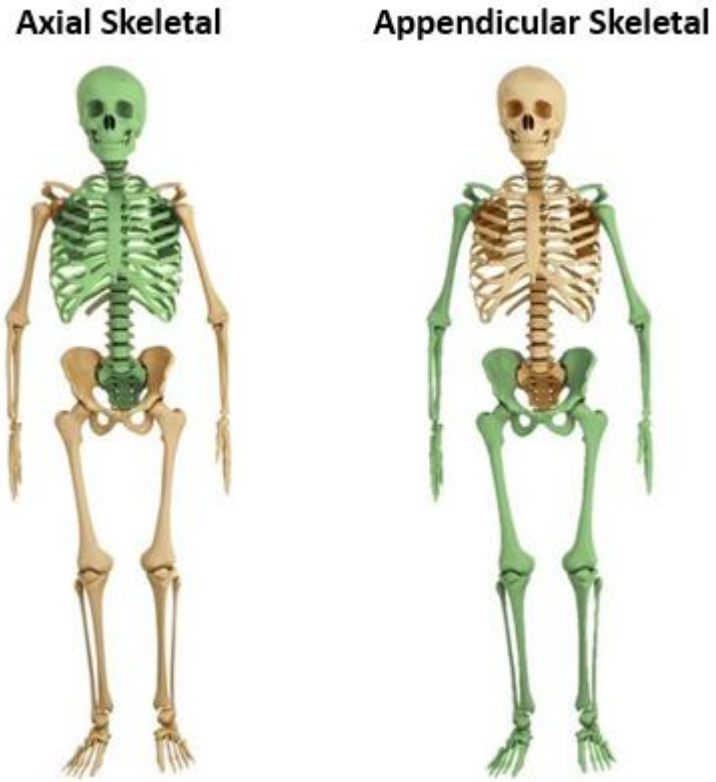
Anatomy Lecture Notes Section 2: The Axial and Appendicular Skeleton

The Skeletal System has two Divisions – the Axial Skeleton and the Appendicular Skeleton.
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 (see image below), 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.



Using the 2 images above as a frame of references, the axial skeleton (left) is composed of the bones in the skull, vertebral column and the ribcage of the chest. The appendicular skeleton (right) is composed the bones that attach (append) to the axial skeleton, and 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 to and therefore 'hanging off' of the axial skeleton.

The term appendicular comes from ***appendicula***, which is the diminutive of appendix, both meaning 'small appendage'. Elsewhere in the body, there is a structure called the **vermiform appendix** (often just called the appendix) which is hanging onto the intestine like an appendage. There is also the appendix in a textbook, as a sort of attachment that is added on at 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. For example, in the skull when a structure is called a process it is often named for the bone it is going toward, not the bone it is a part of. These notes are to provide basic information about bone structures that will be very helpful in any anatomy course.

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" (right). 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, the occipital bone, and the 2 parietal bones.

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

A. Sutures – these are actually articulations (joints), they are specifically immoveable 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 for the easy identification of the different bones and specific processes of the skull.

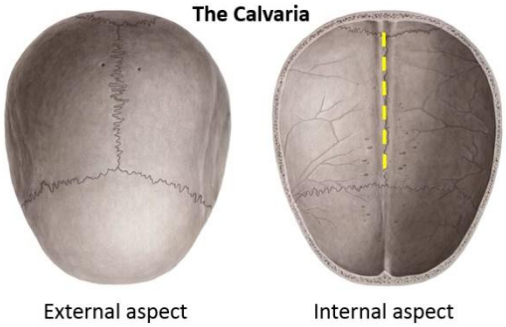
B. Bones of the Skull: Cranial Bones

1. Occipital Bone (1)

a) Foramen magnum – means 'hole big', the large passageway for the spinal cord to exit the cranium.
b) Occipital condyles – these articulate with the 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 at the nape of the neck.
f) Jugular foramen – only seen when connected to temporal bone. Passageway for nerves, and the exit route of the internal jugular veins from the cranium.

2) Parietal Bones (2)

a. Groove for superior sagittal sinus – this is a shallow groove (sulcus) 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.



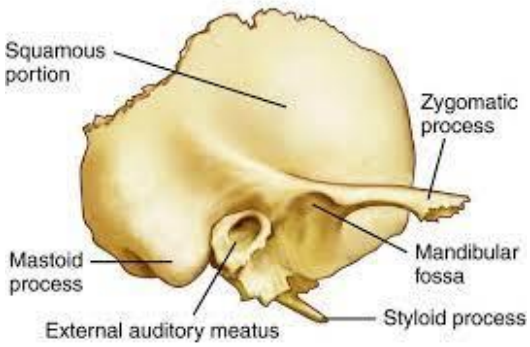
Looking at the internal aspect of the calvaria in the image at left, the dashed yellow line (on right) identifies the long deep groove running along the inner surface of the roof of the skull where the sagittal suture is located, sandwiched right in the middle of the two parietal bones.

3) Frontal Bone (1)

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

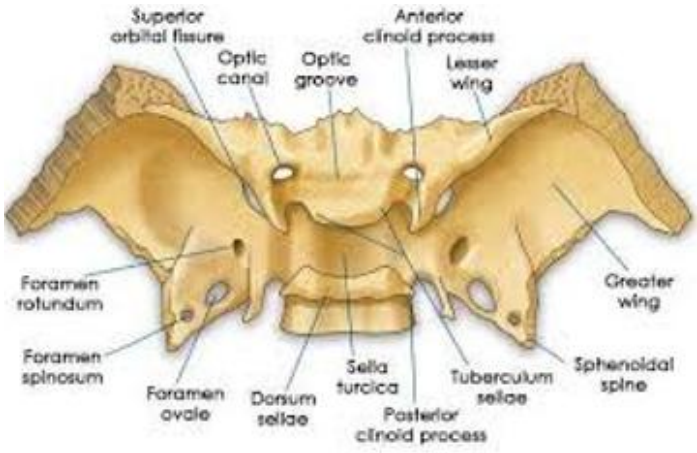
4) Temporal Bone (2)

a) Squamous portion – the flat thin superior part of this bone, helps to make the squamous suture.
b) Petrous portion – meaning 'rock' or hard portion (like petroleum or petrified). This is found on the internal aspect of skull and separates the posterior from the middle cranial fossae.
c) Mastoid process – rounded lump behind ear, the term 'mastoid' means breast-like.
d) Zygomatic process – reaches toward zygomatic bone, contributes to the zygomatic arch.
e) Mandibular fossa – the shallow depression that holds the articular condyle of the mandible.
f) External auditory canal – outer entrance to the tympanic membrane (ear drum).
g) Internal auditory canal – internal passageway within the petrous portion.
h) Styloid process – sharp pointy process, stylus means stake or needle.
i) Carotid canal – passageway for entry of the internal carotid artery into the cranium.
j) Jugular foramen (only seen when temporal bone is joined with occipital). This very large passageway is for the passage of internal jugular vein, in addition to the passage of the glossopharyngeal, vagus, and accessory nerves.



