

Locomotion & Posture Module

Module Learning Outcomes

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Bones

Learning Outcomes

- Recognise, Describe and Interpret:
 - Function, structure, classification & features of bones
 - Composition of skeleton

Function of the Skeleton

- Structural
 - Supportive framework for body
 - w/ Muscle attach points
 - System of levers for locomotion
 - Protection of organs
- Metabolic
 - Source of calcium
- Houses bone marrow
 - Haematopoiesis

Composition of Skeleton

- Invertebrates
 - Dense connective tissue
- Lower vertebrates
 - Cartilage (Chondrostei)
- Higher vertebrates
 - Bone
 - Developmentally formed by ossification of connective tissue and cartilage

Common anatomical features

Articular surfaces/Processes & Depressions

- Where tendons attach
- Articulation with adjacent bones

Bone Structure

Two types of bone

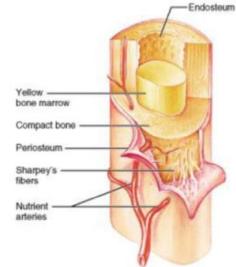
- **Compact/cortical**
 - Forms outer layer of bone
 - 60-70% mineral
 - hydroxyapatite
 - 30% organic
 - Type I collagen
 - Water
 - Bone marrow in central medullary cavity
 - Young animals – red
 - Adult marrow - yellow
- **Spongy**
 - Located internally
 - Short/irregular/flat bones
 - Extremities of long bones
 - Red bone marrow between spicules

Long Bones

- **Epiphyses**
 - Extremities
 - Generally thin cortical bone
 - Except area of high tension
 - Articular cartilage (freely movable joints)
 - Epiphyseal plate: growth plate
- **Diaphysis**
 - Shaft
 - Thick layer of cortical bone
 - Medullary cavity
 - Nutrient foramen
- **Metaphysis**
 - Disappears in adulthood

Periosteum

- 2-layer membrane
 - Fibrous: outer layer
 - Attachment tendons/ligaments
 - Blood vessels
 - Cellular: osteogenic layer
 - Bone production

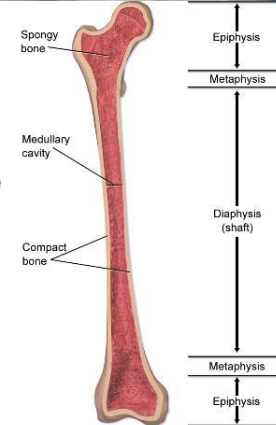
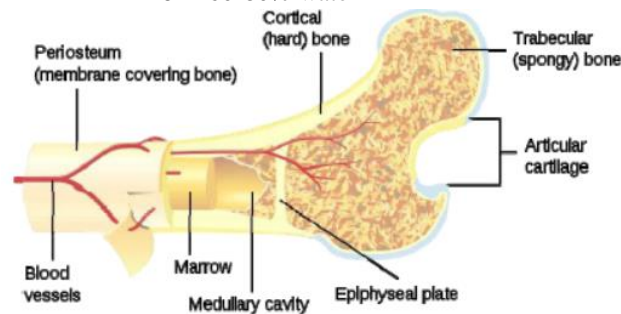
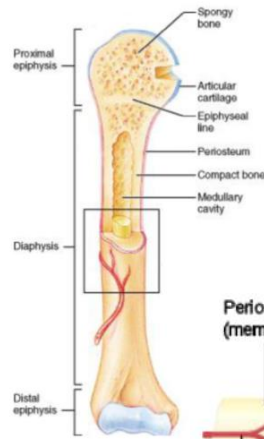
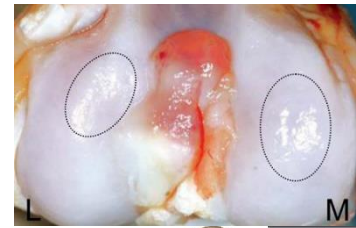


Endosteum

- Membrane lines inner hollow centre
- Contains osteoblasts

Articular cartilage

- Hyaline
 - Covers articular surfaces
 - Glassy appearance
 - No nerves or blood vessels
 - Absorbs shock
 - 60-80% water



