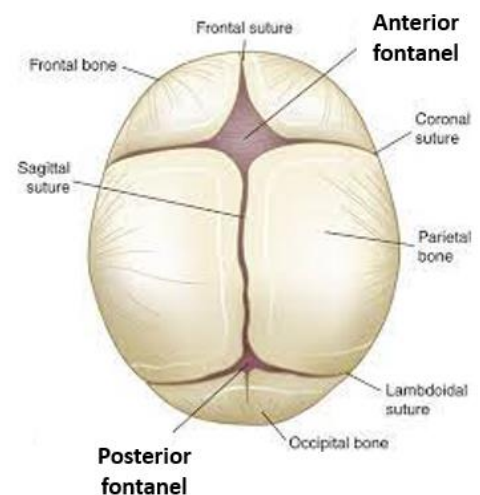
The four paranasal sinuses are:

- 1) Frontal sinus
- 2) Ethmoid sinus
- 3) Sphenoid sinus
- 4) Maxillary sinus

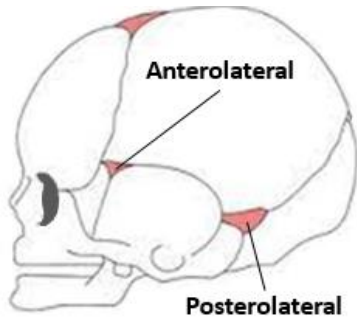
There is also a sealed sinus, called the mastoid sinus of the temporal bone. Often these are called the mastoid air cells.

**C. Fetal Skull** – In order to allow for the continuous growth and development of the skull in utero and after birth during infancy, many bones of the skull are interconnected by a dense fibrous structural called a fontanel (or fontanelles). The meaning of this word in Latin is “little fountain”. These structures may be better known to some as the “soft spots’ on a baby’s head. There are 4 major fontanel (or fontanelles) that we will cover in the developing skull:

1. Frontal (anterior) – the largest fontanel and takes the longest to fuse and become completely closed, usually closing in about 18 months. This is the most conspicuous region where the babies pulse may be seen at the fontanel, located between the 2 frontal and 2 parietal bones in the developing skull.



2. Posterior (occipital) – located in the back of the skull, between occipital and parietal bones.



3. Anterolateral (sphenoid) – located towards the front between parietal, sphenoid, and temporal bones.

4. Posterolateral (mastoid) - located towards the back between temporal, occipital, and parietal bones.

#### D. Spinal Column

The Spinal Column has 4 main regions:

Cervical (neck); Thoracic (chest); Lumbar (lower back) and Sacral (lowest portion)

- a) Cervical 1-7 have transverse foramina.  
Special C<sub>1</sub> – atlas, no centrum, articulates w/ occipital bone superiorly and axis inferiorly.  
C<sub>2</sub>- axis – has a superior process, the dens, around which the atlas articulates in a side-to side motion.  
C<sub>7</sub> - has long straight spinous process, referred to as the cervical prominens.
- b) Thoracic – 1-12, ribs attached, will have costal facets for ribs.
- c) Lumbar – 1-5 large, blocky spinous processes.
- d) Sacrum 1-5 fused into one block.
- e) Coccyx – 1-3/5 sections, partially fused.

#### 2. Curvatures - normal

- a) Primary – the direction of a fetal spinal curvature, concave anteriorly.
  - a. Thoracic
  - b. Sacral
- b) Secondary – convex anteriorly, occur later in development.
  - a. Cervical - develops when able to hold head up.
  - b. Lumbar - develops when able to stand, the weight bearing vertebrae.

#### 3. Abnormal Curvatures of the Vertebral Column

- a) Kyphosis – exaggerated thoracic curvature, “hunchback”, ‘dowager’s hump’.
- b) Lordosis – exaggerated lumbar curvature, “swayback”.
- c) Scoliosis – lateral curvature mainly in thoracic region.

