THE VERTEBRAL COLUMN:

- Axial skeleton:
  - Vertebral column
  - Rib cage
  - Skull

- Vertebral column:
  - Supports skull above
  - Provides anchorage for the ribs
  - Protects the spinal cord.

- Each bone in vertebral column = vertebra
  - 7 cervical vertebra
  - 12 thoracic vertebra
  - 5 lumbar vertebra
  - 5 fused sacral segments (wedged between the 2 sides of the pelvis).
  - Coccyx (4 fused bones)

- Verterbae are stout – provides the strength needed to support the weight of the trunk
- Esp. stout in lower parts of the column
- Vertebral column held together by strong ligaments and muscles

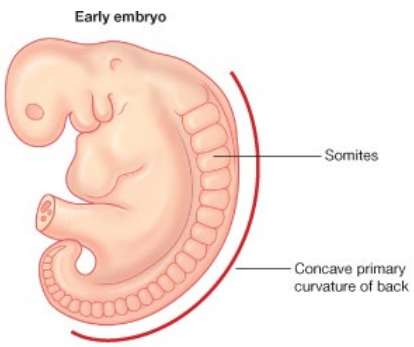
Infants:
- Vertebral column flexed like a letted 'C'
- This anterior felxure: **primary curvature**

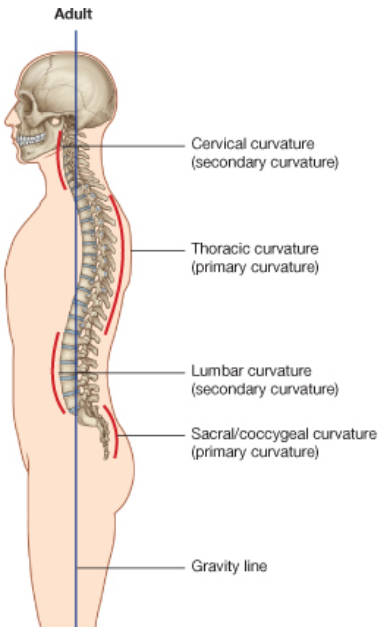
- During development, 2 secondary curvatures develop in <u>cervical & lumbar</u> regions.
- Both of these secondary carvatures are concave posteriorly.
- **Secondary cervical curvature:**
  - Develops as children begin to hold their head up
  - Due to development of muscluar support needed to balance head:
    - Strong extensor muscles in back of neck needed to counter tendancy for head to fall forward onto chest.
- **Secondary lumbar curvature:**
  - Develops as children learn to walk upright & balance on 2 feet.

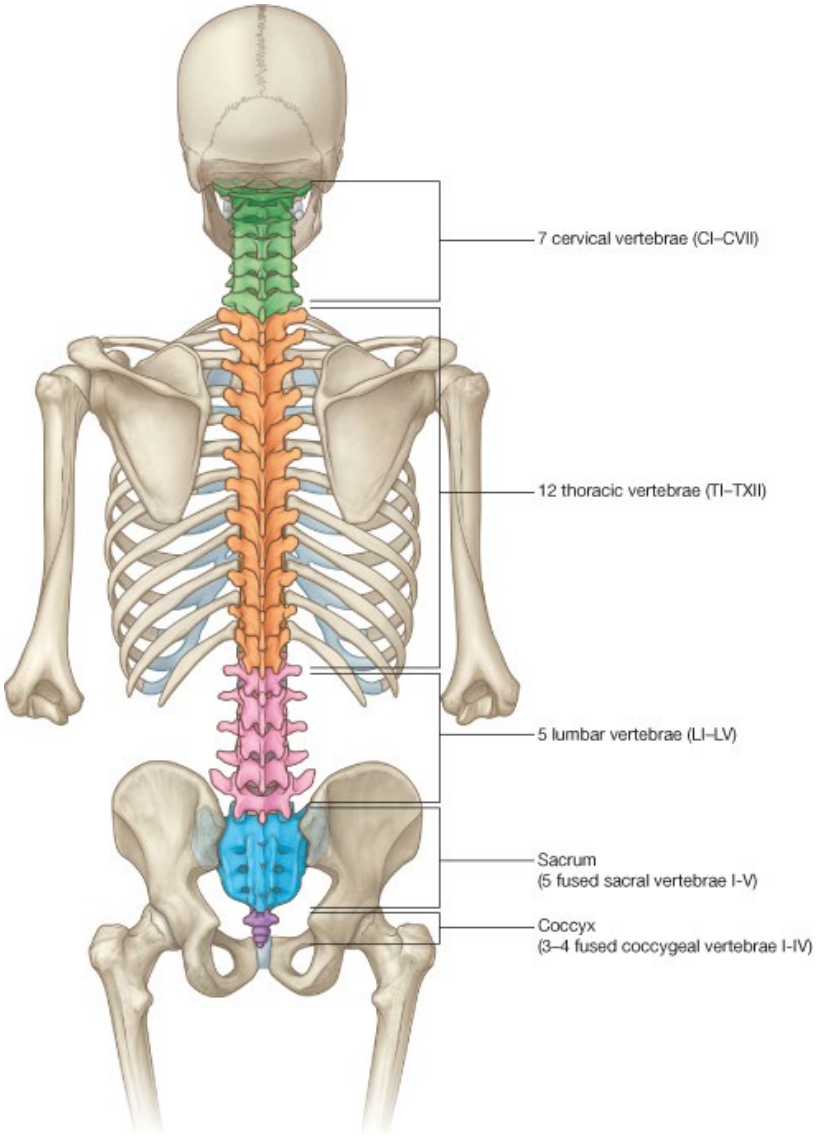
- ***Lardosis*** is an increased <u>*anterior convexity*</u> of vertebral column – especially common in the <u>lumbar</u> region.

- ***Kyphosis*** is a <u>*posterior covexity*</u> of the vertebral column

- ***Scoliosis*** is a <u>*lateral curvature & rotational deformity*</u>
- Scoliosis often occurs together with lardosis / kyphosis





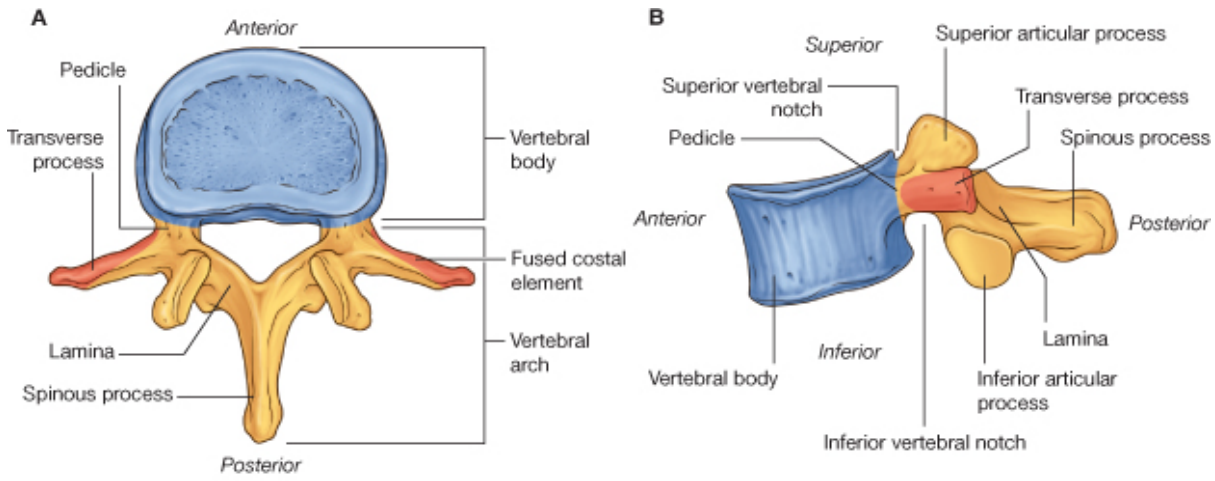


THORACIC VERTEBRAE:

- Vertebrae differ in shape from region to region, but there is a basic pattern
- Each vertebra consists of 2 main parts:
    - **Body**
    - **Verterbal arch**
- Body and arch together enclose a hole – the **vertebral foramen**

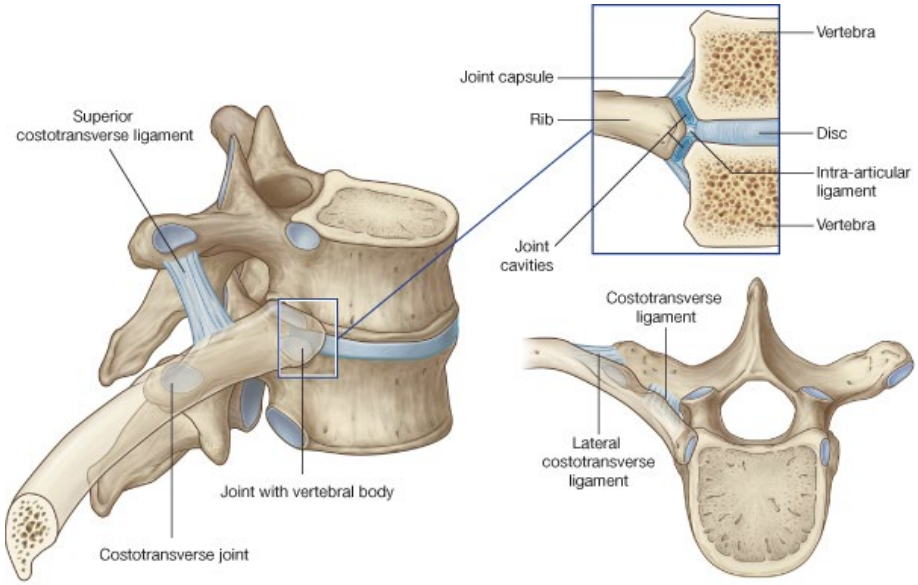
- 3 boney processes arise from the vertebral arch:
    - **Spinous process**
        - Projects backwards & downwards from middle of vertebral arch
    - **R & L transverse processes**

- Transverse processes divide the vertebral arch into 2 parts:
    - **Pedicle** lies between the body and the transverse process
    - **Lamina** lies between the transverse process and the spinous process
- The laminae bear the spinous process



- Each thoracic vertebra articulates with a pair of ribs
- Vertebrae in the <u>cervical & lumbar segments</u> also have a 'costal element' which represents an undeveloped rib.
- Sometimes these elements are well developed – **cervical / lumbar ribs**

- On lateral surface of all thoracic vertebrae (except T1, T11 & T12), there are **hemifacets** at the top and bottom for articulation with the ribs.
- Each rib articulates with *vertebrae of its own number, and the vertebra <u>above</u>*
- Δ head of rib straddles the intervertebral disc between the 2 vertebral bodies.
- Ribs T1, T11 & T12 articulate only with the thoracic vertebra of their own number.
- The ribs also articulate with the <u>transverse processes</u> of the vertebra at a different **synovial joint**.