Common anatomical features

Articular surfaces/Processes & Depressions

- Where tendons attach
- Articulation with adjacent bones

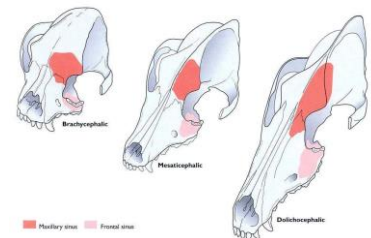
Bone Structure

Two types of bone

- **Compact/cortical**
 - Forms outer layer of bone
 - 60-70% mineral
 - hydroxyapatite
 - 30% organic
 - Type I collagen
 - Water
 - Bone marrow in central medullary cavity
 - Young animals – red
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- **Spongy**
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 - Short/irregular/flat bones
 - Extremities of long bones
 - Red bone marrow between spicules

Bone classification – Shape

- Long - Humerus
- Short - Tarsal bones
- Flat – scapula
- Irregular – vertebrae



Specialised Bones

- Pneumatic – air filled cavity
- Sesamoid – near freely moving joints “ball bearing” like function
- Splanchnic – located in soft tissue (ossa cordis, os penis)



Bone is living tissue

- Supplied by nerves, blood and lymphatic vessels
- Repairs following damage
- Self-remodelling in response to stresses
 - E.g. Bone fracture resulting in more stress on one side
 - Bone deposition on this side, other side thins
- Can be affected by disease processes
 - Inflammation, infection, and neoplasia

Bone growth

- Growth genetically predetermined
- Growth plate = Physis
- **Maximal growth:**
 - results from free choice feeding of a food with excess of nutrients required for growth. Growth rate is maximal.

- **Controlled growth:**
 - results from restriction of food amount or specific nutrients to produce slower growth, with no change in ultimate adult size
- Controlled growth minimises skeleton risks

Biomechanical Characteristics

- Physical activity
- Hormones
 - PTH, GH, Steroids, Calcitonin
- Lack of activity
- Age
- Gravity
- Bone deposits

Bone modelling & Remodelling

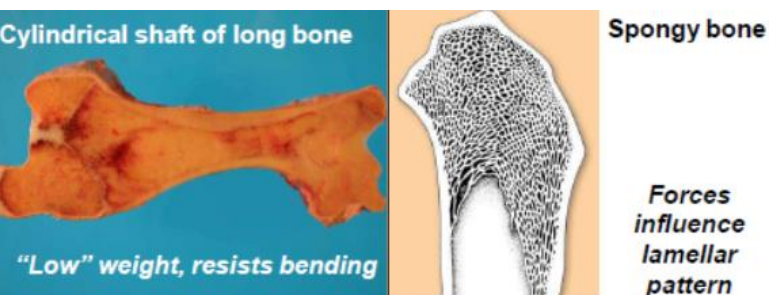
- Bone formed on/in existing bone
 - Due to Activation formation (A-F) or activation resorption (A-R) sequence
- Occurs during growth and healing
 - Minimally after skeletal maturity
- Osteoblasts & osteoclasts act independently at different sites
- Potential to create or resorb large amounts of bone
- Changes shape, curvature, or cortical thickness of a bone

Bone Remodelling

- Bone is resorbed & formed at same place
 - Occurs by ARF sequence (activation resorption sequence)
 - Occurs due to secondary osteon formation
 - Occurs from growth to death
- Main normal physiologic mechanism for altering bone material organization & mass in adult skeleton.
 - E.g. asymmetrical adaptive remodelling of metacarpal bones in greyhounds
- At best, leads to maintenance of bone; but with age it leads to net loss of bone (osteoporosis).

Biomechanical Performance

- Optimal performance relative to weight



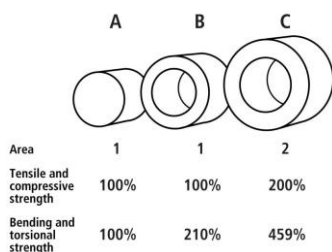
- Dynamic structure – responds to external forces

The Law of Bone Remodelling

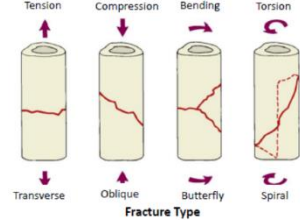
Bone is laid down where it is needed and removed where it is not needed

Bone Modelling

- Inherent long bone strength responds to mode of external loading force



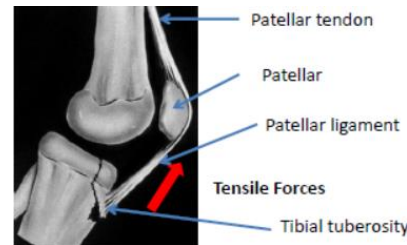
- Clinical relevance is potential fracture type as a result from the force