#### 4. The Vertebrae

- a) Body (centrum)
- b) Neural Arch made up of lamina and pedicles.
- c) Neural Foramen/Vertebral Foramen – surrounded by centrum and neural arch.
- d) Spinous Processes – unpaired.
- e) Transverse Processes – paired.
- f) Superior articulating Processes – paired.
- g) Inferior articulating Processes – paired.

## E. Ribs and Sternum

### 1. 12 Pairs of Ribs.

- a) 7 Pairs of true ribs: Each attach to sternum by cartilage.
- b) 5 Pairs of false ribs: There are 3 false, attaching indirectly to sternum via the costal cartilage of ribs 5 and 6 and 7, and 2 are floating pairs – these have no sternal attachment at all, and ‘float’ in the back muscles.

### 2. Sternum (develop as 3 separate bones).

- a) Manubrium – ‘handle’ (manu-) of sternum.
- b) Body – bulk of the ‘breast bone’.
- c) Xiphoid – sword like ending.

## The Appendicular Skeleton

Names are very important.

This is because the names of structures most often provide a lot of information about the bone itself, what it is next too or what is sitting on it. A couple of ideas to give students as they start this section is to listen to the names and determine what it is providing you with. If there is something named greater, chances are there will be a lesser; if there is a posterior, chances are there will be an anterior; if a superior, an inferior; etc. In addition, names of structures often give other information, like what region it is associated with (acromion process is associated with the shoulder), or what other structure we will encounter later is sitting on that bone region, like how the iliacus muscle sits in the iliac fossa of the ilium.

## I. Upper Limb: Pectoral Girdle

### 1. Clavicle

- a) Sternal end – articulates with sternum.
- b) Acromial end – flared out portion that makes shoulder area with the acromion process.
- c) Conoid tubercle - site for the attachment of a ligament to the coracoid process.

### 2. Scapula

- a) Acromion – represents the lateral and superior tip of the shoulder.
- b) Coracoid process - hooked process, deep in shoulder for muscle attachment.
- c) Scapular spine - long ridge on posterior aspect, divides the posterior fossa.
- d) Subscapular fossa – shallow depression on anterior surface.
- e) Supraspinous fossa - depression above the spine.
- f) Infraspinous fossa - depression inferior to the spine.
- g) Superior border – the top portion of the bone (imagine an upside-down triangle).
- h) Medial (vertebral) border, it is thin and sharp, like a blade.
- i) Lateral (axillary) border, this is thick and creates the armpit (axillary) area.
- j) Superior angle – the highest portion of the scapula.
- k) Inferior angle – the lowest portion of the scapula.
- l) Glenoid cavity (fossa) - articulation point with the head of humerus.
- m) Supraglenoid tubercle – for muscle attachment.
- n) Infraglenoid tubercle – for muscle attachment.

## A. Arm

### 1. Humerus

- a) Head – the large expanded articulating surface at proximal end of this bone.
- b) Greater tubercle – larger process near head.
- c) Lesser tubercle – smaller process near head.
- d) Intertubercular groove - groove going in between the two tubercles.
- e) Anatomical neck - just distal to the head.
- f) Deltoid tuberosity - roughened area where muscle inserts
- g) Condyle - medial portion of distal end.
- h) Olecranon fossa - posterior distal depression for olecranon process to sit in.
- i) Coronoid fossa - anterior distal depression for coronoid process to sit in.
- j) Medial epicondyle – area above the medial condylar surface.
- k) Lateral epicondyle – area above the lateral condylar surface.
- l) Trochlea - means pulley, articulating surface for ulna (the medial condyle)
- m) Capitulum - "little head" articulating surface for radius (the lateral condyle)

### 2. Ulna

- a) Olecranon process - bulky proximal end, olecranon means 'elbow'.
- b) Trochlear (semilunar) notch - articulates with the trochlea of the humerus.
- c) Coronoid process - high pointed process just distal to the trochlear notch.
- d) Radial notch - proximal and lateral to the trochlear notch, articulation point with head of radius.
- e) Ulnar head - rounded portion at distal end of this bone.
- f) Styloid process - distal pointed process near head.