5) Sphenoid Bone (1)

a) Greater wings – the largest flared out portion of this bone.
b) Lesser wings – the smaller upper portion.
c) 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.
d) Optic foramen (canal) – passage for the optic nerve bringing in sensory information from the eye.
e) Superior orbital fissure – a large, jagged opening at the top of the orbital (eye socket).

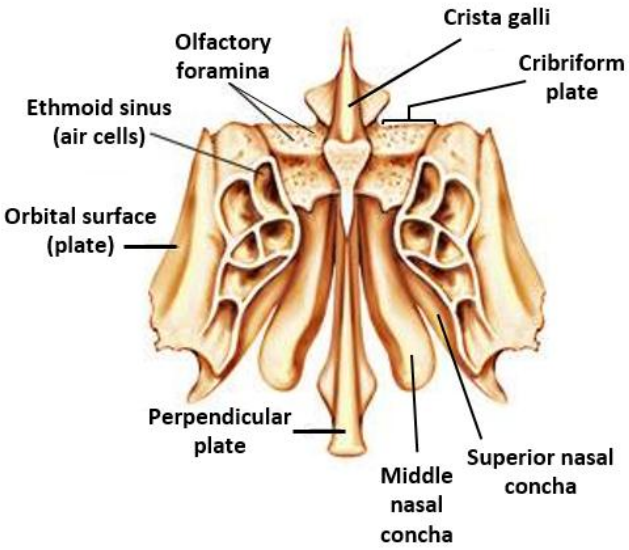


f) Foramen rotundum – has a round shape, for passage of the maxillary nerve.
g) Foramen ovale – an ovale shape, for passage of mandibular nerve.
h) Foramen spinosum – has a spiny small shape, for passage of middle meningeal vessels.
i) Sphenoidal sinus – the body of the sphenoid bone is a hollowed sinus cavity.
j) 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)

a) Crista galli – the site of attachment for the cranial meninges, it means 'crest of the chicken'.
b) Cribriform plate – a sieve-like superior region where holes exists for passage of the many branches of the olfactory nerve to make their way into the nasal cavity below.
c) Olfactory foramina – these are many holes on the cribriform plate for the olfactory nerve branches.
d) Perpendicular plate – long structure going down to the vomer to form the bony nasal septum.
e) Superior nasal conchae – the top massive shell-like structure of ethmoid.
f) Middle nasal conchae – the bottom shell-like structure of ethmoid.
g) 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 the nose, where eyeglasses would sit.

2) Maxillae Bones (2)

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

3) Mandible Bone (1)

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

4) Zygomatic Bones (2) – the cheek bones of the face, the word zygote means 'union'.

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 the 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). There are 3 pairs: 1) **Malleus**, 2) **Incus**, and 3) **Stapes**.

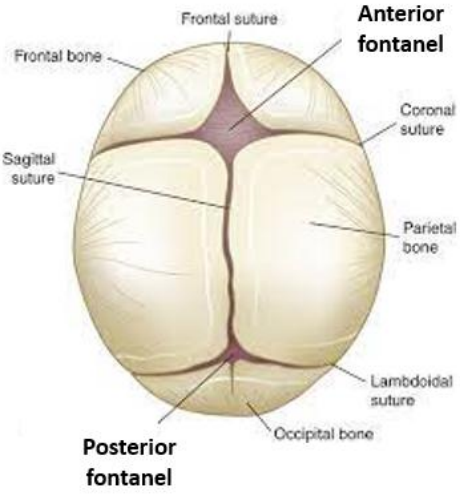
Sinuses: In the skeletal system a sinus is a hollow cavity or chamber in bone that is lined with a mucous membrane, producing mucus that drains into the nasal cavity.
There are 4 **paranasal sinuses** (para means next to), all of them open into the nasal cavity. All of them are lined with a mucous membrane 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

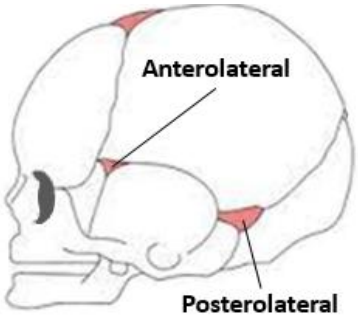
There is also a sealed sinus, called the mastoid sinus of the temporal bone. Often these are called the mastoid air cells.

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 structure called a **fontanel** (or fontanelle). 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 fontanels (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 baby's pulse may be seen at the fontanel, It is 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 of the developing skull 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_1 – atlas, no centrum, articulates w/ occipital bone superiorly and axis inferiorly.
   C_2- axis – has a superior process, the dens, around which the atlas articulates in a side-to side motion.
   C_7 - 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 to 3 or 5 very small partially fused vertebrae.

