Cells to Systems

LECTURE 6

THE SKELETON

LECTURER

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INTENDED LEARNING OUTCOMES

At the end of this lecture, you should be able to:

- Describe the position, relationships, form, and appearance of the major bones of the quadruped skeleton, information used to understand the skeleton scaffold within the body, radiography, and as landmarks during clinical procedures.
- Identify the major bones in novel animals, as not all animals treated by veterinarians will be domestic species.

KEY WORDS

- Axial skeleton: skull, mandible, hyoid, vertebral column (cervical, thoracic, lumbar, sacral, caudal vertebrae), thoracic skeleton (thoracic vertebrae, ribs, sternum).
- Appendicular skeleton: bones of the forelimb and hindlimb.
- Bones of the forelimb: pectoral girdle (scapula, clavicle, coracoid), humerus, radius and ulna, carpal bones, metacarpal bones, digits (phalanges).
- Bones of the hindlimb: pelvic girdle (ilium, ischium, pubis, acetabulum), femur, tibia and fibula, tarsal bones, metatarsal bones, digits (phalanges).
- Features on bones: process, tuberosity, epicondyle; fossa, foramen, fissure, canal, duct, condyle, articular facet.
- Specialised bones: sesamoids, splanchnic bones, pneumatic bones.

LECTURE NOTES

The skeleton serves to support the body and provide its basic shape, as well as anchor the leverage system used for locomotion and provide protection to delicate structures.

We use the dog as a ‘universal plan’ in this course as their skeleton contains nearly all the bones you would find in domestic species. From this universal plan, the name and function of a bone in an unfamiliar species can be deduced from careful observation and extrapolating from the basic quadruped skeletal plan using the relative positions and relationships which are almost always conserved.