Bone Radiographic Examples

Tensile loading

- Generally from muscles
- Can stimulate bone growth
- Fractures are usually an avulsion
 - Other injuries include sprains, strains, inflammation, bony deposits
 - Human example: Osgood-Schlatter's disease
 - Repetitive injury during growth
 - Quadriceps muscle group exerts increased load on tibial tuberosity
 - Inflammation



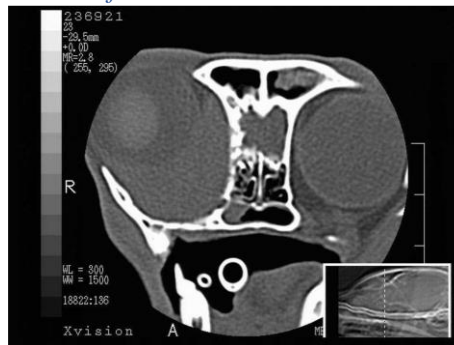
Fracture Repair



Osteosarcoma

- “Osteo” – bone
- “Sarcoma” – type of malignant tumour

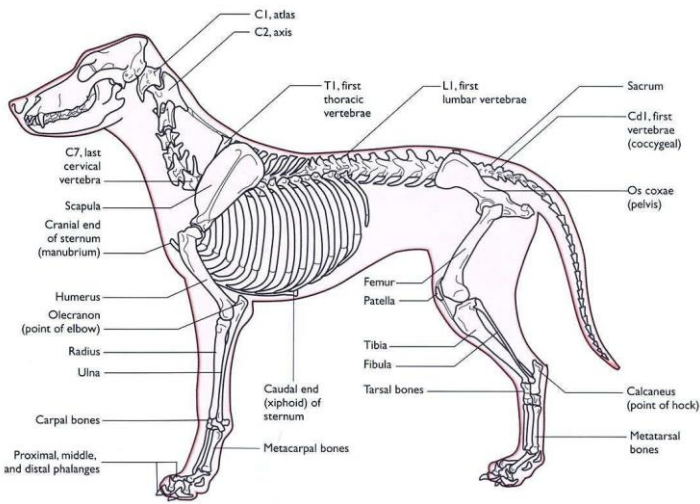
Bone: Infection



Computer tomography (CT) scan of a cat skull with a fungal infection

Skeleton

- **Axial**
 - Skull & mandible
 - Hyoid apparatus
 - Vertebral column, ribs & sternum
- **Appendicular**
 - Forelimb (thoracic limb)
 - Hindlimb (pelvic limb)
- **Heterotrophic**
 - Os penis, ossa cordis

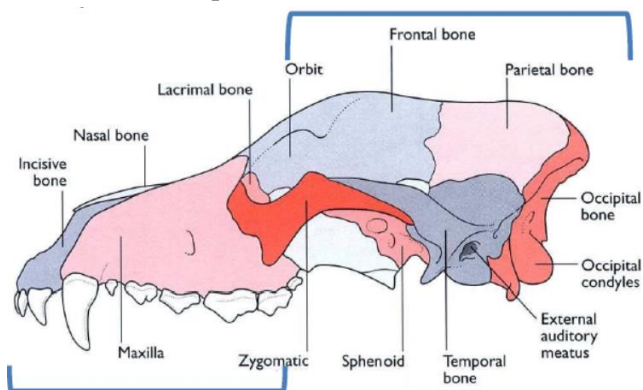


Axial Skeleton

Bones of the head, neck, trunk & tail.

Skull

- Many individual bones joined firmly by connective tissue which may ossify with age
- Consists of a **facial portion** housing the nasal cavity, forming the upper jaw and the **cranium** which encloses and protects the brain



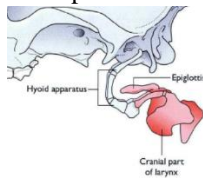
- 3 facial shape classifications
 - Relative length of facial portion
 - *Brachycephalic* (short)
 - *Mesaticephalic* (average)
 - *Dolichocephalic* (long)

Mandible

- Lower jaw
 - Two halves united rostrally in the median plane

Hyoid apparatus

- Several small elongated bones joined by cartilage
- Supports the tongue & larynx

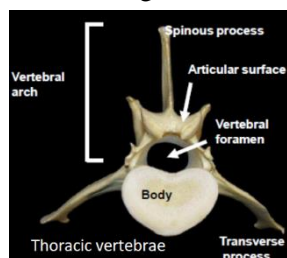


Vertebral column

- Consists of individual vertebrae through which the spinal cord courses

Cervical

- Mammals: 7
 - excluding dugong
- Transverse foramina
 - Allows passage of vertebral artery, vein and sympathetic trunk
- Intervertebral foramina
 - Spinal nerves