2. The Normal Curvatures of the Spinal Column

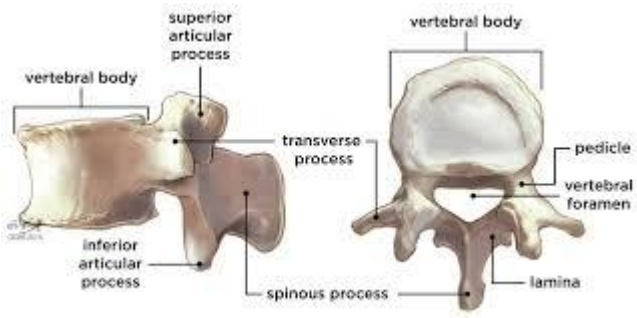
a) **Primary** – in the direction of the original fetal spinal curvature, concave anteriorly.
   a. Thoracic
   b. Sacral
b) **Secondary** – in the opposite direction to primary, convex anteriorly, occurs later in development.
   a. Cervical – develops when able to hold head up.
   b. Lumbar – develops 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 (deviation from midline), 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

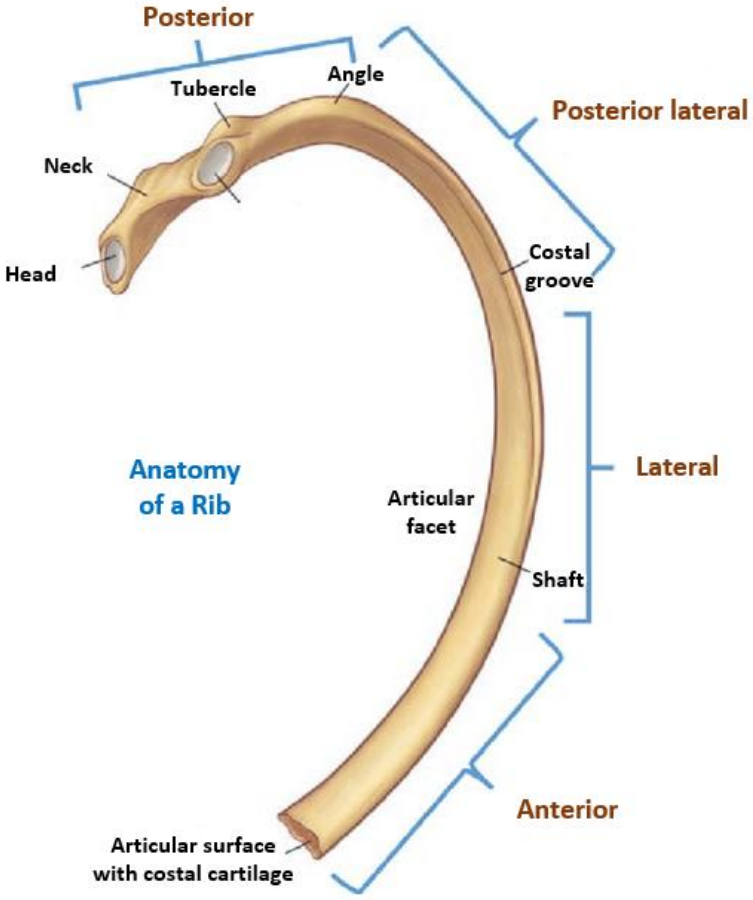
1. The 12 Pairs of Ribs

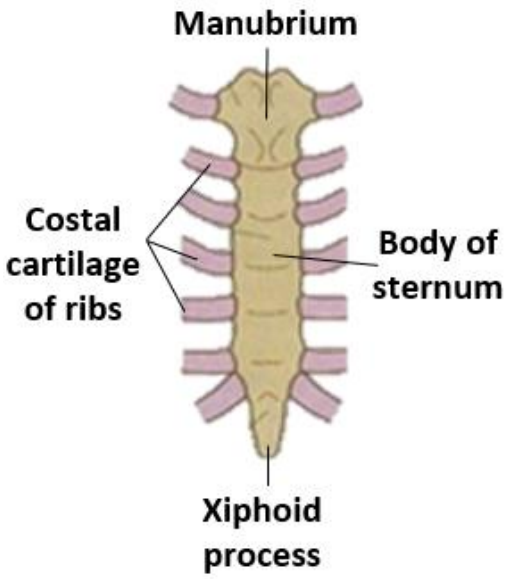
a) There are 7 pairs of **true ribs**, they are the first seven ribs. Each of these ribs attaches directly to the sternum by costal cartilage. True ribs are also called **vertebrosternal ribs**, this indicates that they come from the vertebrae directly to the sternum.

b) There are 5 pairs of **false ribs**: There are 3 false ribs, numbers 8, 9 and 10. These three ribs attach indirectly to sternum via the costal cartilage of rib 7. False ribs are also called **vertebrocostal ribs**, this indicates that they come from the vertebrae to costal cartilage, and do not directly articulate with the bony sternum with their own costal cartilage.

c) Of the 5 false ribs, the last 2 pairs, ribs number 11 and 12, are called **floating ribs** – these have no sternal attachment at all, and 'float' in the back muscles. Floating ribs are also called **vertebral ribs**.

To the right is a typical rib labeled with the common structures that can be found on essentially all ribs. The posterior aspect of the rib is where it attaches to the thoracic vertebrae, the posterior lateral aspect is where the most significant curvature takes place, and the anterior aspect is where the rib attaches to the costal cartilage (a type of hyaline cartilage) that fuses into the sternum (see figure below).





2. Sternum (develop as 3 separate bones)

a) Manubrium – this is the 'handle' of sternum, manu is from manus, meaning hand.

b) Body – this is bulk of the 'breastbone'.

c) Xiphoid – the pointed inferior projection, xiphoid means sword-like. This process is an important frame of references for performing CPR (cardiopulmonary resuscitation). When the xiphoid process is located, place hands about two finger-widths above this process, positioning hands over the lower half of the sternum – this is where compressions should be performed.

Passageways: The Foramina, Fissures and Canals of the Skull

When studying the anatomy of the skull, it is important to be able to identify the various passageways that exist within the skull that allow for structures to enter and exit the brain. There are many foramina (plural for foramen), fissures and canals found in many bones of the skull. Each of these structures has a purpose, and **Table 1** below lists the major blood vessels and nerves that pass through these openings.

Table 1. The 'holes' in the skull and the structures that pass through them.