AXIAL SKELETON

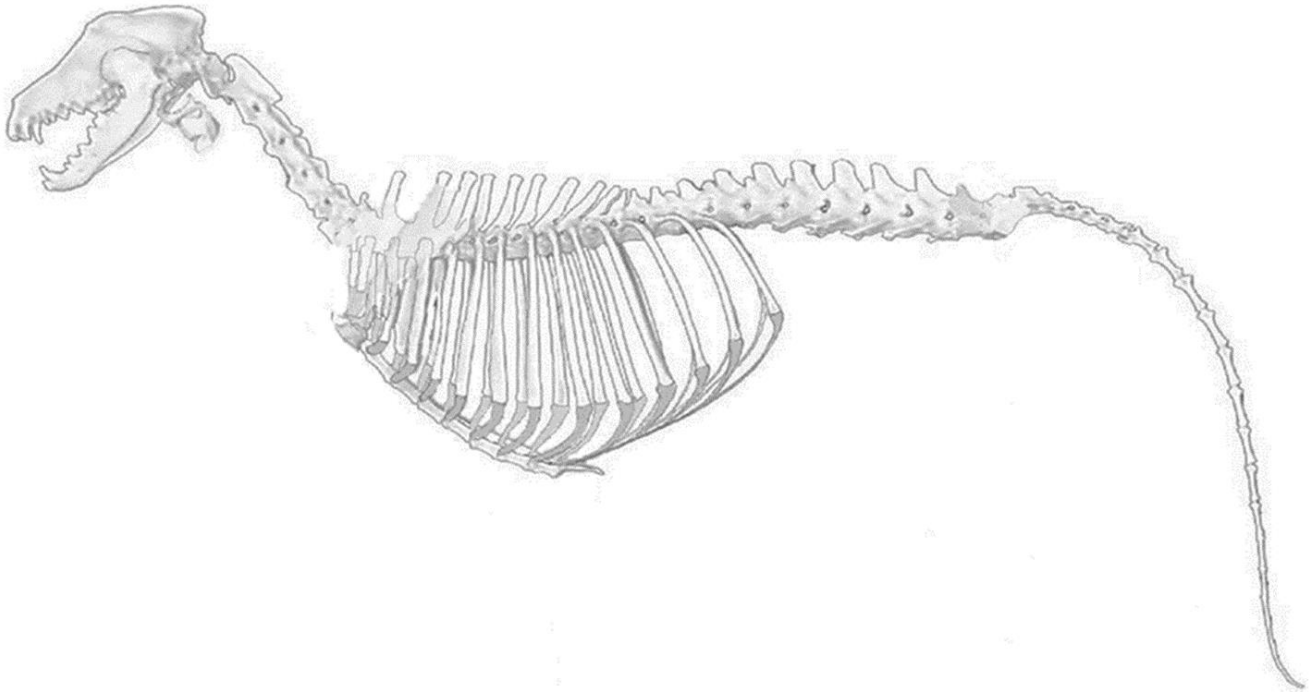


Image by Dr Helen Davies

Skull

The skull is formed by the interlocking of many bones. The joints between these bones are fibrous 'sutures' which are flexible when the animal is young and growing but with age, the sutures fill with bone to form a single structural unit. The skull is bilaterally symmetrical - that is, when cut along the median plane, the left and right sides contain the same structures. All the unpaired bones are located on the midline, and while unpaired, their left and right parts are mirror images.

Paired (left and right):

- Incisive
- Nasal
- Maxillary
- Lacrimal
- Frontal
- Parietal
- Temporal (squamous, petrosal, tympanic)
- Palatine
- Pterygoid
- Zygomatic

Unpaired (single bone on midline):

- Occipital
- Sphenoid complex
    - basisphenoid
    - presphenoid
- Vomer
- Ethmoid

Mandible

The mandible is formed by two mirrored bones that meet at the **intermandibular joint**.
The teeth found in the skull and mandible reflect the diet of the animal and are useful in the deduction of the type of animal skeleton being observed.

Hyoid

The hyoid is a complex of 9 bones which suspends the tongue, larynx, and pharynx from the skull and supports the tongue by connecting it to the larynx. The joints between the bones varies between species, or even within species. They are commonly synovial joints but can also be fibrocartilage or fused by bone.

They hyoid can be divided into 2 parts. The 'suspensory apparatus' consists of the hyoid components connecting the tongue to the tympanic region of the skull (the tympanohyoid cartilage, stylohyoid, epihyoid, ceratohyoid and basihyoid bones).

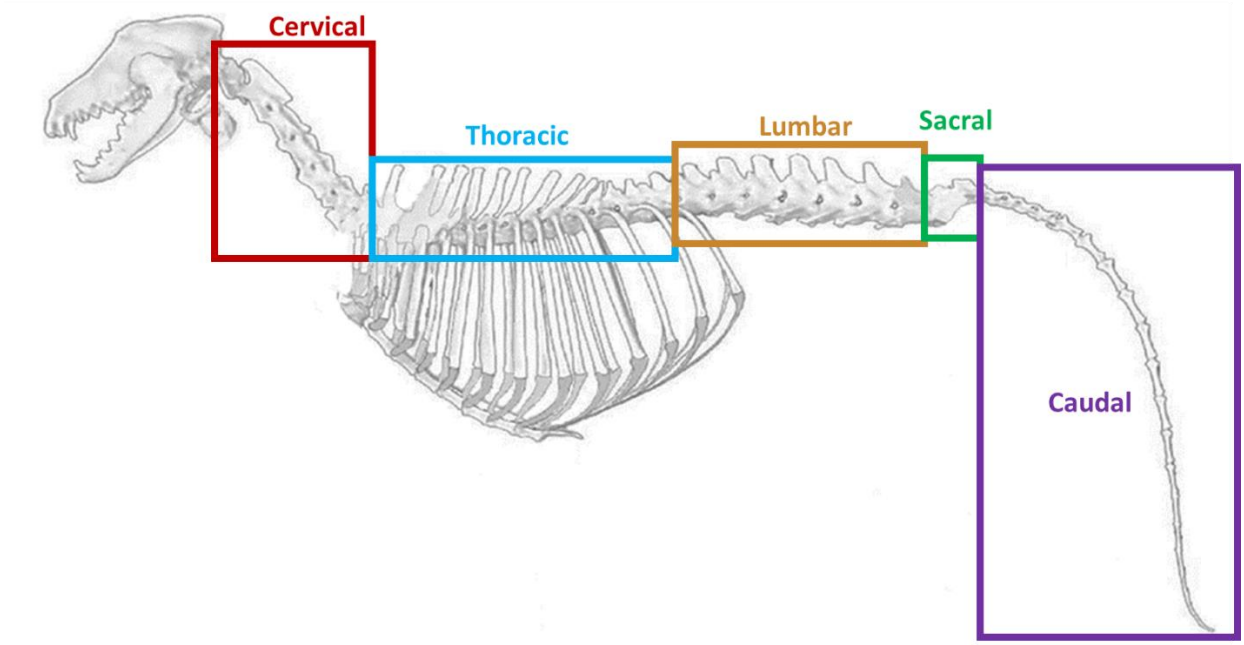
The 'hyoid apparatus' (equivalent to the human hyoid bone) consists of the basihyoid and thyrohyoid bones that connect the tongue to the larynx.