Thoracic

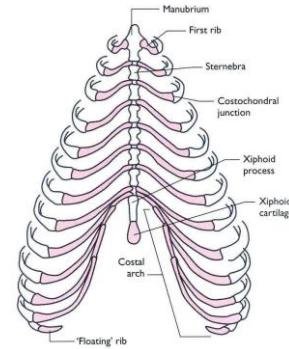
- Dog: 13
- T11 – anticlinal vertebra
 - Spinous process projects straight up

Lumbar

- Dog: 7
- Elongated cranial directed transverse process

Sacral

- All mammals: individual sacral vertebrae fused
- Dog: 3 fused vertebrae
- Supports all the weight of the abdominal organs & structures without aid of the ribs
 - Clinically: chronic hair loss
 - Flea allergy dermatitis
 - Hip dysplasia
 - Sacral nerve pain



Caudal

- Dog: 20 approximately

Ribs

- Correspond in number to the thoracic vertebrae with which they articulate

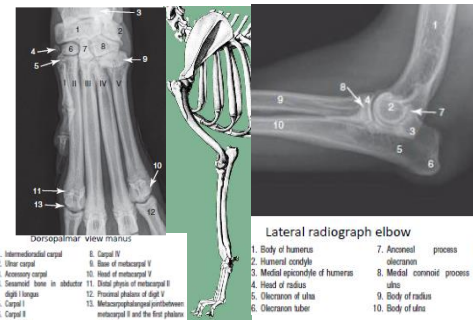
Sternum

- Consists of individual bones united by cartilage:
 - dog: 8 bones
 - 1st sternebra is called the manubrium
 - 8th sternebra is called the xiphoid process

Appendicular Skeleton

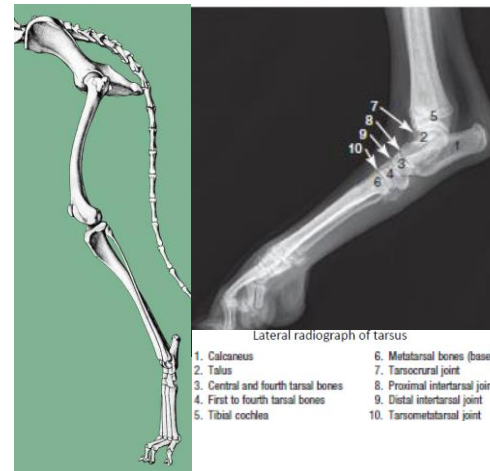
Forelimb

- Scapula
- **Shoulder**
- Humerus
- **Elbow joint**
- Radius
- Ulna
- Carpal bones (Dog: 7)
- Metacarpal bones (Dog: 5)
- Phalanges (singular: phalanx)



Hindlimb

- Pelvis
- **Hip**
- Femur
- **Knee (stifle)**
- Tibia
- Fibula
- Tarsal bones (Dog: 7)
- Metatarsal bones (Dog: 5)
- Phalanges: proximal, middle, distal
 - polydactyl



Heterotopic skeleton

- Os penis
 - Penile bone aiding in sexual intercourse
 - Maintains stiffness
 - Not present in humans
- Ossa cordis

Foundations of Veterinary Science A Locomotion and Posture Gross Anatomy Practicals

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Practical 7: Vertebral Column

Components:

- Bones of the vertebral column
- Joints of the vertebral column
- Muscles of the vertebral column
- Imaging of the vertebral column

Vertebral Column Notes

Bones of the Vertebral Column

- 50 irregular bones within 5 regions
 - Cervical (7 vertebrae) C1-C7
 - Thoracic (13 vertebrae) T1-T13
 - Lumbar (7 Vertebrae) L1-L7
 - Sacral (3 vertebrae[fused]) S1-S3
 - Caudal (≈20 vertebrae) Ca1-Ca20

Vertebral column function:

- Locomotion and posture
 - Vertebral column a flexible rod through which propelling forces transferred through body
 - Attachment point for limb muscles
- Protection of the spinal cord
 - This lies in vertebral canal
- Formation of the thoracic, abdominal and pelvic cavities
 - These protect the viscera