Skull Structure	Major Vessels	Major Nerves
Foramen magnum	Vertebral arteries & veins.	Medulla Oblongata of Brain becomes the Spinal Cord.
Foramen rotundum	None.	Maxillary branch of Trigeminal N. (Cranial N. V).
Foramen ovale	Accessory meningeal artery.	Mandibular branch of Trigeminal N. (Cranial N. V).
Foramen spinosum	Middle meningeal artery.	None.
Foramen lacerum	Internal carotid a. leaves carotid canal to enter cranium via foramen lacerum.	None.
Supraorbital foramen	Supraorbital artery & vein.	Supraorbital N., Ophthalmic N.
Infraorbital foramen	Infraorbital artery and vein.	Infraorbital N., Maxillary branch of Trigeminal N. (V).
Superior orbital fissure	Superior and inferior ophthalmic veins.	Oculomotor N. (III); Trochlear N. (IV); Lacrimal, Frontal and Naso-ciliary branches of Ophthalmic N. (V); and Abducens N. (VI).
Inferior orbital fissure	None.	Maxillary branch of Trigeminal N. (Cranial N. V).
Olfactory foramina	None.	Olfactory N. (I).
Jugular foramen	Jugular vein.	Glossopharyngeal N (IX); Vagus N. (X) and Accessory N. (XI).
Hypoglossal canal	None.	Hypoglossal N. (Cranial N. XII).
Carotid canal	Internal Carotid artery.	None.
Optic canal	Ophthalmic artery.	Optic N. (Cranial N. II).
Internal acoustic meatus	None.	Vestibulocochlear N. (XIII).
Obturator foramen*	Obturator artery and vein.	Obturator nerve.

**Nothing passes through this structure; its purpose is to lighten the pelves and give it more flexibility.*

The Appendicular Skeleton

Like anywhere else in anatomy, the names used in the skeleton very important. As we will see, the names of bone structures most often provide a lot of information about the bone itself, what it's next too, or what is sitting on it. It is strongly suggested in this section that students listen to the names and determine what information the name is providing you with. If there is something named called 'greater', chances are there will be a lesser; if there is a posterior, there's likely an anterior; if a superior, an inferior; etc. In addition, names of structures often give other information, like what region it is associated with, e.g., acromion process is associated with the shoulder, or what other structure will be associated with it later, e.g., how the supraspinatus muscle sits in the supraspinous fossa of the scapula.

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 (like a beak), deep within shoulder for muscle attachment.
c) Scapular spine – long ridge on the posterior aspect, divides the posterior fossae.
d) Subscapular fossa – shallow depression on anterior surface. A muscle sits there.
e) Supraspinous fossa – depression above the spine. A muscle sits there.
f) Infraspinous fossa – depression inferior to the spine. A muscle sits there.
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.

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 (or sulcus) going in between the two tubercles.
e) Anatomical neck – just distal to the head (a very thin line).
f) Surgical neck – a narrowing of humerus below the greater and lesser tubercles.
g) Deltoid tuberosity – roughened area where the deltoid muscle inserts.
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 the ulnar 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.

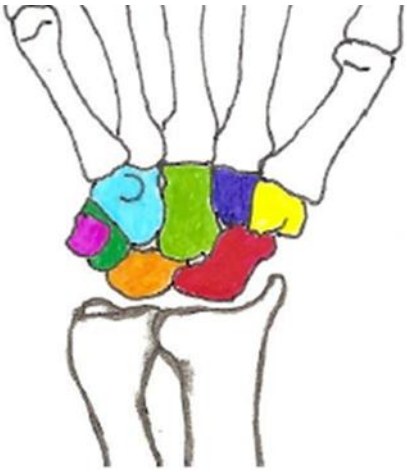
4. Carpals – These are small boxy bines that are best viewed as 2 rows of 4 bones each.

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 mnēmonikos, 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: ***S**ome **L**overs **T**ry **P**ositions **T**hat **T**hey **C**an't **H**andle***
The first letter of each word is how the name of carpal bone starts, from the first carpal bone to the last.

Here are the 8 bones 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 both sides (L and R) of the os coxae and sacrum in its entirety.

a) False (greater) pelvis – this is the area between iliac ala (wings) and iliac crests, a larger area.
b) True (less) pelvis – this is the area completely surrounded by bone, a smaller area.
c) Pelvic brim – top of the 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 – the slightly raised line going along the margin of the pelvic inlet.
g) Obturator foramen – the 'hole' in the os coxa to lighted and make bone more flexible.

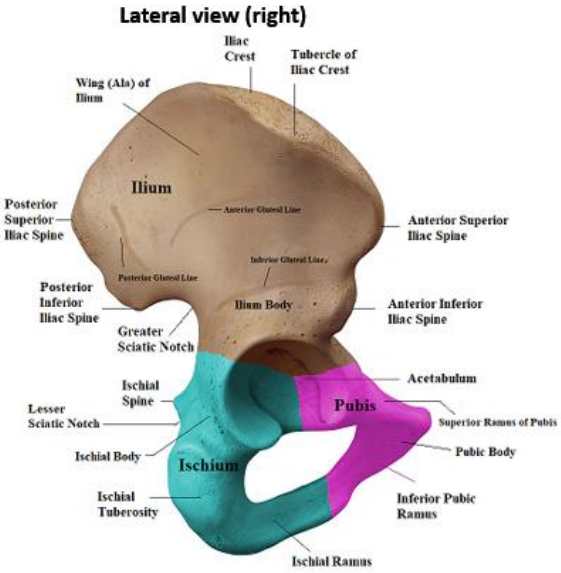
B. Comparison of Male and Female Pelvises

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°: Male smaller, shaper angle, usually less < 90°.
e) Female – thin pubic ramus: Male – everted inferior pubic ramus.

C. Os Coxae (Composed of 3 Bones)

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

a) Iliac crest – the top ridge-like structure of this bone. This is not the "hip bone", the hip is actually a joint between the head of the femur and the socket (acetabulum) of the os coxa.
b) ball-and-socket joint that connects the thigh bone () to the pelvis (hip bone).
c) Auricular surface – auricle means ear, an ear-shaped articulating surface with the sacrum.
d) Iliac fossa – shallow depression on the body of ilium for the iliacus muscle to sit in.
e) Greater sciatic notch – passageway for the sciatic nerve.
f) Anterior superior iliac spine – top point on the front.
g) Anterior inferior iliac spine – lower point on the front.
h) Posterior superior iliac spine – top point on the back.
i) Posterior inferior iliac spine – bottom point on the back.