- 12 thoracic vertebra sit one on top of the other → the vertebral fomanina from a continuous tube – **vertebral canal**
- The vertebral canal contains the **spinal cord**
- Between each vertebra, there is an exit on the right and left sides from the vertebral canal.
- These are called **intervertebral foramina**

- The intervertebral foramina are bounded:
    - Anteriorly: **vertebral body + intervertebral disk**
    - Above & below: **pedicles**
    - Posteriorly: **synovial facet joints between vertebral arches of adjacent vertebra.**

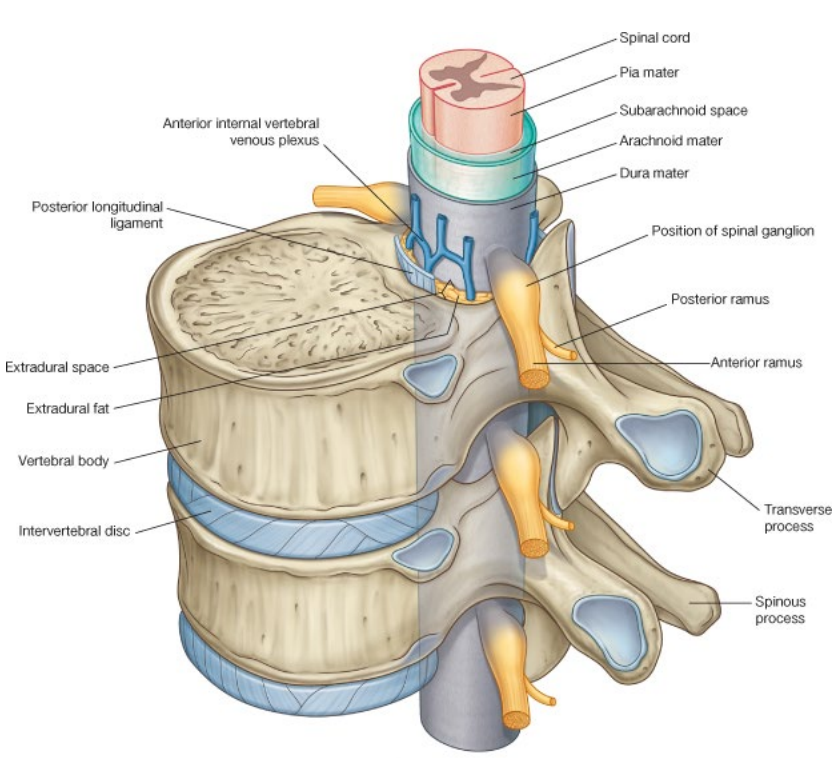
- The intervertebral foramina allow several structures to pass out:
    - Nerves
    - Arteries
    - Veins

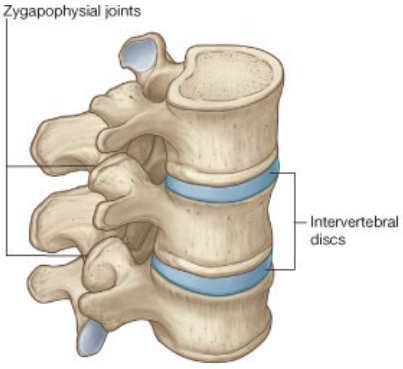
- Vertebra are joined together by means of joints & ligaments
- 2 articulations between any 2 vertebra:
    - Body – body (IVD)
    - Vertebral arch – vertebral arch (facet joint)

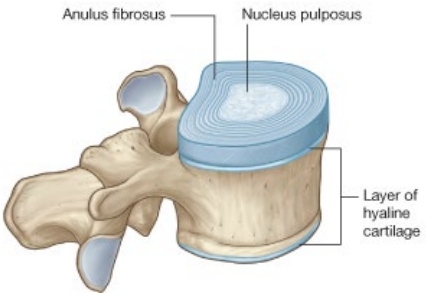
Body-body joint:

- Secondary cartilaginous joint
- Called the **intervertebral disc**
- Covering the surface of each vertebral body in the region of the intervertebral disc is a **thin layer of articular cartilage**.
- vertebral body – hyaline cartilage – intervertebral disc – hyaline cartilage – vertebral body
- Strong fibrous cartilage unites these layers of cartilage
- Can withstand strains in any direction
- The fibrous tissue only exists around the periphery of the disc – **annulus fibrosus**
- The center of the disk is not fibrous – it is a gelatinous ball called the **nucleus pulposus**
- The body of the vertebra can move around the nucleus pulposus mass in any direction
- If the annulus fibrosus and nucleus pulposus was only articulation between the two discs, the column would be freely moveable in all directions.

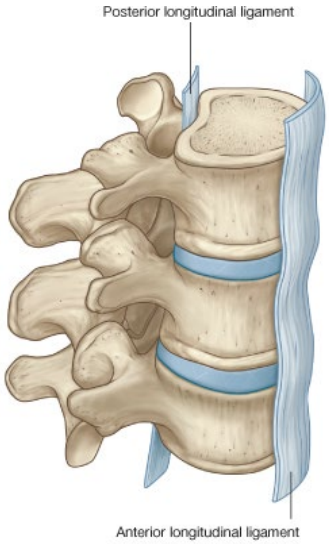
- The annulus fibrosis can sometimes degenerate posteriorly
- Nucleus pulposus can then herniate through the posterior aspect of the body, into the intervertebal foramen
- Spinal cord or spinal nerve may be compressed
- ***Herniated intervertebral disc ("slipped disc")***







- Vertebral bodies are held together by <u>longditudinal ligaments</u> as well as the intervertebral disk.



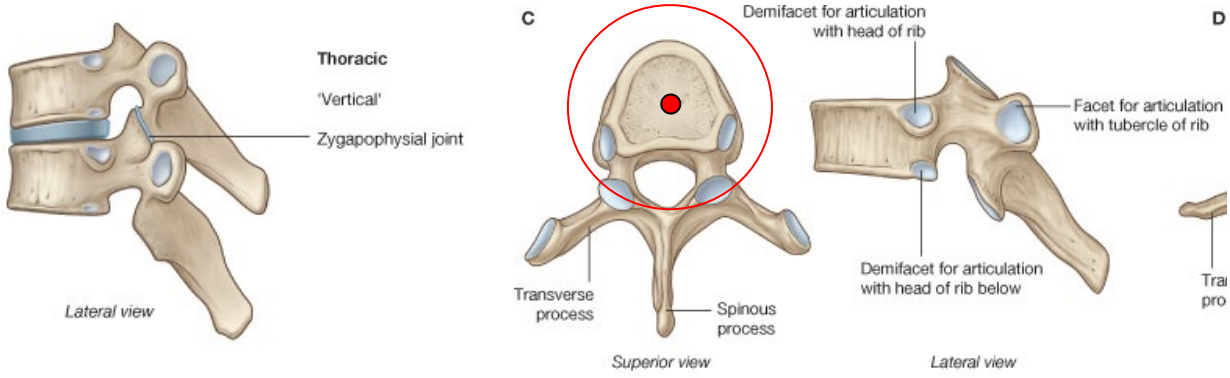
- **Anterior longditudinal ligament:**
  - Extends from cervical region → sacrum
  - Unites the anterior surfaces of the vertebral bodies
  - <u>Not</u> attached to the intervertebal discs

- **Posterior longdiudinal ligament:**
  - Extends from vertebra to vertebra in the vertebral canal behind the bodies
  - <u>Attached</u> to each intervertebral disk
  - Narrows over each body

Vertebral arch – vertebral arch joint:

- **Zygapophysial joint / facet joint**
- Vertebral arches articulate with one another by means of synovial joints
- Each <u>vertebral arch</u> has **4 articular facets:**
  - 2 for articulation with the vertebra above
  - 2 for articualtion with the vertebra below
- The **plane** at which the articular facets are set depends on the level of the vertebra.
- The plane of movement of these joints limits the otherwise universal movement permitted by the body-body articulation.

- In the **<u>thoracic</u>** <u>region</u> the facets lie at the arc of a circle
- Centre of the circle is usually at the nucleus pulposus
- Flexion is limited
- Articular facets allow mostly a rotational movement, but even this is not great, since the ribs also limit movement between thoracic vertebra.

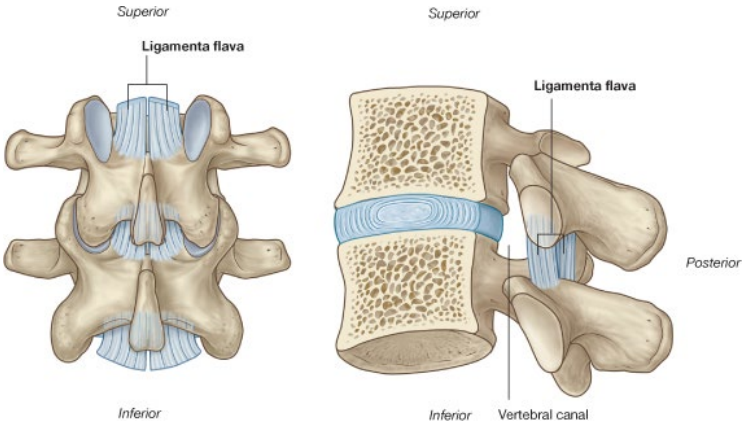


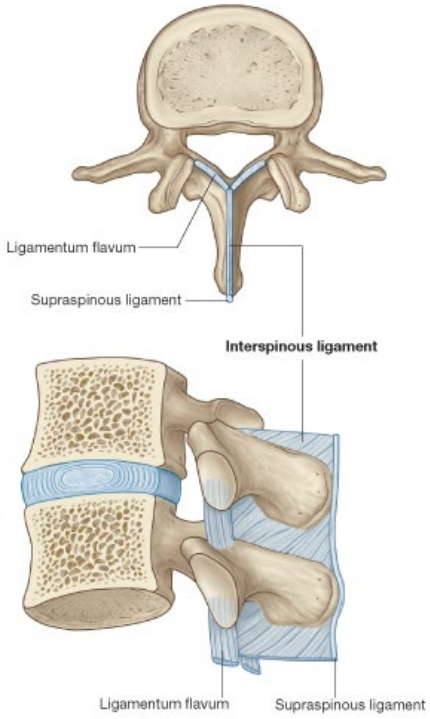
- Several **ligaments** also attach the vertebral arches together:

- **<u>Ligamenta flava</u>** are yellow elastic ligaments that bind <u>adjacent laminae</u> together

- **<u>Supraspinous</u>** & **<u>interspinous ligaments</u>** bind the spinous processes together
  - *Supraspinous:* binds the <u>tips</u> of the spinous processes
  - *Interspinous:* binds the <u>bodies</u> of the spinous processes together

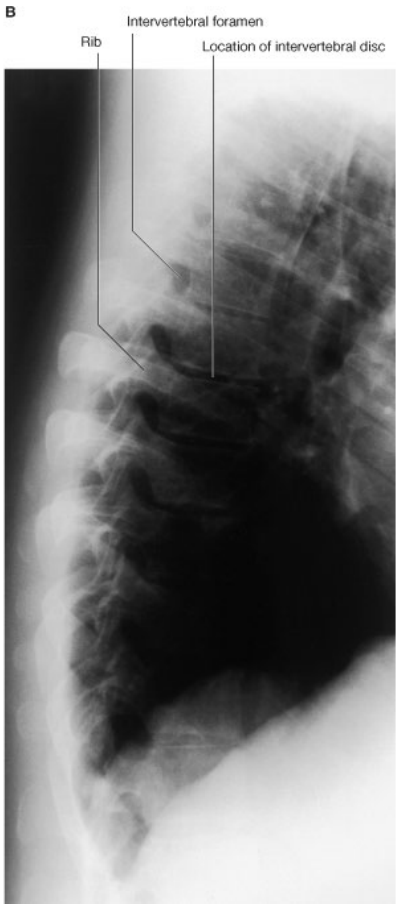
- **<u>Intertransverse ligaments</u>** bind the transverse processes together





Thoracic vertebrae on a radiograph:

- Not easy to see the thoracic vertebrae on a radiograph as they are largely obscured by the ribs
- Radiographs are usually either:
  - <u>Lateral</u>
  - Or <u>anteroposterior</u>
- A lateral view shows clearly the *intervertebral foramen* (seen more clearly if view is slightly oblique).