### 3. Radius

- a) Radial head - proximal flat "disc" shaped structure.
- b) Neck – narrowing after head and distal to radial tuberosity.
- c) Radial tuberosity – protruding rough patch near proximal end, muscle attachment.
- d) Styloid process – pointed process on distal end of this bone.
- e) Ulnar notch - distal medial depression and surface for articulation with head of ulna.

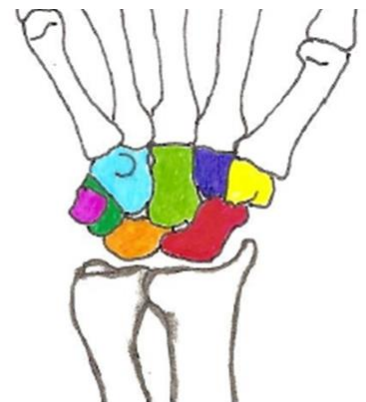
### 4. Carpals – These are small boxy bones that are best viewed as 2 rows of 4 bones each.

Note: The value and benefit of using 'mnemonic sayings' cannot be underestimated. A mnemonic device is a way of making a pattern with letters or words, that are unrelated but assist us in remembering something that is complex or unfamiliar. The word mnemonic is from the Greek mnēmōnikos, meaning 'of memory', related to Mnemosyne "remembrance".

Here is an example of a mnemonic sayings for remembering the order of the 8 carpal bones of the wrist.

#### **Carpal Mnemonic: *Some Lovers Try Positions That They Can't Handle***

The first letter of each word is how the name of carpal bone starts, from the first carpal bone to the last.



Wrist, Hand and Fingers: Anterior View



Here are the 8 bone presented in 2 rows of 4 bones, from thumb side (lateral to medial):

Proximal Row:            **1) Scaphoid      2) Lunate      3) Triquetrum      4) Pisiform**

Distal Row:            **5) Trapezium      6) Trapezoid      7) Capitate      8) Hamate**

5. Metacarpals - hand bones, there are five, numbered from thumb side using Roman numerals (I-V).

6. Phalanges (singular is Phalanx) – these are the finger bones, there are only 2 phalanges in the thumb (proximal and distal), and 3 in all others, numbered from thumb side, named proximal, middle, and distal.

## II. Lower Limb: Pelvic Girdle

**A. Pelvis** – is the entire os coxa and sacrum.

- a) False (greater) pelvis - between iliac ala (wings) and iliac crests, a larger area.
- b) True (less) pelvis - completely surrounded by bone, a smaller area.
- c) Pelvic brim - top of true pelvis
- d) Pelvic inlet - space enclosed by pelvic brim
- e) Pelvic outlet - space bounded by ischial tuberosity, coccyx, and inferior border of pubis.
- f) Arcuate line – line going along the margin of the pelvic inlet.
- g) Obturator foramen – the ‘hole’ in the os coxa to lighten and make bone more flexible.

### B. Comparison of Male and Female Pelvises

- a) Female – oval, larger inlet: Male – heart shaped, smaller.
- b) Female – ischial spines more vertical: Male – tip inward.
- c) Female – pelvis broader, shallow: Male - narrower, deeper.
- d) Female – larger pubic angle, usually over  $> 100^\circ$ : Male smaller, sharper angle, usually less  $< 90^\circ$ .
- e) Female – thin pubic ramus: Male – everted inferior pubic ramus.

### C. Os Coxae (Composed of 3 Bones)

1. **Ischium** – this is the ‘butt bone’.

- a) Ischial spine – pointed portion, in between greater and lesser sciatic notch.
- b) Lesser sciatic notch - just inferior to the spine, the smaller of the 2 sciatic notches.
- c) Ischial tuberosity – large rough patch on inferior portion – this is the actual structure that bears weight when seated.
- d) Ramus – this ramus (branch) meets pubic ramus above halfway in between the two bones.

2. **Ilium** – this is the large flared "wing" of pelvis.