2. 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 the weight of the body when seated.
d) Ramus – this ramus (branch) meets inferior pubic ramus above it halfway in between the two bones.

3. Pubis – this is the pubic bone, in the front of the os coxa.

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

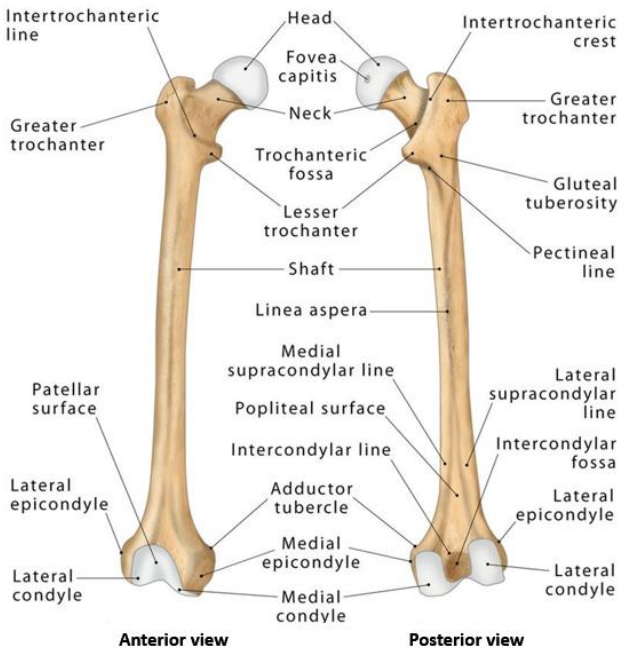
D. Bones of Lower Extremity

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 – this is the site of fracture when the "hip" is broken.
c) Greater trochanter – very large process that is at the greatest width of hips.
d) Lesser trochanter – posterior to the greater trochanter.
e) Intertrochanteric line – faint raised 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 associates with femur.

2. Patella – the knee bone.

a) Base – has anterior superior edges.
b) Apex – the inferior point.
c) Facets – faces and rides against the femoral condyles.



3. Tibia - the 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 the tibia.
c) Lateral condyles - articulating surface at lateral proximal expansion of the tibia.
d) Tibial tuberosity - proximal anterior roughness, for muscle attachment (the quadriceps).
e) Anterior crest – the sharp anterior border along length of the tibia, the part that hits coffee tables. : /
f) Medial malleolus – the term malleolus means 'hammer', this expanded process creates the inside (medial) ankle region, it is the most distal projection of this bone.

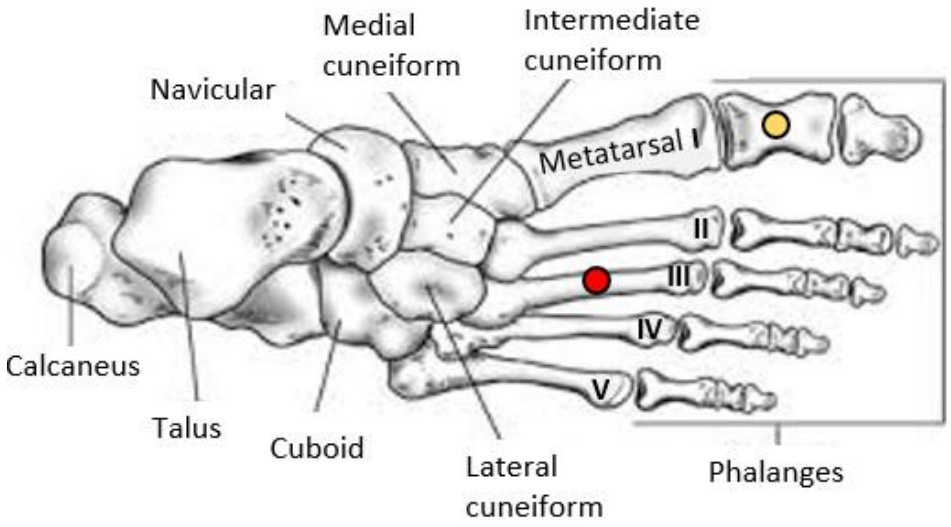
4. Fibula – the thin lateral bone of the leg.

a) Fibular head – this is the articulating portion at the proximal end of this bone.
b) Interosseus border – sharp edge along the medial length of bone, where it articulated with tibia.
c) Lateral malleolus – the outside (lateral) ankle region, the most distal point of this bone.

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

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

1) **Calcaneus** – the largest bone of the tarsal, it is the heel bone. Also bears weight.
2) **Talus** – central weight bearing bone, makes a hinge joint articulation with the tibia.
3) **Navicular** – boat shaped bone above the cuneiforms.
4) **Cuboidal** – cube shaped bone, the most lateral of the tarsals as they articulate with the metatarsals.
5) **Medial cuneiform** – the innermost (medial) of the 'wedge' bones of the foot.
6) **Intermediate cuneiform** – the one in the middle of the 'wedge' bones of the foot.
7) **Lateral cuneiform** – the outermost (lateral) of the 'wedge' bone of the foot.



Above is a superior view of the bones of the right foot.

6. Metatarsals – There are 5 bones (just like for the hands), and they are numbered from the big toe (hallux) as one (in Roman numerals, I) going from the medial side to the most lateral pinky toe as five (in Roman numerals V).

7. Phalanges – These are the toe bones of the foot, numbered and named just like the fingers of the hand. In the anatomical position, we count the digits (I to V) from medial to lateral. The big toe (hallux) has only 2 phalanges (proximal and distal), the rest have 3 phalanges; proximal, middle, and distal.

Name the bone at the yellow dot. _____.

Name the bone at the yellow dot. _____.

Answers:
Proximal phalanx I
Metatarsal III

Etymology of the Bones of the Wrist and Hand

The etymology of any word, in the simplest terms, is about the **origin** of the word. It's a study of the history of a word and its original meaning, linking it back to various forms and meanings from its original language, and accounting for any other parts added or changed throughout history, including additions from other languages. As an exercise, what is the etymology of the word etymology?