CERVICAL VERTEBRAE:

- Smaller and more delicate than thoracic vertebrae
- **7** cervical vertebrae
- First and second are important and have special names:
    - C1: **atlas**
    - C2: **axis**
- Atlas + axis are important in supporting the skull and allowing movements:
    - Atlas: nodding of head
    - Axis: rotation of head

Typical cervical vertebra (C3-C7)

- Bodies:
    - Small & delicate
    - Oval shaped
- Bodies are joined together by intervertebral disks
- Intervertebral joints are strengthened by:
    - Anterior longditudinal ligament
    - Posterior longditudinal ligament

- **Vertebral foramen**:
    - Triangular in shape
    - Very large, as the spinal cord is largest at this level

- **Body** of cervical vertebra have small upturned lips on upper lateral margins
- Each lip is called an **uncus** (aka ucinate process)
- The uncus and body of next vertebra are joined by **uncovertebral joints**
- Uncovertebral joints:
    - Found only between cervical vertebrae
    - Associated with rotational movements of cervical column

Transverse process

- The transverse processes of all cervical vertebrae have a hole in them – **foramen transversarium**
- The foramen transversarium of the cervical vertebrae lie one on top of the other – creating 2 tunnels.
- A **vertebral artery** runs up through these foramen transversarium
- The vertebral artery is a branch of the subclavian artery on each side.
- The right & left vertebral arteries enter the foramina transversaria of **C6**
- Enters the brain through **foramen magnum**:
    - Supplies brain & spinal cord with blood

- Transverse process has:
    - **Anterior tubercle**
    - **Posterior tubercle**
- These tubercles give rise to muscles of the neck (middle layer muscles):
    - Scalenus anterior
    - Scalenus medius
    - Scalenus posterior
- Only the posterior tubercle belongs developmentally to the transverse process
- The *anterior* tubercle is a degenerated cervical rib and is a **costal element**
- Sometimes the anterior tubercle of C7 is large – can form a complete '**cervical rib**'

Clinical complications of a cervical rib:

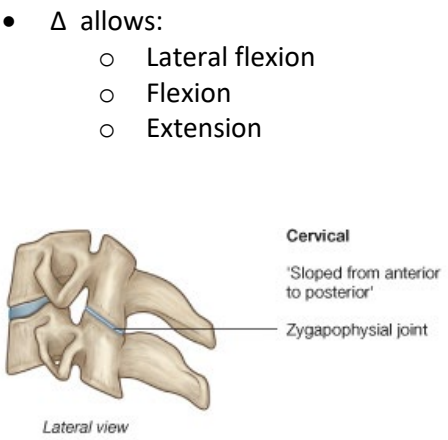
- Impede bloodflow into subclavian vessels
- Stretch lower nerve roots of brachial plexus (esp. T1 – medial cord [ulnar]) → weakness in small muscles of hand.

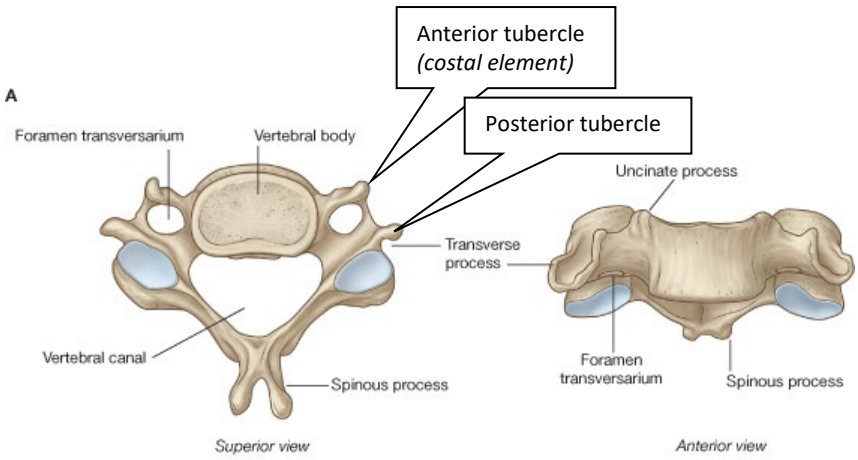
Spinous process:

- The spinous processes of the cervical vertebrae are **bifid**

- All of the processes of the cervical vertebrae are united by ligaments:
    - Supraspinous ligament
    - Interspinous ligament
    - Intertransverse ligament

- Like the thoracic vertebrae, the cervical vertebral arches are joined together by **synovial joints**
- The facets for these synovial joints do not lie on the arc of a circle as in the thoracic region
- Δ allow little rotation between individual typical cervical vertebrae (C3-C7)
- Instead lie on a coronal plane (vertical)
- Δ allows:
    - Lateral flexion
    - Flexion
    - Extension





- The laminae are united by **ligamenta flava**

- **C7** is the most prominent of the cervical vertebrae
  (Note: the uppermost thoracic vertebrae may be more prominent)
- Spinous process of C7 can easily be palpated in the neck
- Δ C7 vertebra is called **vertebra prominens**
- Use vertebra prominents to count down the other vertebrae.

Atlas (C1) & Axis (C2)

- **Atlas** has no body
- Simply a ring of bone comprising of:
  - **Anterior arch**
  - **Posterior arch**
- The two arches are united on either side by two **lateral masses**
- Lateral masses made up of:
  - Transverse processes
  - Articular facets
- Why is atlas like this?
  - Supports the skull
  - Allows for nodding movement – between superior articular facets and occipital condyles of the skull

- **Axis** does have a body
- On top of the body sits a peg of bone – **dens / odontoid process**
- Dens is said to be the body of the *atlas* which has become attached to the *axis*
- The dens projects into socket within the ring of the atlus – allows rotation of the atlas & head around the dens.

- Both atlas and axis have **foramen transversarium** in their transverse processes.
- The vertebral arteries pass through these.
- Having reached the foramen transversarium of the atlas, the vertebral artery curves back over the lateral mass of the atlas and its posterior arch
- → enters the vertebral canal & foramen magnum

Articular surfaces of the atlas & axis:

Superior articular facet of atlas – occipital condyles of skull

- **Atlas**: the **superior articular facet** of the atlas is:
  - Concave
  - Kidney shaped
- Each superior articular facet accepts an occipital condyle at the base of the skull
- This is a **synovial joint**
- Allows the 2 facets to slide against each other.
- Allow only nodding movement of the head:
  - Flexion
  - Extension
- *Slight* degree of side-to-side rocking is also possible.
- **No** rotation is possible at this joint

Superior articular facets of axis – inferior articular facets of atlas

- Articulation between atlas and axis.
- **Axis:** the **superior articular facets** of the axis lie either side of the base of the dens
- Articulate with the inferior facets of the atlas
- **Synovial joints**
- Allow *only* **rotation** of atlas ring on the axis around the dens.
- The articular surfaces must be <u>flat</u> in order to allow this.

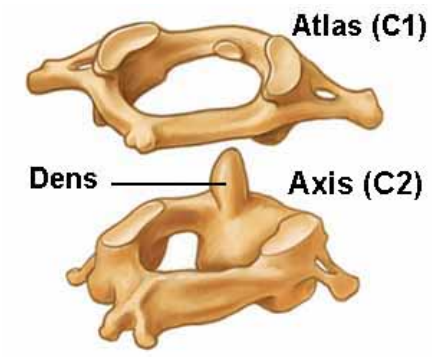
- Strong ligaments stabilise these joints

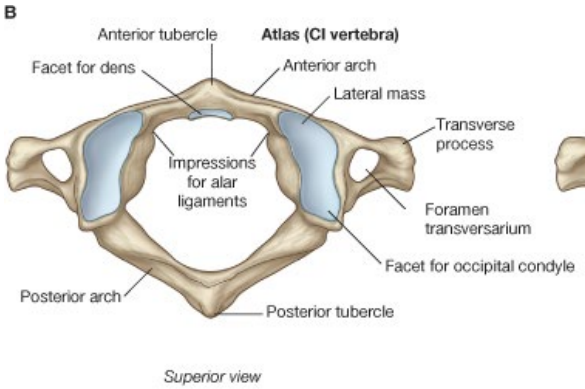
- Dens is inserted into a socket formed by:
  - <u>Anterior arch</u> of atlas
  - **Transverse ligament**
- This is a **synovial** peg & socket joint – allows <u>rotation</u>
- **Transverse ligament** is continuous upwards and downwards, as a second layer of support.
  - Upper continuation:
    - Attaches to the skull
    - Hides 3 short ligaments (see below)
  - Lower continuation:
    - Attached to the body of the axis

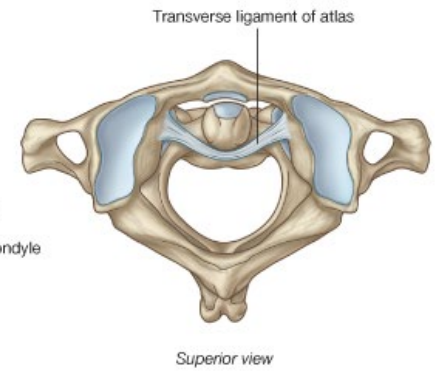
- **3 ligaments**: connect…
  - <u>dens</u> → <u>interior</u> of the <u>base of skull</u>

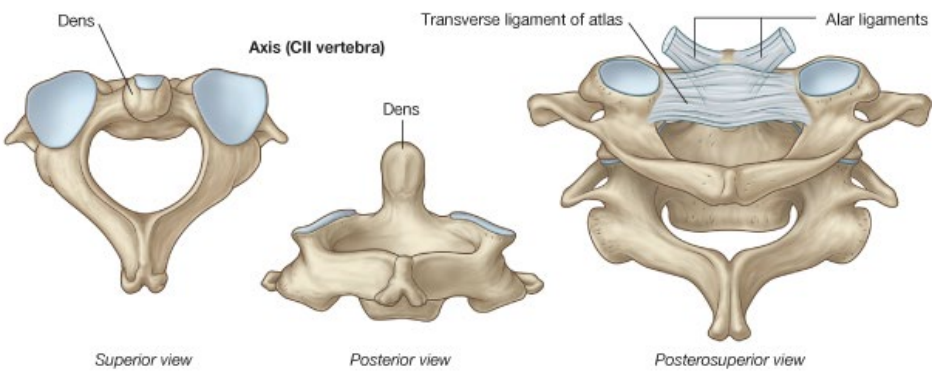
- The transverse ligament + 3 ligaments to the base of skull = **cruciate ligament**