Vertebral column

The vertebral column, or the 'spine', runs from the skull to the most caudal tip of the body. The column is composed of individual vertebrae (vertebrae = plural, vertebra = singular) which interconnect in a complex arrangement to allow all the movements required for the central axis of the body.

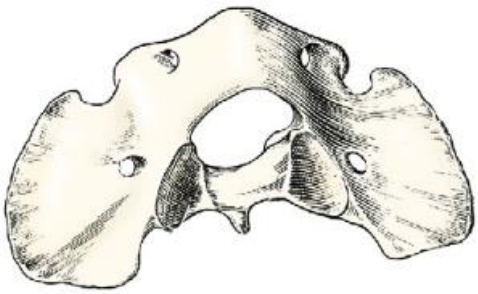
The vertebral column is divided into regions based on their location in the body:

- Cervical (C) – in the neck
- Thoracic (T) – in the thorax/chest; all thoracic vertebra articulate with ribs
- Lumbar (L) – in the lumbar region, above the abdomen
- Sacral (S) – articulate with the pelvis
- Caudal (Ca) – in the 'cauda' or tail



The shape of the first two cervical vertebra has evolved to provide specialised functions to these vertebrae. The first cervical vertebra – C1 – is broad and flat, and articulated with the caudal skull in a manner that only allowed flexion and extension. In other words, the 'atlantooccipital' joint only allows the skull to move in a dorsal and ventral direction, producing the nodding or 'yes' head motion. Because C1 is holding up the body's important control centre, it is also termed '**atlas**' after the Greek god Atlas who holds up the world.

The joint between C1 and C2 only allows rotation, allowing the head to shake or make the 'no' head motion. Reflecting this, C2 is also termed '**axis**' as it is the bone around which the head rotates.



Atlas (C1 vertebra)

Axis (C2 vertebra)

Adapted from: *Miller's Anatomy of the Dog* (4th edition)

Thoracic skeleton

The thoracic skeleton, or 'ribcage', consists of the thoracic vertebrae, ribs, and sternum. The ribs are long, slender bones that wrap around the lateral sides of the thorax dorsally to ventrally. All ribs articulate with thoracic vertebra, however, only some articular with the sternum (sternal ribs), others join to other ribs (asternal ribs) and sometimes the last rib is not attached at all ventrally (floating rib). The sternum is a complex of 8 bones, that is fused in some species. The individual bones are referred to as sternebrae. The first sternebra has a special name, the **manubrium**, as does the 8th sternebra, the **xiphoid process** which is extended further caudally by a **xiphoid cartilage**.