- a) Iliac crest - top of this bone, some may consider this the "hip bone".
- b) Auricular surface – auricle means ear, an ear-shaped articulating surface with the sacrum.
- c) Iliac fossa – shallow depression on the body of ilium for muscle to sit in.
- d) Greater sciatic notch - passageway for the sciatic nerve.
- e) Anterior superior iliac spine - top point on the front.
- f) Anterior inferior iliac spine - lower point on the front.
- g) Posterior superior iliac spine - top point on the back.
- h) Posterior inferior iliac spine - bottom point on the back.

### 3. Pubis – this is the pubic bone.

- a) Pubic symphysis – fibrocartilage pad where the 2 pubis bones come together.
- b) Pubic tubercle – processes on either side of symphysis for muscle attachment.
- c) Superior ramus – leading to body of pubis from ilium.
- d) Inferior ramus – leading to ramus of ischium.

## D. Bones of Lower Extremity

### 1. Femur – largest bone in the human body.

- a) Head with fovea capitis (the ligamentum teres attaches here to tether femur to acetabulum).
- b) Neck – site of fracture when the “hip” is broken.
- c) Greater trochanter - greatest width of hips.
- d) Lesser trochanter - posterior to the greater trochanter.
- e) Intertrochanteric line – faint line connecting the two trochanters on the anterior aspect.
- f) Intertrochanteric crest – thicker process connecting the two trochanters on the posterior aspect.
- g) Linea aspera - rough line along posterior length of this bone.
- h) Pectineal line – area for muscle attachment.
- i) Gluteal tuberosity – rough area for gluteal muscle attachment.
- j) Medial and lateral supracondylar ridges - part of the linea aspera.
- k) Popliteal surface - behind the knee, the popliteus muscle (that unlocks the knee) sits there.
- l) Medial condyle – large articulating surface at the distal end of femur, medial side.
- m) Lateral condyle - large articulating surface at the distal end of femur, lateral side.
- n) Intercondylar fossa - deep depression between the femoral condyles.
- o) Medial epicondyles – area above medial condyle.
- p) Lateral epicondyles - area above lateral condyle.
- q) Patellar surface - where patella associated with femur.

### 2. Patella

- a) Base - anterior superior edges.
- b) Apex - inferior point.
- c) Facets - ride against the femur condyles.

### 3. Tibia - heavy medial bone of leg.

- a) Intercondylar eminence - elevated ridge between the lateral and medial condyles.
- b) Medial condyle – articulating surface at medial proximal expansion of tibia.
- c) Lateral condyles - articulating surface at lateral proximal expansion of tibia.
- d) Tibial tuberosity - proximal anterior roughness, for muscle attachment (the quadriceps).
- e) Anterior crest – the sharp anterior border along length of tibia, the part that hits coffee tables.
- f) Medial malleolus – the ‘hammer’ expansion process, the inside ankle bone, most distal projection.

### 4. Fibula - thin lateral bone of leg

- a) Fibular head - proximal end.
- b) Interosseus border - sharp edge along the length of bone, where it articulated with tibia.
- c) Lateral malleolus – the outside ankle bone, most distal point of this bone.

**5. Tarsals** – These are the bones of the foot, there are 7 of them.

*Mnemonic: **C**ute **T**illie **N**ever **C**ould **C**ooperate*

Naming the tarsal bones from the posterior of the foot to anterior:

Calcaneus – the largest bone of the tarsal, it is the heel bone. Also bears weight.

Talus – central weight bearing bone, makes a hinge joint articulation with the tibia.

Navicular – boat shaped bone above the cuneiforms.

Cuboidal – cube shaped bone, the most lateral of the tarsals as they articulate with the metatarsals.

Medial cuneiform – the innermost (medial) of the 'wedge' bones.

Intermediate cuneiform – the one in the middle of the 'wedge' bones.

Lateral cuneiform – the outermost (later) of the 'wedge' bones.

**6. Metatarsals** – There are 5 bones (just like the hands), they are numbered from the big toe hallux (I) on medial side, to the most lateral pinky toe (V).

**7. Phalanges** – These are the toe bones of the foot, numbered and named just like the fingers of the hand. The big toe (hallux) has only 2 phalanges (proximal and distal), the rest have 3 phalanges; proximal, middle, and distal.