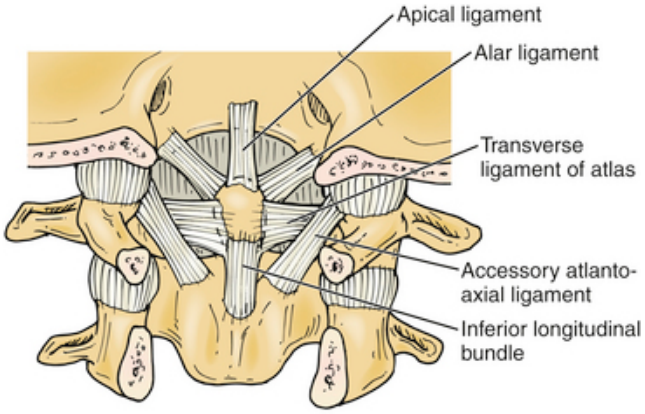
- On the posterior surface of the cruciate ligaments, the **posterior longditudinal ligament** continues
- It continues up into the base of the skull as a third layer of support
- In the region of the skull the posterior longditudinal ligament is known as the **membrana tectoria**







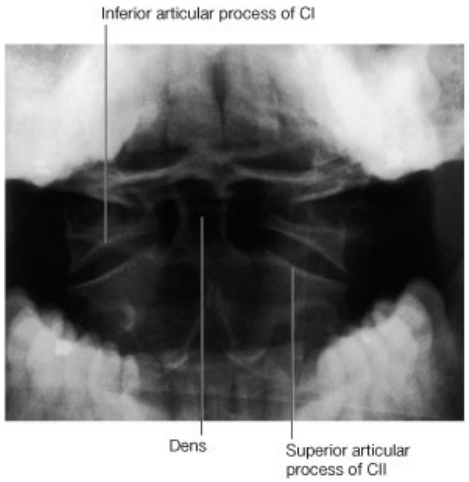




Summary:

- Atlas is sandwiched between the skull and the axis
- Ligaments act to stabilise each of the articulations between these 3 bones:
    - Cruciate ligament:
        - Transverse ligament
        - 3 ligaments from the dens (alar x 2, apical)
    - Posterior longditudinal ligament → membrana tectoria

- Radiographs of atlas and axis are best taken through an open mouth, with plate positioned at back of head & neck.



LUMBAR VERTEBRAE:

- **5** lumber vertebrae
- More massive and stronger than C / T vertebrae
- Short strong processes
- Kidney shaped bodies
- Small vertebral canal

- Bodies are united by intervertebral disks
- Degeneration & herniation of the intervertebral disks is most common between:
    - T12-L1
    - L4-L5
    - L5-S1

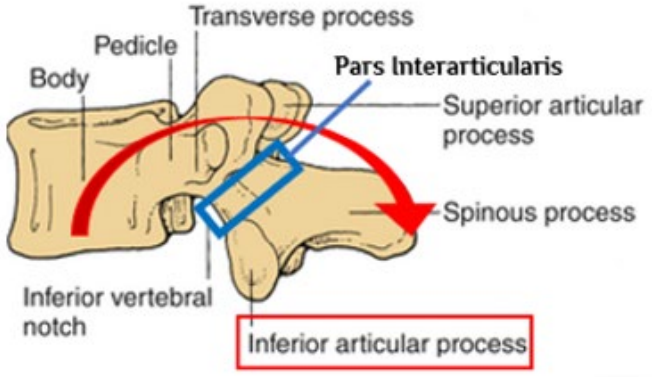
- The vertebral arches of the lumbar vertebrae bear strong transverse & spinous processes
- *Spinous processes*:
    - Not as long as those in the thoracic region
    - Project directly backwards
    - (in the thoracic region they protrude downwards & backwards)
- *Transverse process:*
    - Is a **costal element**
    - The true morphological transverse element is a small mass of bone at the base
    - The costal 'transverse process' of L1 can sometimes be separate, and is united to the body of L1 by a synovial joint – **lumbar rib**
    - Lumbar rib is much rarer than a cervical rib.

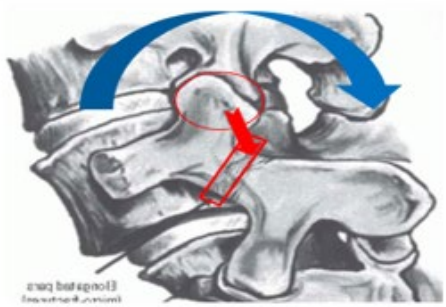
- **Ligaments** uniting arches & processes in the lumbar region are thick & strong.

- Articular facets form synovial joints between the arches
- These joints are aligned in the saggital plane, allowing:
    - Flexion
    - Extension
    - Some lateral flexion
    - NO rotation

- Intervertebral foramina of the lumbar region are bounded by:
    - Anteriorly: body + intervertebral disk
    - Above & below: pedicles
    - Behind: synovial joint between superior and inferior articular facets (facet joint)

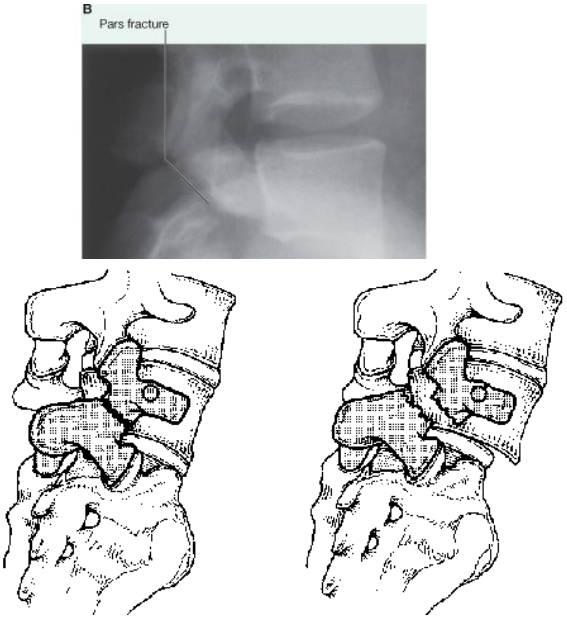
- Region of lumbar vertebrae between supeior and inferior articular facets (of a single vertebra) is known as **pars interarticularis.**





- Traumatic fractures across the pars interarticularis
- On an ***oblique*** radiograph of the lumbar region, the pars interarticularis looks like a 'scottie dog'
    - Nose: transeverse process
    - *Eye*: pedicle
    - *Ear*: superior articular process
    - ***Neck & collar*: pars interarticularis** (between superior & inferior articular facets)

- A pars which is *radiolucent* (transparent) is either fractured or cartilaginous



- **Spondylolisthesis *slippage of the vertebral body***
- **Often anterior displacement of the vertebra above with respects to the one below**
- Due to either:

A. Failure of fusion of vertebral arch with the body during ossification.
    - Both collars of the 'scottie dog' have failed to fuse

B. Bilateral fracture of both pars iterarticularis

- On radiograph, body appears to have slipped a little on the sacrum.

SACRUM AND COOCYX:

- Sacrum consists of 5 vertebrae, fused to form a boney mass
- Triangular in outline
- Upper surface of sacrum articulates with L5:
    - Intervertebral disk between vertebral bodies
    - Synovial joints between articular facets

- On either side the sacrum articulates with the pelvis – but the body weight does not pass through these *joints*.
- Instead the body weight passes through strong ligaments – **sacroiliac ligaments** – which join the sacrum to the pelvic ileum.

- Sacrum is concave anteriorly
- First sacral mass bulges into the pelvic cavity – forms the **promontory of the sacrum**

- On the midline posteriorly, the fused vertebrae can be outlined by 4 transverse ridges of bone
- These boney ridges represent the ossified intervertebral discs of the sacral region

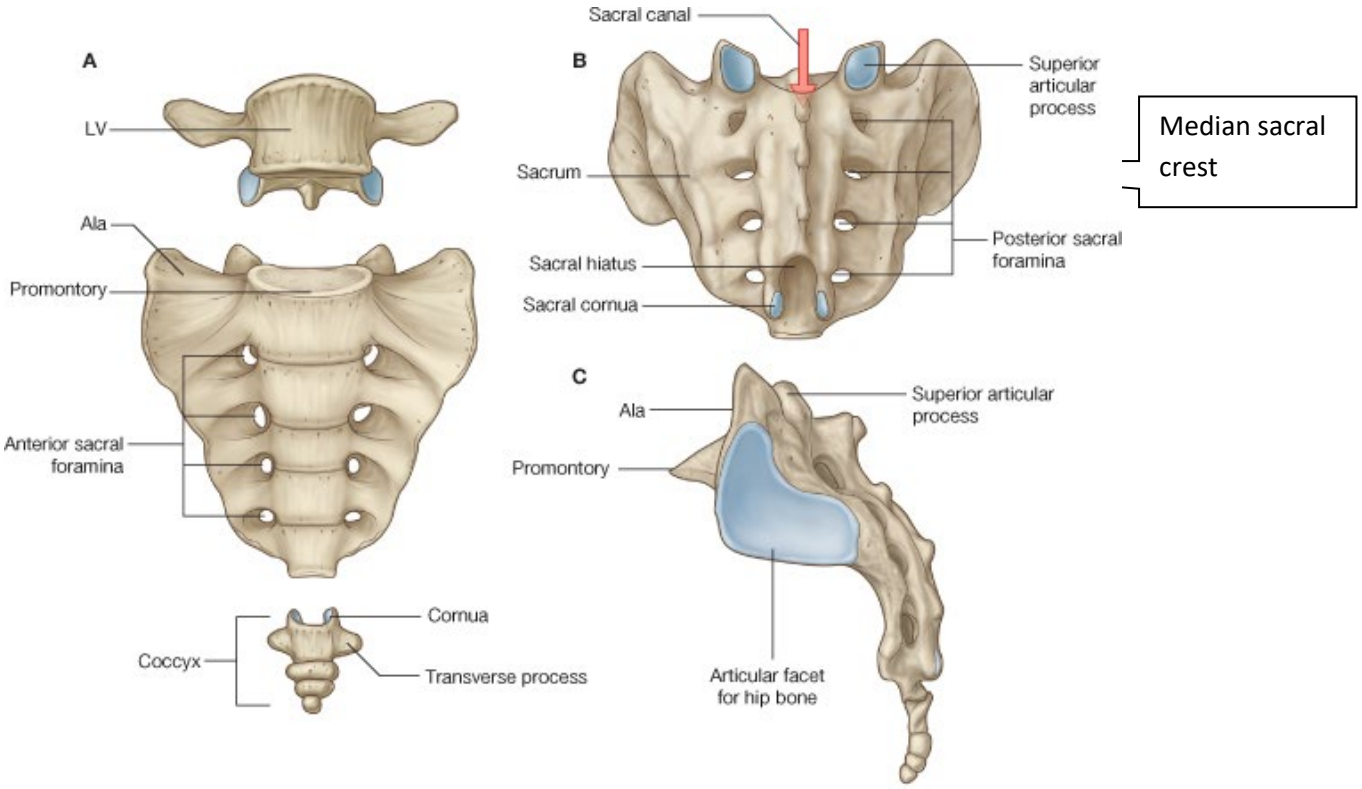
- On either side of the midline are 4 **anterior sacral foramina**
- Sacral ventral rami pass through these foramina