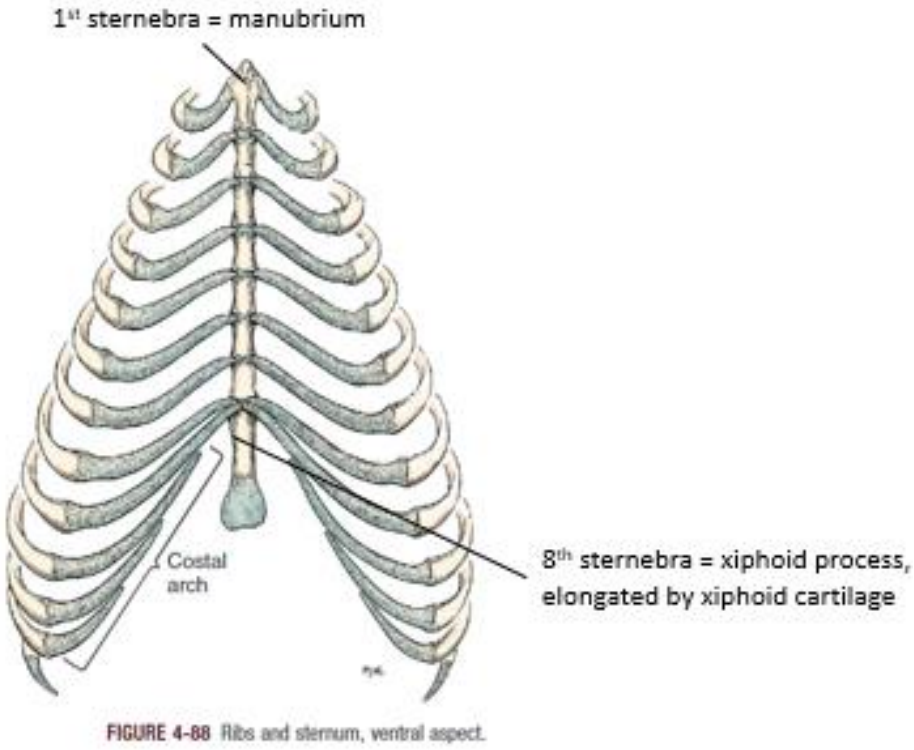


FIGURE 4-88 Ribs and sternum, ventral aspect.

Adapted from: *Miller's Anatomy of the Dog* (4th edition)