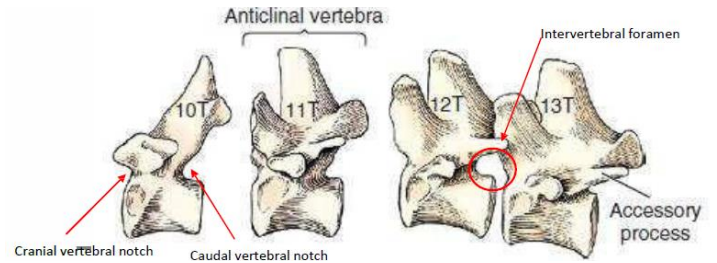
General features of the vertebrae

Body:

- Constricted centrally and bound cranial and caudally by vertebral end plates
- Intervertebral disc lies between end plates

Vertebral arch:

- Consists of paired pedicles and paired lamellae
- Extending dorsally from the dorsal lateral portions of the body, it forms a short tube, the vertebral foramen.
- Vertebrae foramen collectively form the vertebral canal – surrounds spinal cord
- Vertebral arch has two indentations as it attaches to the body.
 - The shallow cranial vertebral notch and the deeper caudal vertebral notch.
 - When articulated, the caudal notch of the cranial vertebrae and the cranial notch of the caudal vertebrae form a foramen, the intervertebral foramen.
 - The spinal nerve roots and blood vessels pass through this foramen.



- Most vertebrae have large # of processes that act ligament and muscle insertion points
 - **Dorsal spinous processes:**
 - Formed from the fusion of paired lamellae
 - **Transverse processes:**
 - Paired lateral (or ventrolateral projections) from the vertebral arch
 - **Articular processes:**
 - Paired cranial and caudal processes
- Some vertebrae show additional processes such as the mammillary processes and accessory processes

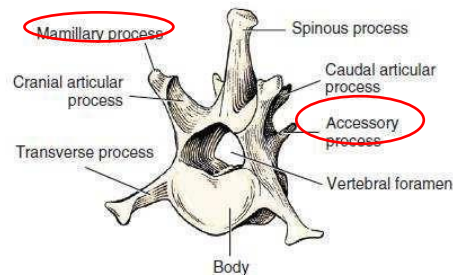


FIGURE 4-70 First lumbar vertebra, cranial lateral aspect.

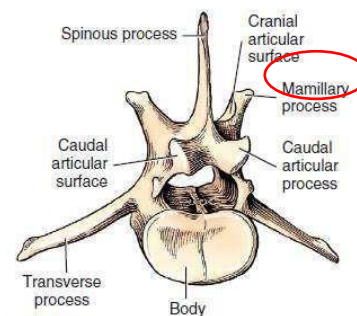


FIGURE 4-71 Fifth lumbar vertebra, caudal lateral aspect.

Cervical vertebrae

C1&C2 are significantly different from others

- 1st cervical vertebra (C1) is the **atlas**
 - Lacks dorsal spinous process
 - Well-developed transverse processes – **wings of the atlas**
 - Vertebral body greatly reduced - known as the **ventral arch**.

- Has paired cotyloid (cup-shaped) cavities both cranially (cranial articular fovea) and caudally (caudal articular fovea).
 - form articulations with the rounded occipital condyles of the skull (cranially) and the cranial articular surface of the dens (caudally).
- It has two paired foramen:
 - The **alar foramen** in the transverse process, allows passage of the vertebral artery.

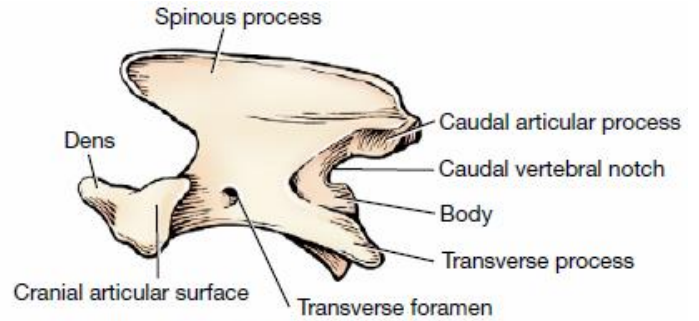
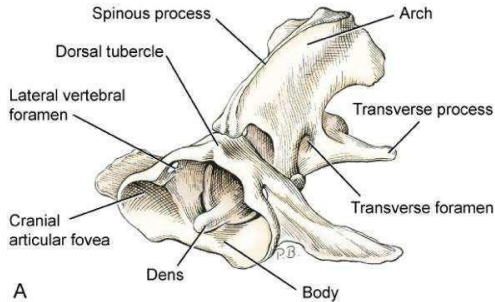
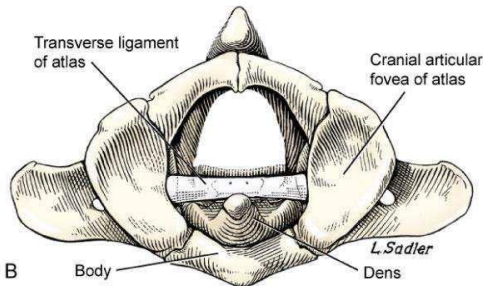


Fig. 2-66 Axis, left lateral view.