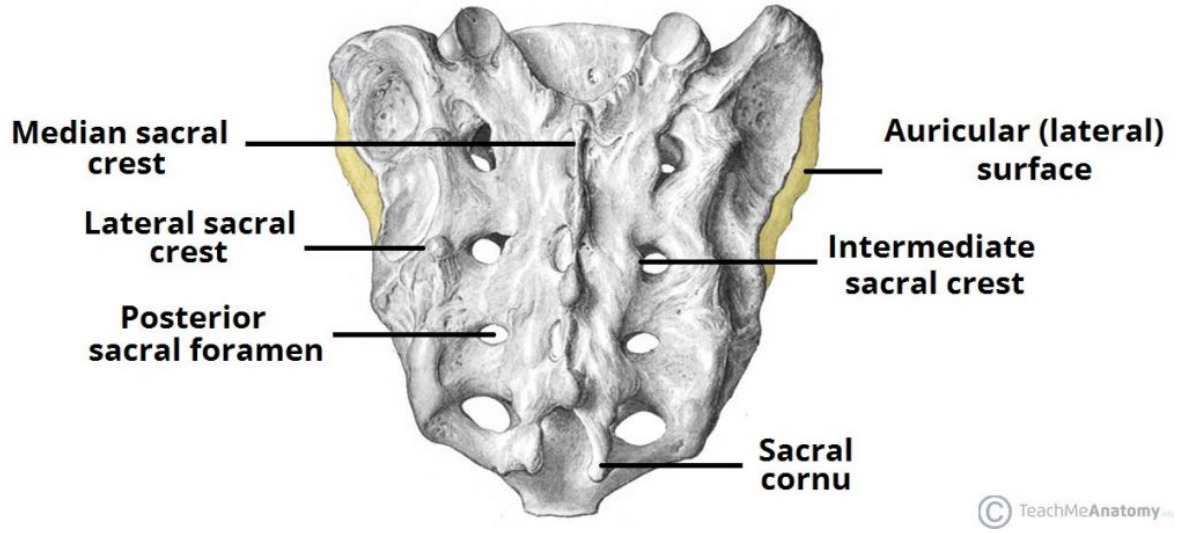
- On the lateral sides of the foramina are 2 massive **lateral masses (ala)** of bone
- The lateral masses + the bone between them and the foramina, represent the **costal elements** of the sacral vertebrae.

Posterior surface
- Posterior surface of the coccyx is convex
- In the midine posteriorly – **median crest** – represents the fused spinous processes.
- In the midline below the median crest (posteriorly), the vertebral canal opens out at the **sacral hiatus**
- The sacral hiatus is such because the posterior part of the vertebral arch at this level remains deficient throughout life.
- In life the hiatus is closed with a little loose fibrous tissue

- Lateral to the midline crest on either side is the **articular crest**
- Articular crest represents the fused articular processes of the sacral vertebrae.

- **4 posterior sacral foramina** transmit the dorsal rami
- 5th sacral foramina is formed on either side of the sacral hiatus.
    - From the 5th foramina arise the:
        - Small 5th sacral nerve
        - Coccygeal nerves
- Lateral to the posterior foramina is a **lateral crest** representing the fused transverse processes of the sacral vertebrae.



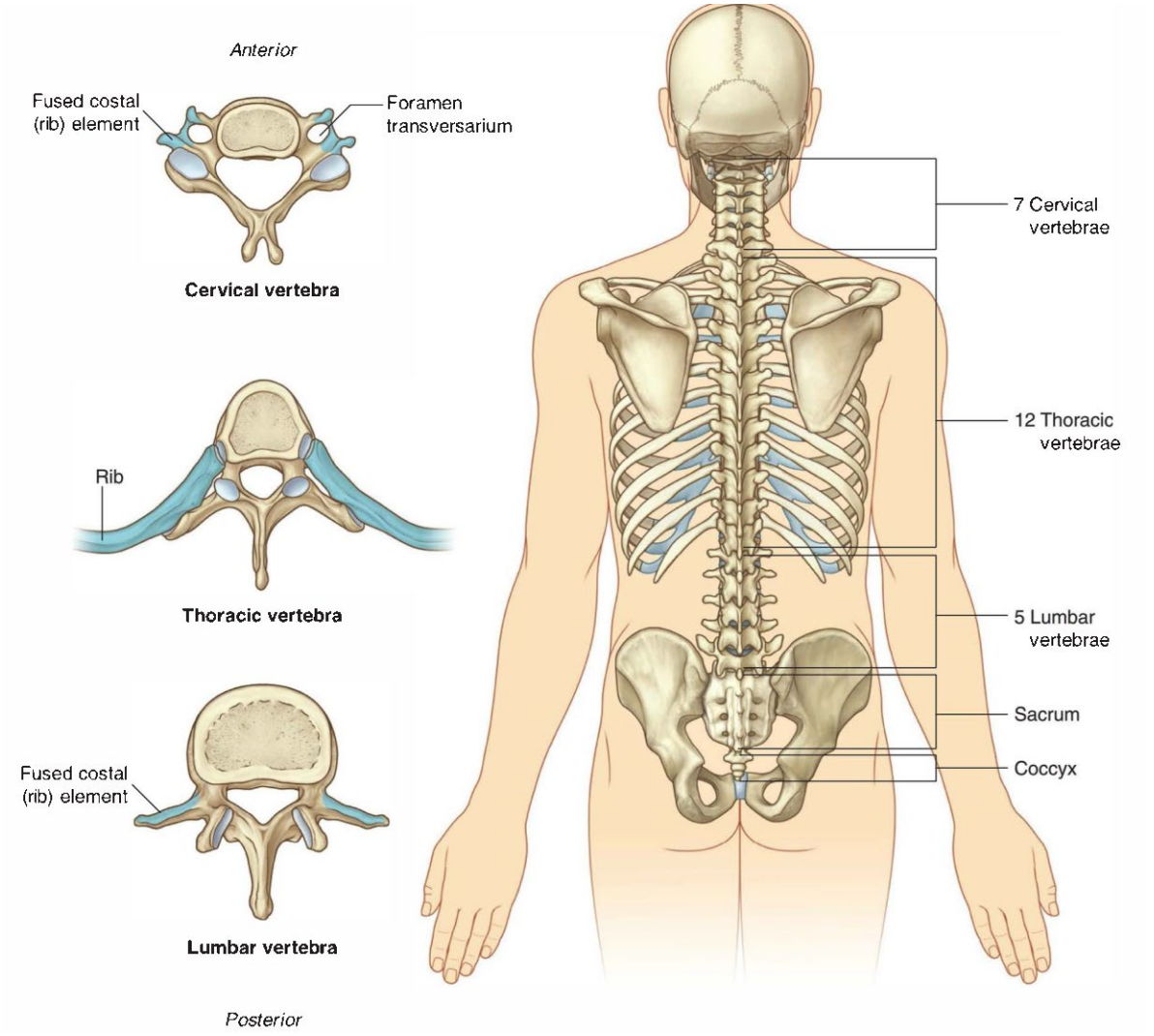


Sex differences between the male & female sacrum:

- Comparison of with of body and ala of the S1 segment:
    - *Women* have wider sacral alae (lateral masses) such that the vertebral body makes up less of the width of the sacrum
- In *women* the sacrum as a whole is wider, but the bodies of the sacral vertebrae are narrower.

- **Local anaesthetic** can be introduced to the <u>extra-dural space</u> by passing a needle into the region of the sacral hiatus.
- Anaesthesia of lower sacral & coccygeal nerves is useful in obstetric procedures on the vagina.

- **COCCYX** is all that is left of the tail
- **4** fused bones
- Joined to apex of sacrum:
    - <u>intervertebral disk</u>
    - <u>Two small lateral synovial joints</u>

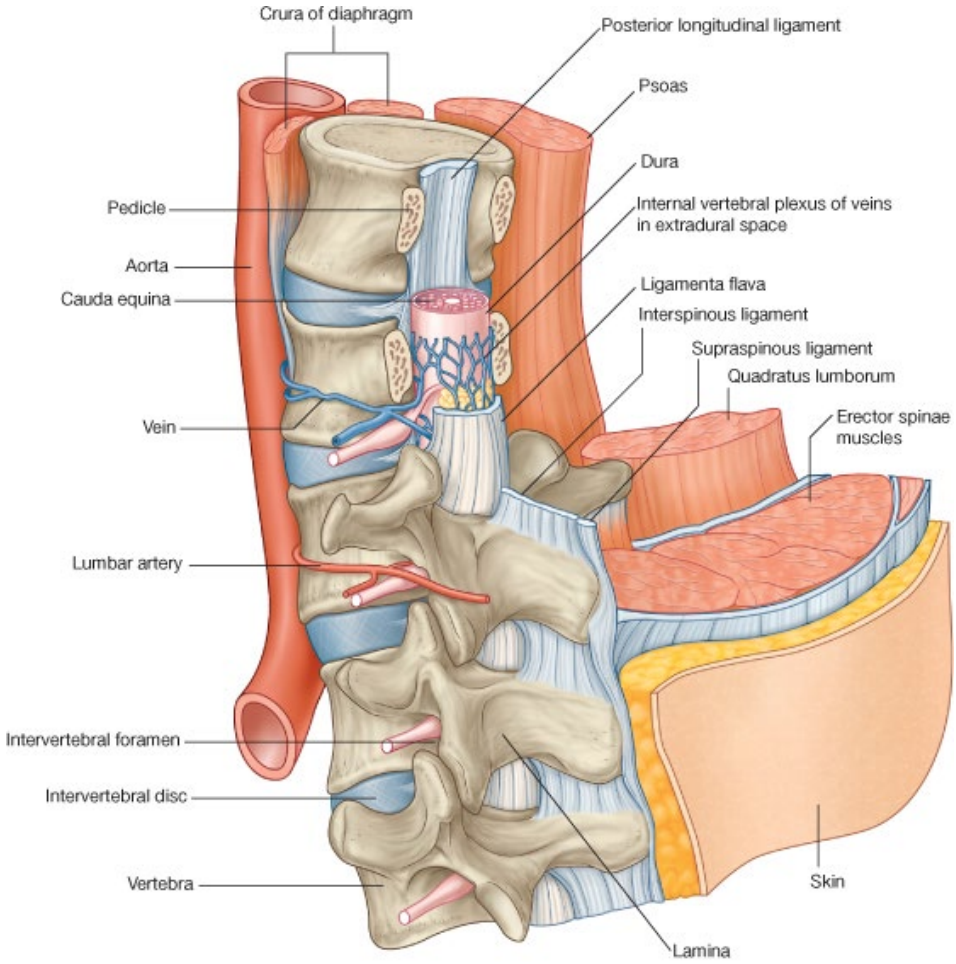


CONTENTS OF THE VERTEBRAL CANAL:

- Vertebral canal = smooth-walled tube in which spinal cord lies
- Vertebral canal is lined:
    - *In front* by the **posterior longditudinal ligament** – covering the vertebral bodies & disks.
    - *Behind* by the **ligamentum flavum** – joining adjacent laminae
- Above the canal is continuous with the cranial cavity
- Spinal cord is continous with the brain at this level.