APPENDICULAR SKELETON

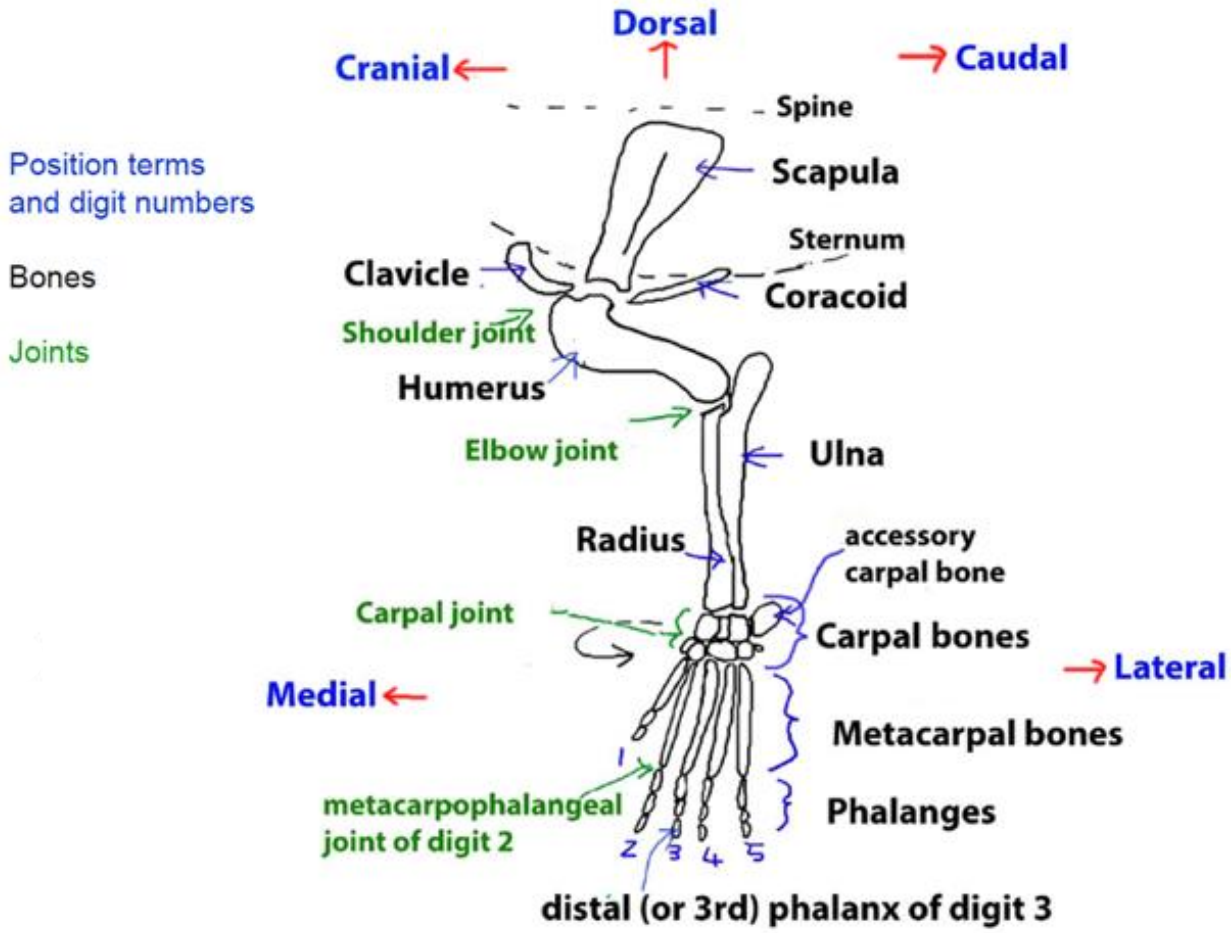
'Universal' forelimb plan

Bones

- Pectoral girdle
  - Scapula, clavicle, coracoid
- Humerus
- Radius, ulna
- Carpus 2 rows of carpal bones
  - 1st row: radial, intermediate, ulnar, accessory
  - 2nd row: carpal bones 1-4 (some species have 5)
- Metacarpus 5 metacarpal bones
- Digits 5, 2-3 phalanges per digit

A 'girdle' is the structures which connect a limb to the main axial skeleton. The forelimb developed from the front fin – or pectoral fin, the one closest to the head – so you will see the term pectoral limb used in sometimes. Where we do use the term pectoral commonly is in relation to the structures involved in the forelimb 'girdle'.

In the 'universal' plan, there are three bones in the pectoral girdle – the girdle which connects the limb which developed from the pectoral fin – to the body. The coracoid and clavicle (when present) articulate with both the scapula and the sternum. By contrast, the scapula is attached to the trunk by muscles which create a 'sling' in which the body cradles.



Limb rotated laterally (in supination) distal to carpus to display digital bones
Adapted from image by Helen Davies

Naming of both the distal forelimb and hindlimb is simplified to a numbering system which begins on the medial side (where our thumbs are located). Hence, the distal row of carpal and tarsal bones, the metacarpals/metatarsals, and the digits are all numbered in this way. The phalanges within a digit are numbered from proximally to distally. That is, phalanx 1 articulates with the metacarpus/metatarsus, phalanx 3 is most distal, and phalanx 2 in between. This numbering system is consistently applied across all species.