Etymology - From Greek, the prefix etym means truth, true meaning, real, literal; and 'ology' is from the Gr. word logia, which when used as the suffix (-ology) refers to a person who speaks in a certain manner, "the character or deportment of one who speaks of a certain subject". More succinctly, it means the "study" of a certain subject. Together, etymology is the truthful, literal study of words.

First, is an overview of the regional landmark anatomy for the forearm (antebrachium) and the elbow (cubital, olecranon, ulna), that then leads to the wrist (carpus) and hand (manus).

Antebrachium - The Latin prefix ante meaning 'before', and the suffix brachium together means forearm.

Cubital - From Latin cubare, meaning 'to lie down', based on the action of reclining on the elbow when in a relaxed lying position, evolving into the term cubitus, meaning 'elbow'. In addition, the terms dorsal and ventral decubitus mean, respectively, lying down with the face up and face down.

Olecranon - Is of Greek origin. Olene = elbow and kranion is head. Thus, it is the head of the elbow. The term 'cranium' similarly has the same root. It is the bulky structure that can be rested on the table.

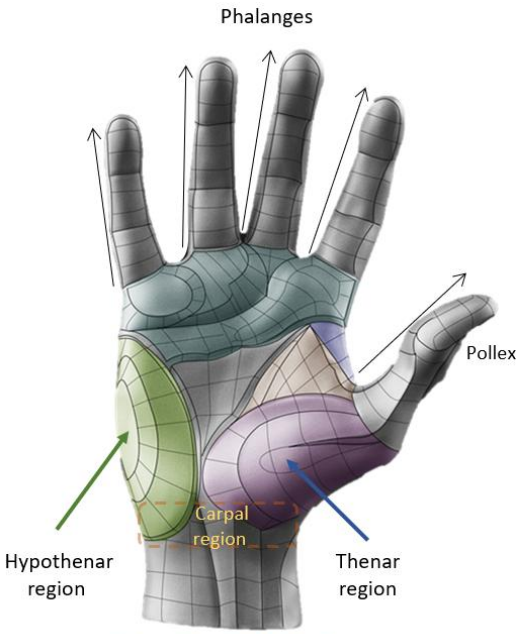
Ulna - Another word for elbow, the Latin renewal of the Greek olene, meaning elbow. As we have seen, this portion of the word can is in olecranon.

Trochlea - A trochlea is a pulley in Latin. The hinge-like action of movement at the elbow between the trochlea (of humerus) and the trochlear notch (of ulna) is similar to the action of a pully.

Styloid - The Greek stylos means a pillar, or stake, or any long, pointed process. The -oid means shaped like or resembling.

Retinaculum - The term retinere is Latin 'to hold back or restrain', thus the diminutive (meaning extremely or unusually small) of that is called a retinaculum, the smaller thing that has that function. The flexor and extensor retinacula of the wrist function to hold their respective tendons in place.

Thenar - The Greek verb thenein means 'to strike', as ins striking with the hand. It was not just the palmar region (palm) but included the thumb. The subsequent anatomical divisions became the thenar region for the base of the palm on the thumb side, and hypothenar for the base of the palm on pinky side.



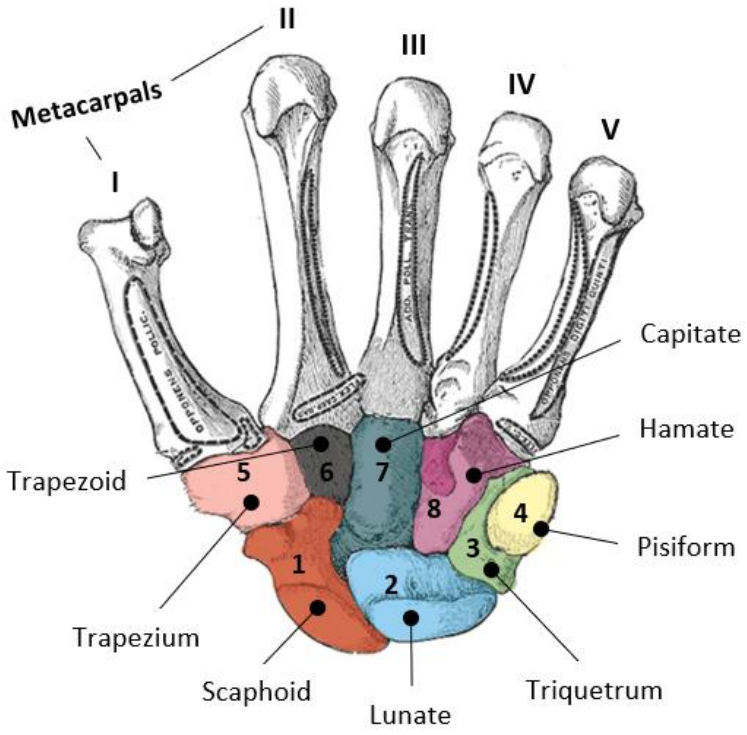
Palmar View Right Hand

Pollex - From the Latin verb pollere meaning 'to be strong'. The thumb is the thick big strong one, after all. The term pollicis is the possessive of the Latin pollex, again for the thumb.

Summary of the Carpals

The term **carpal** is from ancient Greek karpós meaning ‘wrist’. The 8 bones of the wrist can be viewed as 2 rows of 4 bones, and they are named for their unique shapes as described below.

Scaphoid - From Greek skaphe, for something hollowed out, similar to the shape of a small boat (a skiff), and -oid for resembling. It can also be called the navicular, naviculus is a diminutive, meaning little boat.



Carpals

Palmar View Left Hand

Lunate - Luna is Latin for moon and the lunate bone has a crescent shape.

Triquetrum - The prefix tri- means three (as in tricycle, triangle). Quetrum is a corner, so the triquetrum is the three-cornered bone.

Pisiform – From the Latin word pisum meaning ‘pea’, and form meaning ‘shape’. This pea-shaped bone is also about the size of a pea.

Capitulum - The Latin word caput means ‘head’, thus a diminutive of it means ‘little head’. The term decapitate means to loose one’s head. The head of the radius articulates with the capitulum of the humerus, so they meet ‘head to head’. The prefix caput is seen in the word capital, meaning ‘most important’. The capitate is the largest of the wrist bones.