A



B

- **Lateral vertebral foramen** in the vertebral arch, allows passage of the first nerve root and vertebral artery.

- 2nd cervical vertebral (C2) is the **axis**

- **Dorsal spinous process:** cranially overhangs the dorsal arch of the atlas. Caudally attaches to the nuchal ligament
- Transverse process
- **Transverse foramen:** present within the transverse process
- **Dens:** cranioventral peg-like projection, held down by transverse ligament

- C3-C7

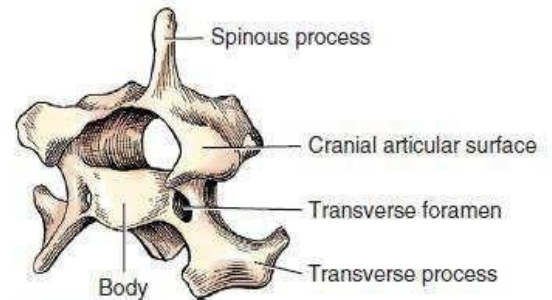
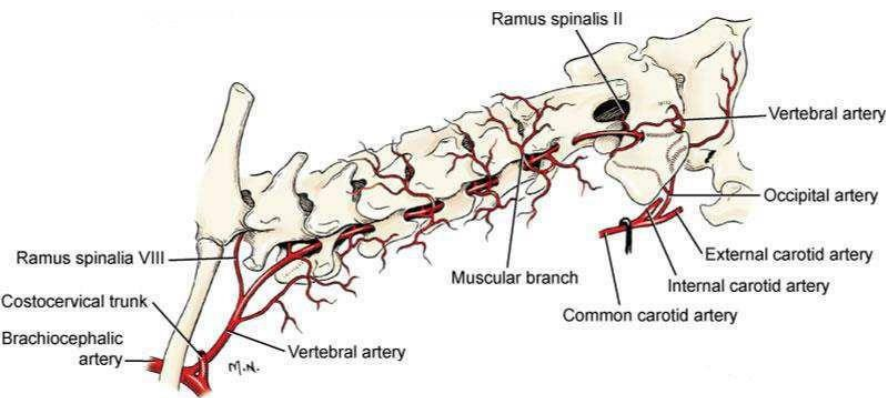


FIGURE 4-56 Fifth cervical vertebra, cranial lateral aspect.

- **Dorsal spinous process**
- **Transverse processes:** paired
- **Large transverse processes of C6**
- Transverse foramen (C3-C6)
- Vertebral foramen/canal
- **Cranial articular processes**
- **Caudal articular processes**



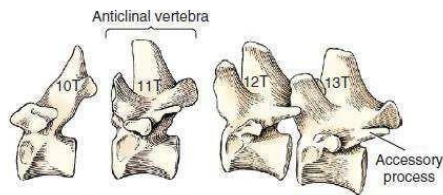


FIGURE 4-66 The last four thoracic vertebrae, lateral aspect.

Thoracic Vertebrae

13 in the dog. The thoracic vertebrae have **very noticeable spinous processes**, although these begin to recess from vertebrae 10-13, where they become smaller and more cranially pointed rather than caudally. There are **minimal transverse processes** on these vertebrae. The ribs articulate here – joining to the **vertebral body** (into the **costal fovea**) as a costovertebral joint. This is joined bilaterally by the intercapital ligament running under the vertebral body. The number of the rib corresponds to the most caudal vertebrae that it's attached to. The attachment is solidified by the costatransverse ligament.

Lumbar Vertebrae

7 in the dog. Has large, **cranially pointed transverse processes**, and well developed **articular processes**. The cranial articular process has a projection called the mamillary process, this assists attachment of the epaxial muscles. The first five have an accessory process that project caudolaterally.