- Below the canal opens at the small sacral hiatus

- At each intervertebral level, the <u>intervertebral foramina</u> give openings in the vertebral canal.



LP layers:

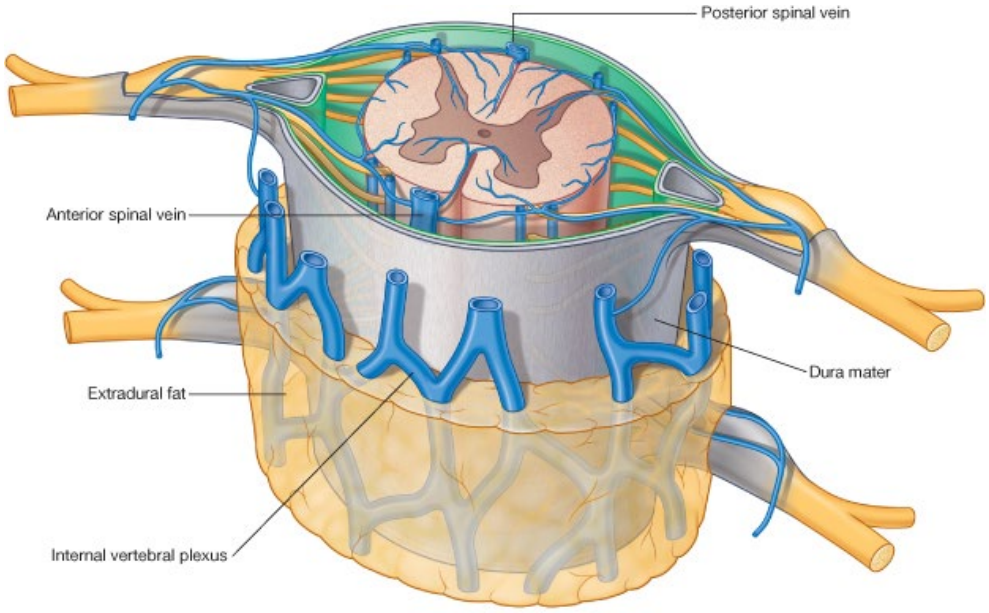
- **Skin**
- **Subcut fat**
- **Supraspinous ligament**
- **Interspinous ligament**
- **Ligamentum flava**
- **Extradural space (fat + internal vertebral venous plexus)**
- **Dura**
- **Arachnoid**
  … Subarachnoid space with CSF

Inside the vertebral canal:

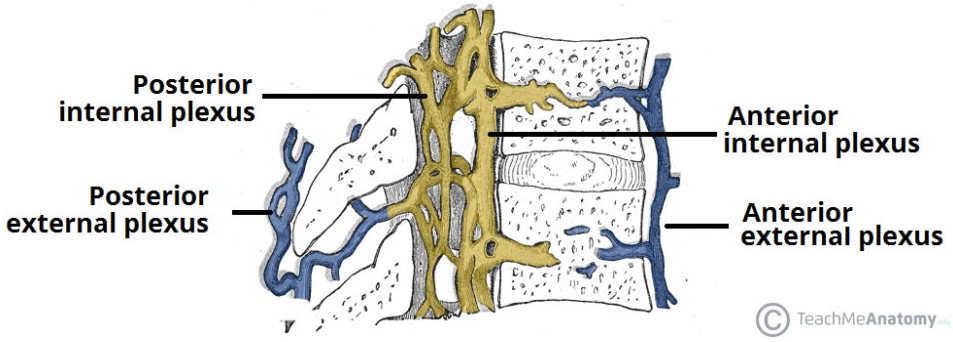
1. **Extradural fat:** Layer of loose fat is is the first thing encountered on opening the vertebral canal
- The vertebral & spinal veins + arteries pass through this loose fat.
- Contains a rich plexus of veins
    - This plexus of veins runs the length of the canal as the **internal vertebral venous plexus**.

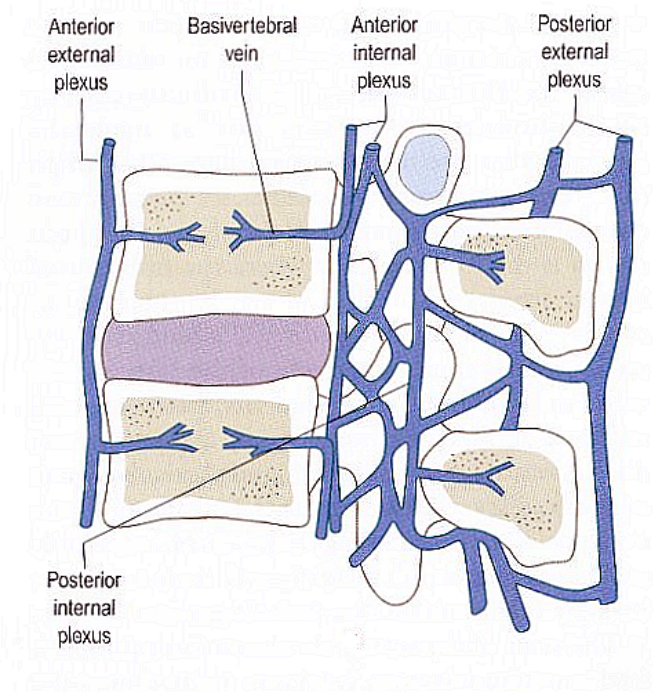
2. **Membranous covering *(meninges)*** of spinal cord liess deep to the loose fat

3. **Spinal cord**



Venous drainage of spinal column





- Blood drains → **internal vertebral venous plexus** (in extradural space) from both:
  - **Spinal cord**
  - **Vertebral bodies**
- Vertebral body of each vertebra contains erythropoeitic bone marrow
- Δ must have good venous drainage to take newly formed RBCs to the circulation.
- Usually **2 basivertebral veins** leaving each vertebral body
- These veins are valveless – blood can move through them in any direction

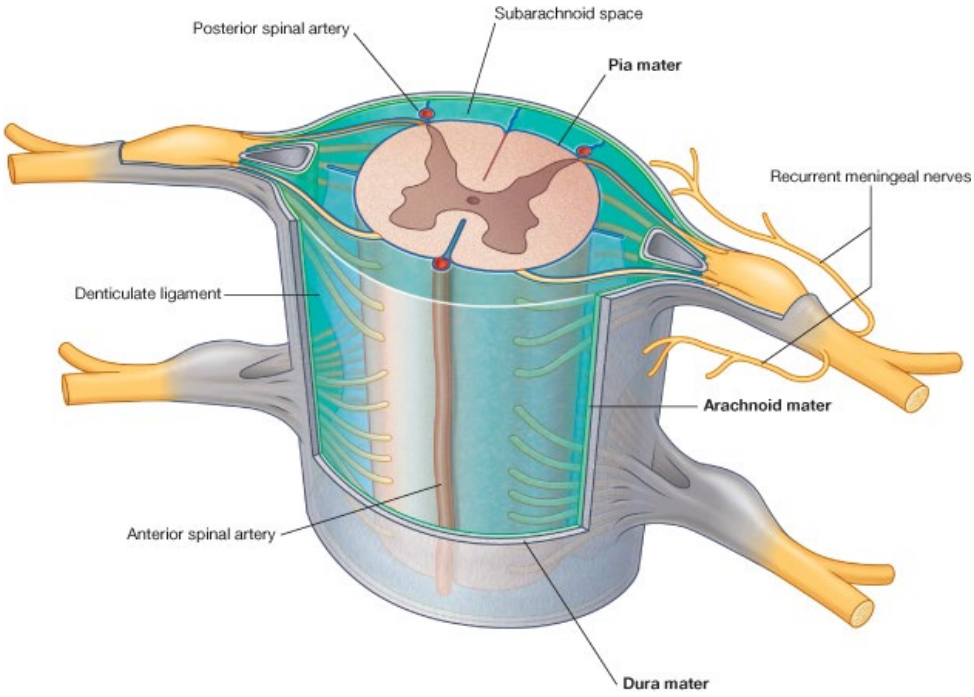
- Internal vertebral venous plexus drains through the intervertebral foramen → **external vertebral venous plexus**.
- The *external* vertebral venous plexus surrounds the entire vertebral column.
- Lies mainly in the muscles masses at the back and front of the column.