Trapezium - From the Greek trapezion which means "a little table", from trapeza meaning "table", itself from (te)tra- "four" and pod- "foot".

Trapezoid - From trapezium above, we can see the addition of the -oid suffix, meaning ‘shaped like’. The trapezion is still Greek referring to a table, an ‘irregular quadrilateral’, again from tra- "four" and peza "foot" or "edge", again meaning "a little table". The inference is it is a littler little table.

Hamate - From the Latin hamatus meaning ‘hooked’. This bone in the human wrist is notable by a hook-like process called the hamulus of the hamate, a process which projects out from its palmar surface.

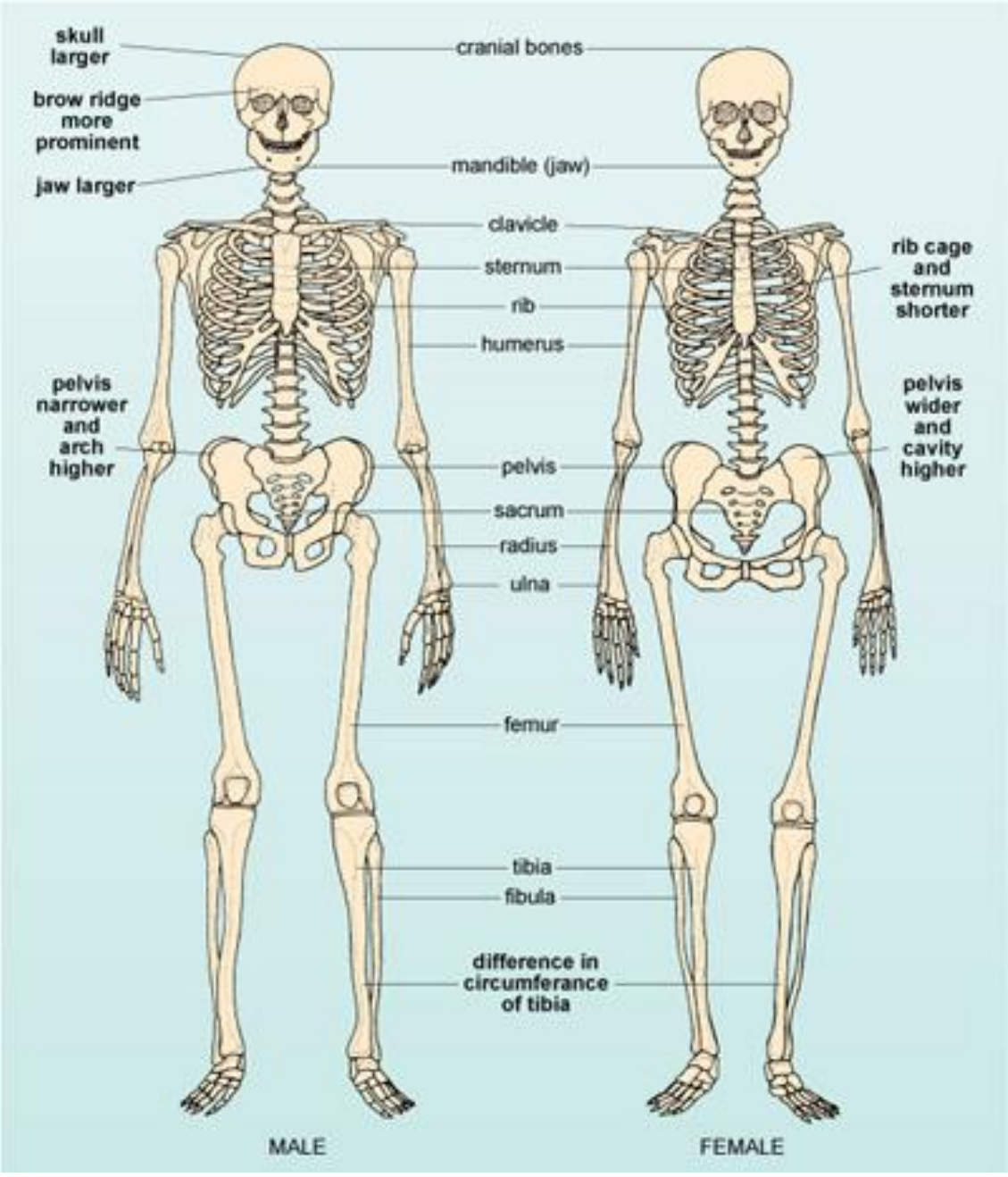
The Hand and the Fingers or Digits

Metacarpals - Meta is Greek for ‘beyond’. Since we know carpal means ‘wrist’, the added prefix meta indicated “beyond the carpals! The metacarpals are the bones of the hand.

Phalanx - This is the word for the ancient Greek line of soldiers in battle, composed of close and deep rank and file infantry. The bones of the fingers are arranged in ranks or rows reminiscent of this formation. In the term phalanges (the plural for phalanx) we can hear the word fingers. These are the finger bones attached to each of the five metacarpals.

The Male and Female Skeletal Design

In general, male skeletons are larger, heavier, and rougher, with more pronounced muscle attachment landmarks than female skeletons. Consistently, female skeletons are smaller, have smoother surfaces, with landmarks that are more delicate and refined. More specifically, there are measurable, statistically significant differences between the male and female skull, digit ratios of the hand, females have a more narrow rib cage, a more angled quadriceps angle (Q-angle), and many easy to identify differences in the male and female pelvis.



Many of the important and striking differences between the male and female skeleton can be seen in the illustration above, such as the larger more square skull of the male, or the much more pronounced quadriceps angle (or Q-angle) for the female. Table 2 below compares some major skeletal regions.

Table 2. Complete the table with information regarding **sexual dimorphism** of the pelvis.