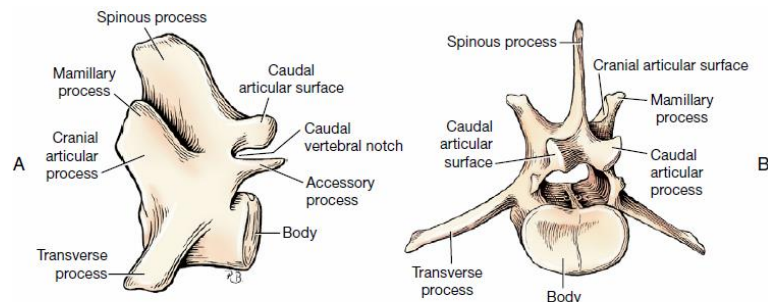


Fig. 2-71 A, Fourth lumbar vertebra, left lateral view. B, Fifth lumbar vertebra, caudolateral view.

3 Sacral Vertebrae

Three fused together in the dog. Has a noticeable **dorsal crest**, **dorsal foramen**, **ventral foramen**, and a large transverse process called the **wing**. Supports the weight of the organs of the pelvic cavity.

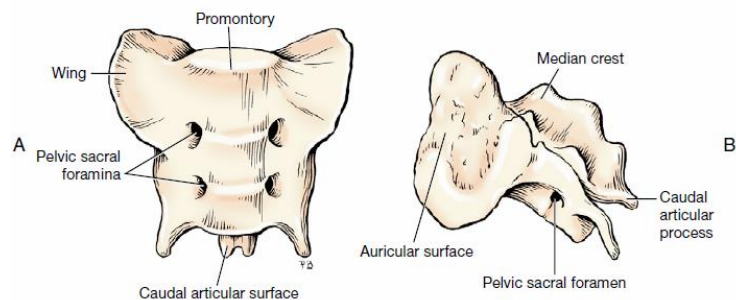


Fig. 2-72 A, Sacrum, ventral view. B, Sacrum, left lateral view.

Caudal vertebrae

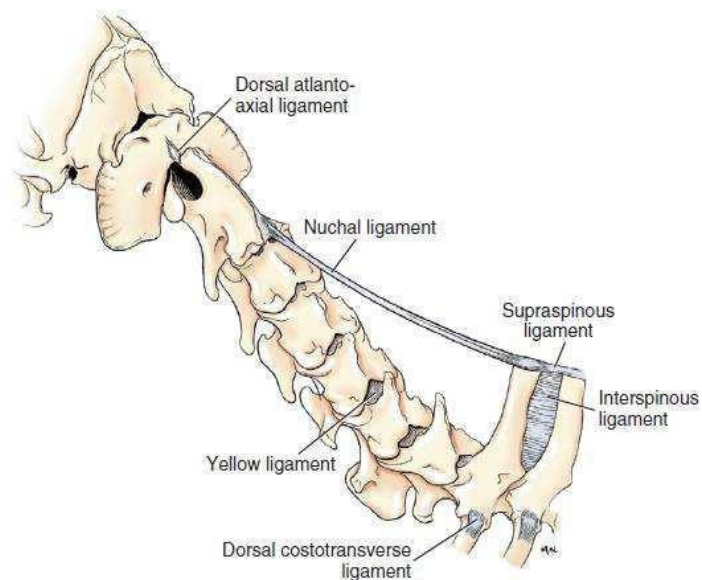
Variable number. Grows progressively simpler.

Articulation of the articular processes (zygapophyseal joints):

Joints of the vertebral column

Intraspinous (join the spinous processes), **intratransverse** (join the transverse processes) ligaments are small & run between individual vertebrae. **Ventral** and **dorsal body ligaments** run along the length of the column.

The **supraspinous ligament** runs along the dorsal surface of multiple spinous processes of the thoracic vertebrae, before culminating in the elastic **nuchal ligament** that runs from the 1st thoracic vertebrae to the axis.



Muscles of the vertebral column

Epaxial: extend spinal column & run along its length.

Three main groups – the transversospinalis, the longissimus, and the iliocostalis.