Forelimb joints

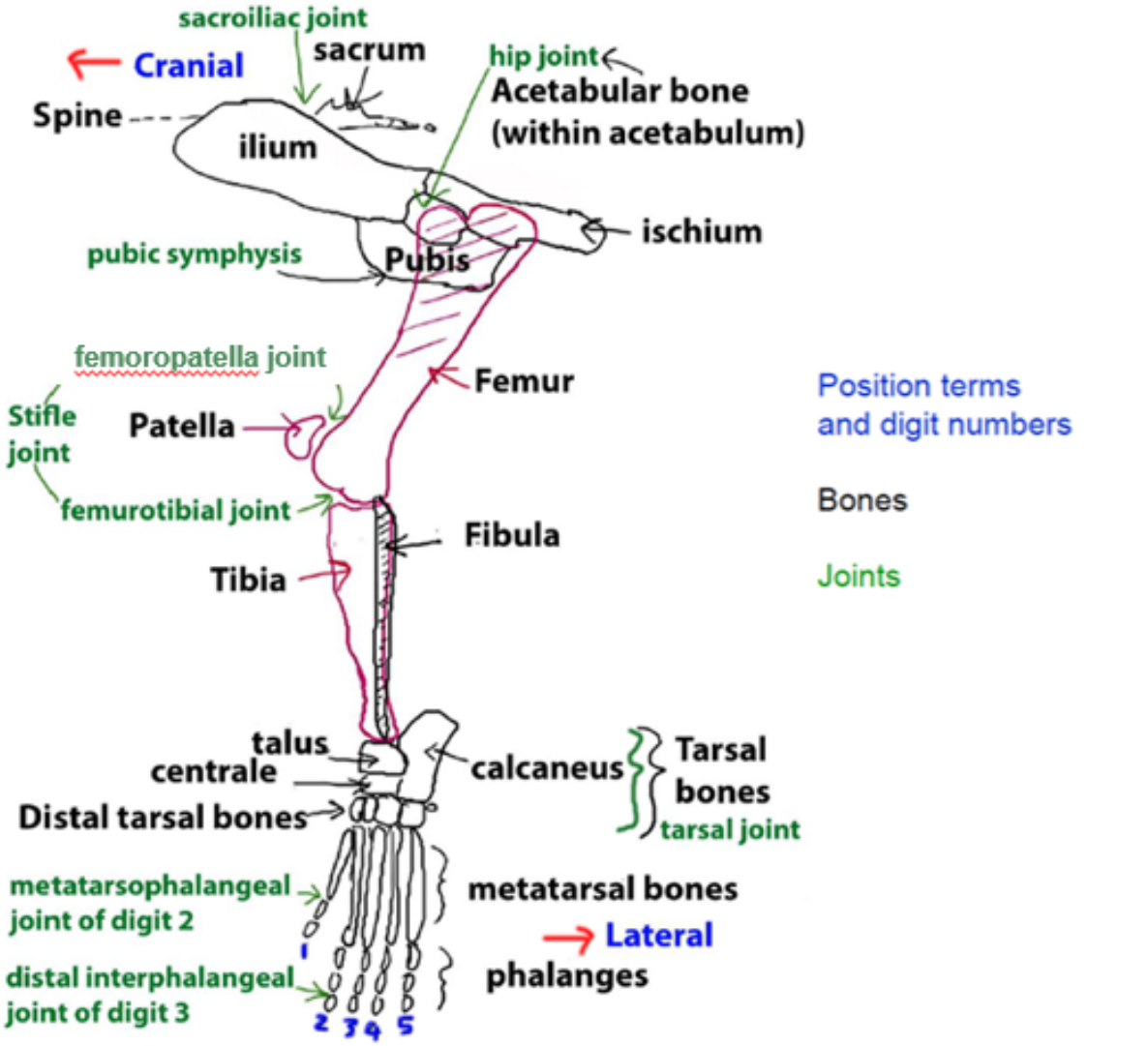
- Shoulder joint – between scapula and humerus
- Elbow joint – between humerus, ulna and radius
- Carpal joint – any joint that involved carpal bones
    - Radiocarpal joint – between radius and proximal carpal bones
    - Middle carpal joint – between proximal (1st row) and distal (2nd row) carpal bones
    - Carpometacarpal joint – between distal carpal bones and metacarpals
- Metacarpophalangeal joints – between metacarpal and phalanx 1 in each respective digit
- Interphalangeal joints – between phalanges
    - Proximal interphalangeal joint – between phalanx 1 and 2
    - Distal interphalangeal joint – between phalanx 2 and 3

‘Universal’ hindlimb plan

Bones

- Pelvic girdle
    - Left and right hip bones (os coxae) - Ilium, ischium, pubis, acetabulum
- Femur (& patella, other sesamoids)
- Tibia, fibula
- Tarsus 3 rows of tarsal bones
    - 1st row: talus, calcaneus
    - 2nd row: centrale
    - 3rd row: tarsals 1-4 (sometimes 5)
- Metatarsals 5 metacarpal bones
- Digits 5, 2-3 phalanges per digit

The term ‘pelvis’ specifically refers to the pelvis girdle and the sacrum together. It is worth noting that in common use, pelvis is more often used to refer to the hip bones alone.