Region	Males	Females
Overall Skeleton	Larger, heavier, with rougher muscle attachment sites	Smoother bone surfaces, smaller, less rugged
Brow Ridge	Pronounced and rounded.	Smooth and flat.
Forehead	Sloping or receding.	More vertical and rounded.
Glabella	Protruding (between eyebrows).	Smooth and delicate.
Mastoid Process	Large and blunt (behind the ear).	Smaller and more pointed.
Chin and Mandible	Square with a more acute (90°) angle.	Rounded, and pointed with a larger, more obtuse (greater than 90°) angle
Occipital Protuberance	More prominent at the back of the skull	Smooth or slightly warped
Eye Orbit	Orbits are more square	Orbits are rounder
* Pelvic Region	(see details below)	(see details below)

Sexual Dimorphism of the Pelvis

The most effect and easy way to determine the sex of a skeleton is to examine the **pelvis**. For this reason a detailed examination of the pelvis can be used to explore the study of sexual dimorphism of the pelvis, which is the distinct difference in size and appearance between males and females. Below in Table 3 some of the major distinctions between the male and female are detailed.

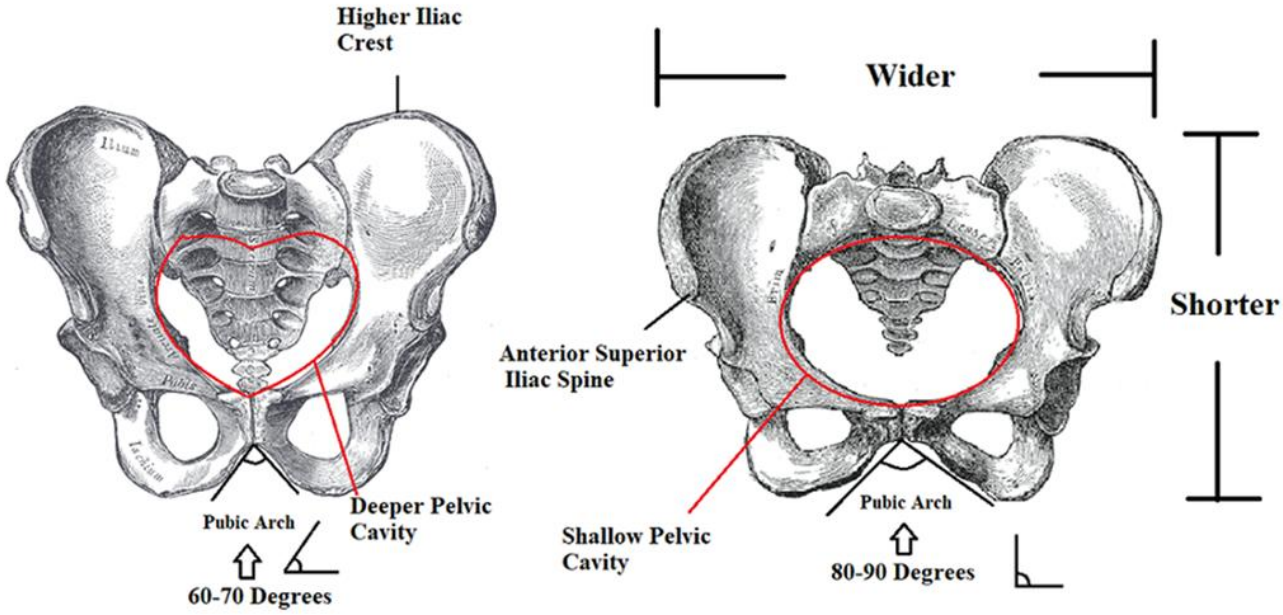
Table 3. Complete the table with information regarding **sexual dimorphism** of the pelvis.

Region	Male	Female
General Appearance	More narrow, robust, heavier, rougher surfaces	More broad, lighter, smoother surfaces
Ischial Spine	Points medially (tip inward)	Points posteriorly (more vertical)
Sacrum	Long, narrow triangle with pronounced sacral curvature	Broad, shorter and flatter
Coccyx	Points anteriorly (immovable)	Points inferiorly (flexible)
Width of Pelvis	Narrower	Wider
Pelvic Inlet	Narrower, heart shaped	Wider, oval to round, more circular pelvic inlet
Pelvic Outlet	Smaller	Enlarged, due to greater separation of the ischial spines
Pubic Symphysis	Longer	Shorter (Can disarticulate with relaxin)
Pubic Arch (Angle)	Smaller arch (less than 90°)	Larger arch (100° or more)
Greater Sciatic Notch	Deep and narrow	Wide and shallow
Obturator	Oval shaped	Triangular shaped
Acetabulum	Directed laterally	Faces slightly anteriorly as well as laterally

Relaxin is a hormone produced by the ovaries and placenta in females, and the prostate gland in men, that acts to loosens ligaments and muscles in the pelvis, allowing for preparation of the birth canal during childbirth. It also affects blood vessel dilation, tissue remodeling in collagen and bone in both sexes, and sperm movement in men.

Male versus Female Pelvis

The illustrations below compare the male (left) and female (right) pelves side by side to understand some of the key differences to be examined.



Male Pelvis **Female Pelvis**

The Female Pelvis is Lighter

Although the female pelvis is wider than the typical male pelvis, these bones are thinner and lighter than the denser, rougher bones of the male pelvis.

The Female Pelvis is Shorter and Wider than the Male Pelvis

The iliac crest of the male pelvis rises higher than the iliac crest of the female pelvis, and there is a greater distance between the anterior superior iliac spines of the female pelvis when compared to the male pelvis. This usually gives women a curvier appearance in the hip region, as compared to the average male. The female pelvic cavity is more shallow because it is shorter, whereas the male pelvic cavity is deeper due to its greater length.

Pubic Arch Differences

Take notice of the notch under the pubic symphysis, which is called the **pubic arch** (also called the subpubic angle), see images above. This arch is measurably wider in women than in men, relating to the role of the pelvis in childbirth. In women, the **pubic angle** will generally be equal to or greater than **80** degrees (obtuse), which is similar to the shape of the letter "L". In men, the pubic arch is narrower, creating a subpubic angle that is usually less than or equal to **70** degrees (acute), making it a similar angle to an upside down "V."

These figures can vary, anatomical research measured the pubic angle on 109 pelvises (or pelves), and they found that women had a possible subpubic angle range of **64-100**^{o}, whereas men had a possible range of **48-81** ^{o}.

There are many more consistent and measurable differences between males and female throughout the entire skeletal system. There are also differences in bone ratios that effect body movement.