- **Iliocostalis system:** most ventral system

- m. iliocostalis, and its parts:
 - M. iliocostalis lumborum
 - M. iliocostalis thoracis

- **Longissimus system:** middle system

- **M. longissimus**, and its parts:
 - m. longissimus lumborum
 - m. longissimus thoracis
 - m. longissimus cervicis
 - m. longissimus atlantis
 - m. longissimus capitis

- **Transversospinalis system:** most dorsal system

- **m. multifidus**
- **m. spinalis et semispinalis**, and its parts:
 - semispinalis thoracis
 - semispinalis cervicis
 - semispinalis capitis, and its two parts
 - m. biventris
 - m. complexus

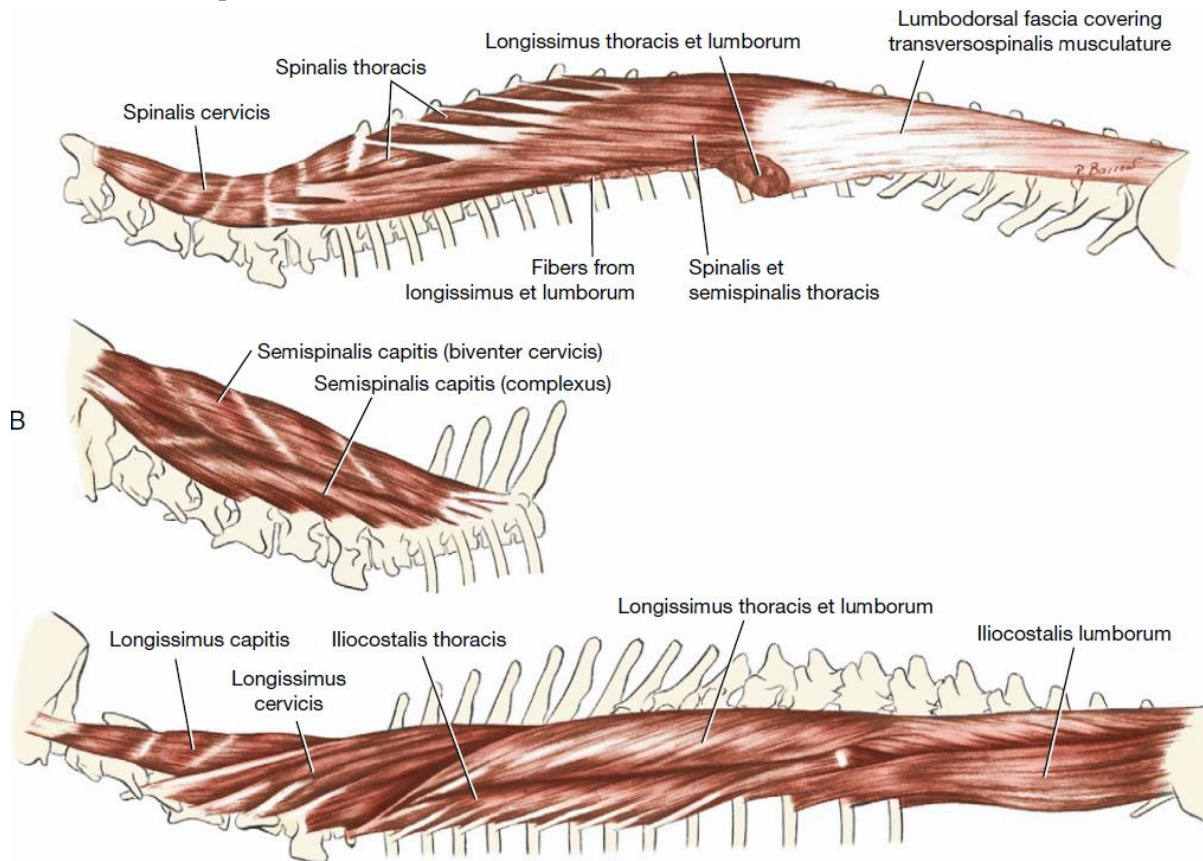
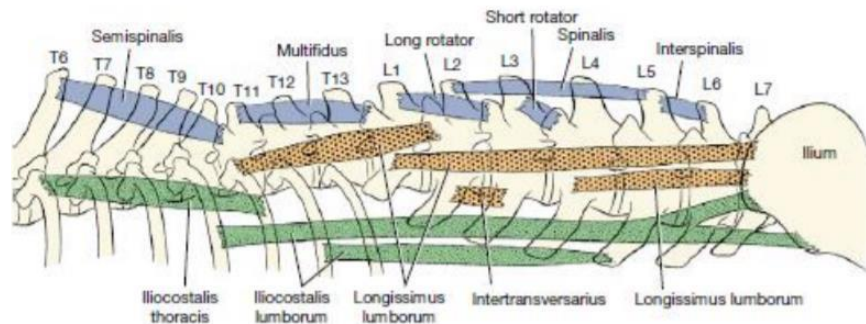


Fig. 2-82—cont'd B, Topography of the epaxial muscles.