Limb rotated laterally (in supination) distal to tarsus to display digital bones

Image by Helen Davies

Hindlimb joints

- Sacroiliac joint – between sacrum and hip bone (specifically the ilium)
- Hip joint – between hip bone and femur
- Stifle joint
    - Femorotibial joint – between femur and tibia, the weightbearing joint of the stifle
    - Femoropatella joint – between femur and patella
- Tarsal joint – any joint that involved tarsal bones
    - Tibiotarsal joint – between tibia and 1st row of tarsal bones
    - Proximal tarsal joint – between 1st and 2nd row of tarsal bones
    - Distal tarsal joint – between 2nd and 3rd row of tarsal bones
    - Tarsometatarsal joint – between 3rd row of tarsal bones and metatarsals
- Metatarsophalangeal joints – between metatarsal and phalanx 1 in each respective digit
- Interphalangeal joints – same as forelimb
    - Proximal interphalangeal joint
    - Distal interphalangeal joint

Features on bones

The many lumps, bumps, holes, and dints of the bones have been given names if they are consistently found throughout a species. There are many terms used to describe these bone features, some of which are:

- Condyle – any articular surface
- Epicondyle – an enlarged bony feature next to or near a condyle, notably the distal humerus
- Head – a condyle which has a ball or 'head' like shape, notably the proximal humerus and femur
- Articular facet – generally used for articular surfaces on the vertebra
- Tuberosity – a large protrusion from a bone surface
- Tubercule – a tuberosity on the proximal forelimb
- Trochanter – a tuberosity on the proximal hindlimb
- Process – a more long and pointy protrusion, notably on vertebra
- Fossa – an indentation in a bone
- Cavity – a large fossa
- Foramen – a hole in a bone, large or small
- Fissure – a gap in a bone, notably in the skull
- Canal – a tubular hole through a bone, usually carrying a structure e.g. nerve, blood vessel
- Duct – a longer canal, often carrying a duct structure.

Specialised bones

Sesamoids are bones that have formed usually within tendons that are subjected to frequent large stresses to improve their durability. The largest sesamoid in the body is the patella, or 'kneecap'. There are several other sesamoids around the stifle joint and they ae plentiful in the distal limbs.

Splanchnic bones are found within soft tissues not involved in locomotion or weightbearing. At this point in time, splanchnic bones have been discovered in the heart (os cordis), the penis (os penis) and the snout of pigs (os rosti).

Birds have specialised **pneumatic bones** to assist them in flight. The core of these bones has been removed and left to empty, thus lightening their overall body weight. Some pneumatic bones are connected to the airways of birds, increasing their lung capacity so to speak.

FURTHER READING

Studdart, Gay & Hinchcliff. *Saunders Comprehensive Veterinary Dictionary*. Available as a downloadable e-book through the University library here.

Singh. *Dyce, Sack & Wensing's Textbook of Veterinary Anatomy* (any edition). Link to its' University library page here.

König & Liebich. *Veterinary Anatomy of Domestic Mammals* (any edition). Link to its' University library page here.

Hermanson, de Lahunta & Evans. *Miller and Evans' Anatomy of the Dog* (any edition). Available as an e-book through the University library here.

Hildebrand. Analysis of Vertebrate Structure (any edition). Link to its' University library page here.

vet-Anatomy, the interactive atlas of veterinary anatomy by IMAIOS. Available through the University library here.

Coulson & Lewis. An Atlas of Interpretative Radiographic Anatomy of the Dog & Cat. Available as a downloadable e-book through the University library here.