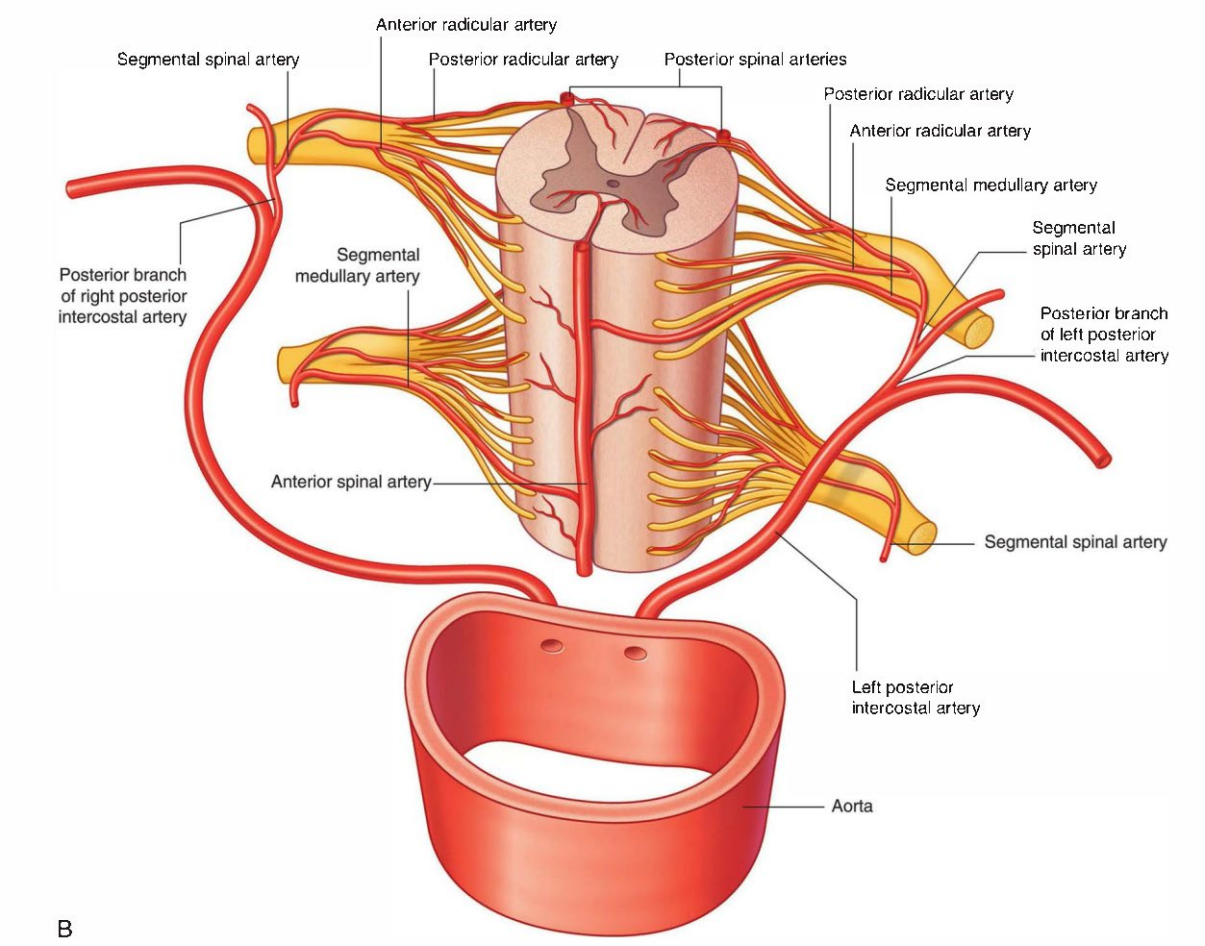
- Eventually the external vertebral venous plexus drains → segmental veins of body wall:
  - Thoracic level: *posterior intercostal veins*
  - Abdomen: *lumbar veins*
- Because the vertebral venous plexuses are **valveless → easy reverse flow.**
- Reverse flow esp. common when intra-abdominal pressure is ↑:
  - Coughing
  - Sneezing
  - Childbirth
  - Lifting heavy loads
- Blood is momentaruly diverted to the venous plexus → ↑pressure in the vertebral column.
- **Then returns to normal route:**
  - **Internal vertebral VP → external vertebral VP → posterior intercostal / lumbar → SVC/IVC**
- **Retrograde venous flow allows easy spread of cancer cells, and so metastasies in the vertebral bodies is not uncommon.**

Arterial blood supply to spinal cord:

- Arterial blood supply to the spinal cord comes mainly from above
- At level of **foramen magnum**, arteries arise from the **vertebral artery:**
    - An **anterior spinal artery**
    - **2 posterior spinal arteries**
- The anterior spinal artery decends along midline groove on the anterior surface of spinal cord
- The 2 posterior arteries pass down the posterior surface of the cord.

- At each spinal level the blood supply is reinforced by **segmental spinal arteries (radicular arteries).**
- Enter the vertebral canal through the **intervertebral foramen**
- These segmental spinal arteries are branches of the segmental arteries of the body wall:
    - Thoracic intercostal arteries
        - Small except for the 1st & 11th thoracic segments





THE MENINGES:

- Removal of extradural fat & internal vertebral venous plexus – allows good view of membranous covering of spinal cord.
- Both the brain & spinal cord are covered with a continuous, 3-layered protective sheath
- This sheath is called the **meninges**
    - Inner layer: **pia mater**
    - Middle layer: **arachnoid mater**
    - Outer layer: **dura mater**

- **Pia meter** is the innermost layer of the meninges.
- Delicate layer
- Closely applied to the neuro-axis
    - Dips into the fissures and indentations of the brain and spinal cord
- Many small blood vessels may run within the pia meter on their way to supply nervous tissue.

- **Arachnoid meter** is the middle layer
- It does not closely invest the brain or spinal cord
- Δ creates a space between the arachnoid & pia layers.
- This is called the ***subarachnoid space***
- The subarachnoid space contains **CSF (cerebrospinal fluid)**
- The CSF acts as a buffer & a shock absorber – protects the NS from trauma
- CSF is produced in the cavities of the brain
- The CSF circulates in the subaracnoid space surrounding both the brain and the spinal cord

- CSF absorbed into the venous blood via **arachnoid granulations** found in the venous sinuses of the cranial cavity.
- Δ there is a circualtion of CSF:
    - Production in cavities of brain →
    - Circulation through subarachnoid space →
    - Absorption into venous blood of cranial cavity via arachnoid granulations

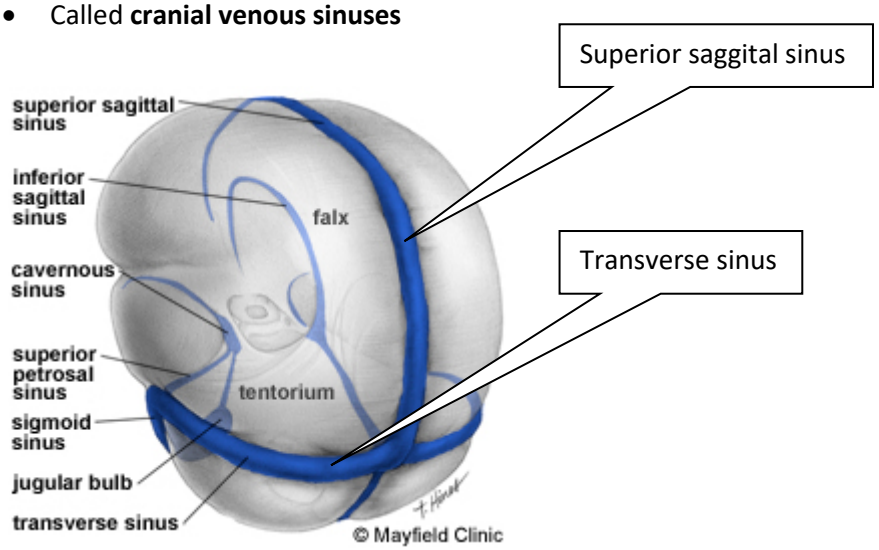
- The arachnoid mater sends fine web-like processes through the CSF to attach to the pia mater

- In some parts of the skull & vertebral canal the subarachnoid space is enlarged → *pools of CSF*
- These pools of CSF are called **cisterns**

- **Dura mater** is the outermost layer of the meninges
- There is only a *capillary interval* between the arachnoid mater & the dura mater – the **subdural space**.
- The dura mater is thick, fibrous & strong
- The **dura mater of the brain is directly continuous with that of the spinal cord**.

- In certain places in the skull, the dura meter is fused to the periosteum of the bone

- In other places theres is gap between the dura mater and the periosteum.
- These gaps are filled with venous blood
- Called **cranial venous sinuses**



- NOTE both cranial venous sinuses & internal vertebral venous plexuses lie within the **extradural space** (i.e. outside the dura mater).

- In the vertebral canal, the dura forms a kind of tube
- Dura is not fused to the periosteum of the vertebra, but is seperated from the walls of the canal by extradural fat & internal vertebral venous plexus
- Space between the dura & boney walls is the **extradural space**

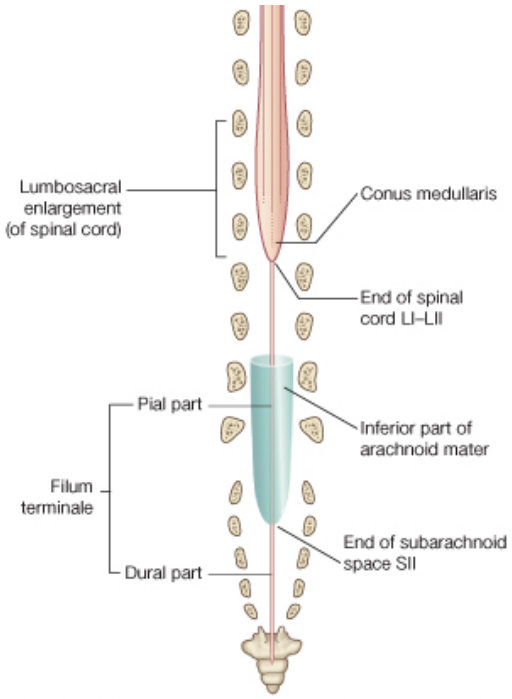
- The dura is drawn out along the spinal nerves through the intervertebral foramina
- The dura attaches to the intervertebral foramina – stabilising the dural tube within the vertebral canal.

- The spinal cord is protected by the meininges and the CSF
- Small processes of the pia mater arise from either side of the spinal cord
- **Arise between dorsal & ventral roots.**
- Pass through the CSF → pierce the arachnoid → attach to the dura
- Called the **ligamenta denticulata**
- *Suspend the cord from the dura in the CSF*
- Lowest ligamentum denticulata is at L1

Spinal cord:
- 18 inches long (in adult)
- Doesn't extend to the end of the vertebral canal
- Reaches to lower border of L2
- *At birth* the cord extends much lower, but as the vertebral column grows at a faster rate, it draws away from the cord.
- Δ in adults the spinal nerves need to run further to reach the intervertebral foramina (esp. for lower lumber & sacral roots).

Arrangement of cord & meninges at lower vertebral column:
- Spinal cord + pia mater end at lower boder of **L2**
- The terminal end of the spinal cord is called the **conus medullaris**
- BUT thin strand of the pia – **filum terminale** – continues down through the subarachnoid space → sacral part of canal.
- The filum teminale pierces the dura and attaches to the *Coccyx 2*
- The role of the filum terminale is similar to that of the ligamentum denticulatum – helps suspend the cord in the CFS.

- The dura & arachnoid do not end with the cord & pia
- The dura & arachnoid continue down to the level of **S2**
- Δ large subarachnoid space in the region between L2-S2 called **lumbar cistern**
- Roots of lumbar & sacral nerves run through this cistern – **cauda equina**



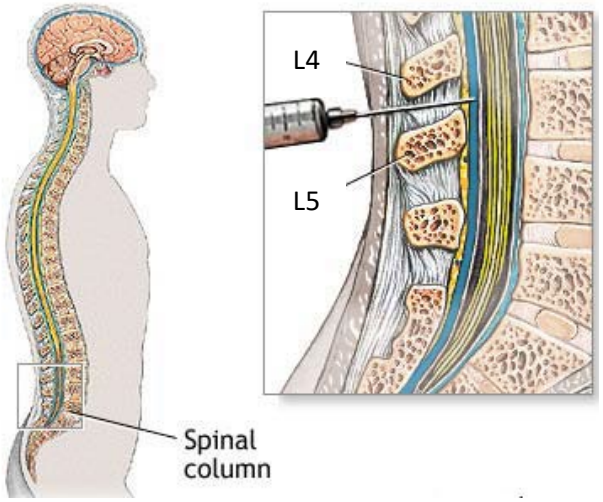
APPLIED ANATOMY OF THE VERTEBRAL CANAL:

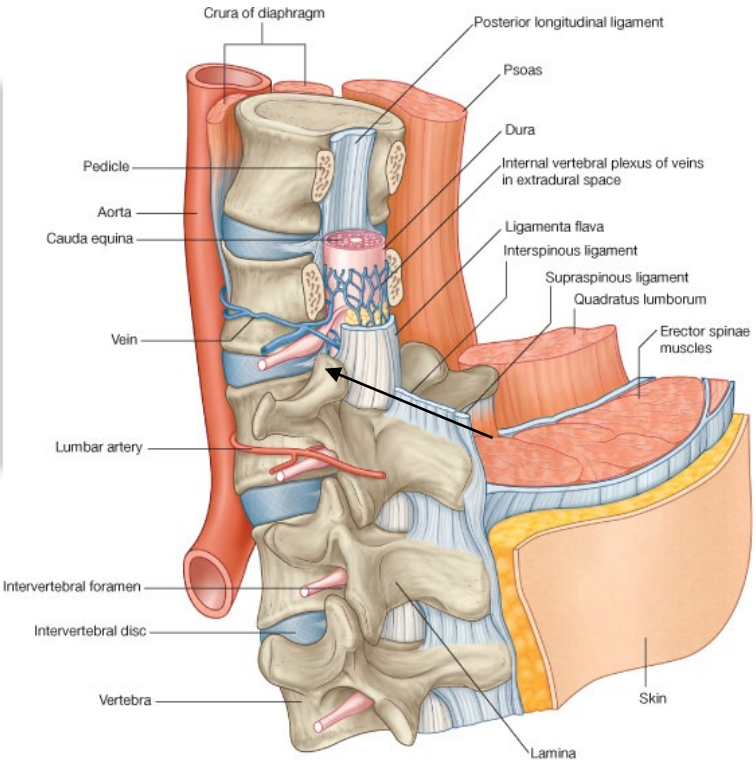
Lumbar puncture
- The lumbar cistern is a convenient place to remove a sample of CSF for **clinical analysis**
- The procedure is a **lumbar puncture**
- Patients back is marked with 2 lines:
  - Vertical: in the midline
  - Horizontal: joins the two iliac crests
- Where the lines cross in the midline is **L4**
- Sterile needle is introduced between **L4-L5** under local anaesthetic.
- Needle passes through:

    - supraspinous & interspinous ligaments
    - → ligamentum flava
    - → extradural fat
    - → dura mater
    - → arachnoid mater
    - → subarachnoid space (containing CSF)
- This level is well below the termination of the spinal cord (at L2) Δ can safely introduce needle into the <u>subarachnoid space</u>.
- CSF is aspirated.
- Do not damage the nerve roots as they float away from the needle in the CSF

- Can also use lumbar puncture to measure the **<u>pressure of CSF</u>**.
- Normally 60-200mm of CSF
- Coughing/sneezing → ↑pressure of CSF due to retrograde blood flow through internal vertebral venous plexus.

- Can also use lumbar puncture to introduce radio-opaque dye to the subarachnoid space
- Allows tumours of the cord to be invesitgated by radiography.
- Called **<u>myelography</u>**





"Slipped discs"

- Degeneration & herniation of the intervertebral disks is most common between:
    - T12-L1
    - **<u>L4-L5</u>**
    - **<u>L5-S1</u>**
- Nucleus pulposus can herniate through the tough annulus fibrosis, exerting **presure on the nerve roots** of L5 & S1
- Can lead to:
    - Pain in lower limb
    - Sensory loss in lower limb
    - Wasting of leg muscles

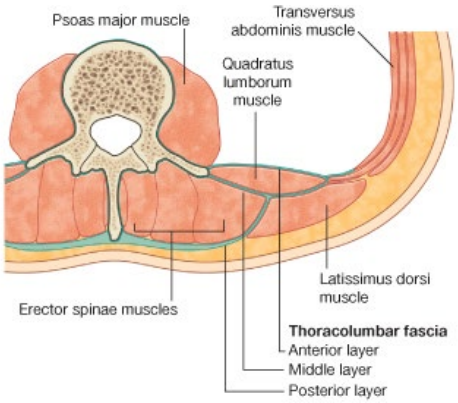
- ‘Slipped disc’ & ‘sciatica’ are extremely common complaints.
- Sciatica results from compression of one of the nerve roots of the sciatic nerve (L4-S3)

MUSCULATURE OF THE VERTEBRAL COLUMN:

- Vertebral column is surrounded by muscles
- Thick & strong muscles in some places
- Weak / absent in others
- Musculature of body wall has 3 layers – but during development muscles of these different layers may migrate to serve different functions.
    - *Internal layer* – lies inside the ribs / costal element of the vertebrae
    - *Middle layer* – lies between the ribs / costal elements
    - *Outer layer* – lies outside the ribs / costal elements

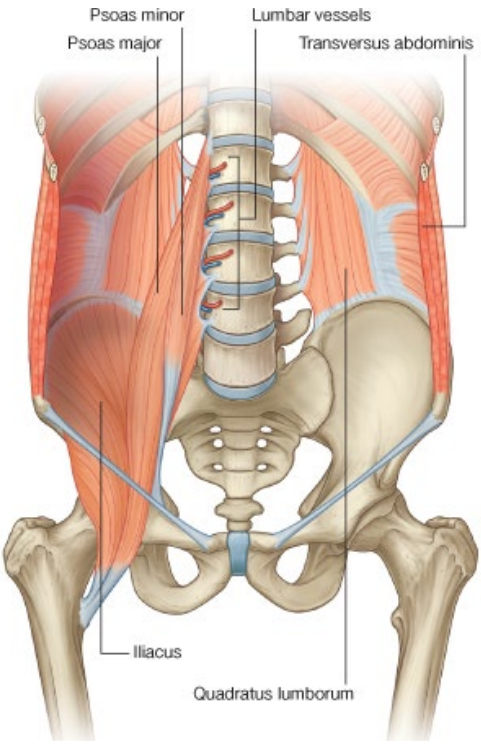
Inner layer muscles:

- **Prevertebral muscles** – in cervical and thoracic regions
- **Psoas major**
- These muscles arise from & insert into the vertebral bodies & discs
- Innervated by ventral rami of approporiate spinal segment.
- Allows **flexion** of the vertebral column.



Middle layer muscles:

- **Scalene muscles** – in neck
    - Origin: arise in part from anterior tubercles of cervical vertebrae transverse processes (i.e. the costal elements)
    - Insertion: first 2 ribs
- **Quatratus lumborum** – in lumbar region
    - Origin: ileum
    - Insertion: transverse process of lumbar vertebrae + 12th rib
    - Allows **lateral flexion** of the vertebral column



Outer layer of muscles:

- **Errector spinae mass**
- Consists of several different muscles
- Strong
- Extends from sacrum → base of skull
- Only muscles in the body supplied by the **dorsal rami** of the spinal nerves

- Fibres of errector spinae are fequently involved in back problems
- Errector spinae mass is divided into 3 main groups:
    - **Sacrospinalis** - superficial
    - **Transverse spinalis** – middle
    - **Rotatores** - deep

- **Sacrospinalis**:
    - Consists of 3 muscle sets which extend from the sacrum → the skull
    - Lie vertically
    - At lowermost part, the muscle arises from the back of the sacrum – covered with a stong aponeurosis.

- **Transverse spinalis:**
    - Also consists of 3 sets of muscles
    - The 3 groups lie one on top of the other in the groove between the spinous & transverse processes of the vertebrae.
    - Arise laterally from parts of transverse processes
    - Insert medially into the midline spinous processes.

- **Rotatores:**

- Run entire length of the column in short spans between each adjacent vertebra.

- **<u>All the muscles of the erector spinae mass are together known as the *intrinsic muscles of the back*</u>**
- The errector spinae mass **<u>extends</u>** the vertebral column
- Extension movements are most marked in the lumbar & cervical regions

- <u>*Smaller, deeper muscles*</u> of the errector spinae muscle mass are able to make <u>fine adjusting movements</u> – including <u>rotation of one vertebra on another</u>

- **<u>Flexion</u>** of the vertebral column is brought about by <u>prevertebral & psoas muscle</u>

- **<u>Lateral flexion</u>** is brought about by the <u>quadratus lumborum muscle (+scalene muscles)</u>

MUSCLES OF THE BACK 1

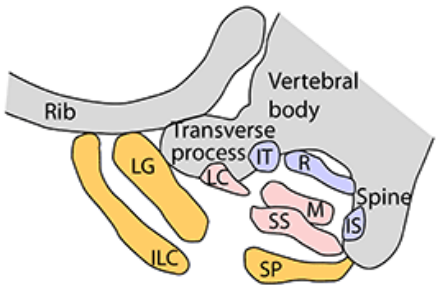
Arranged in three layers with three muscles on each layer
All supplied by posterior primary rami

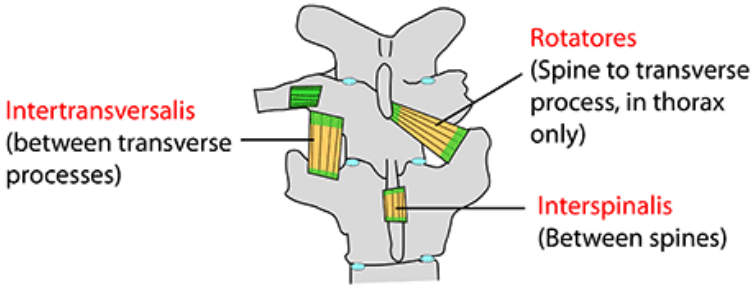
Divided up as follows:

SUPERFICIAL LAYER
- ILIOCOSTALIS (ILC)
- LONGISSIMUS (LG)
- SPINALIS (SP)

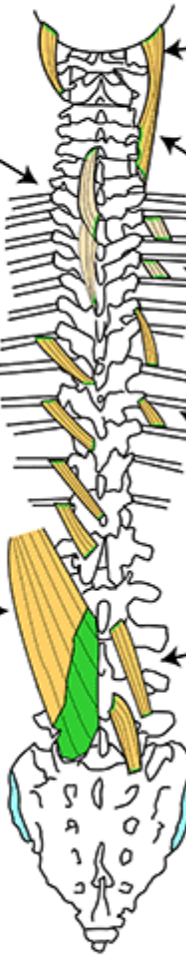
INTERMEDIATE LAYER
- LEVATOR COSTARUM (LC)
- SEMISPINALIS (SS)
- MULTIFIDUS (M)

DEEP LAYER
- INTERSPINALIS (IS)
- INTERTRANSVERSALIS (IT)
- ROTATORES (R)





MUSCLES OF THE BACK 2



Semispinalis

Capitis (Transverse processes C5-7, T1-6 to occiput)

Cervicis

Thoracis

(On multifidus, lower thorax to skull, transverse processes to spinal processes 6 above)

Spinalis
(small, indefinite between spines)

Iliocostalis
(mostly lateral, all levels, angles of last 6 ribs to: lumbosacral spines transverse processes above & below posterior tubercles in cervical region

Levator costarum
(12 slips from transverse processes C7-T11 to posterior angle of rib below

Longissimus
(Medial, thoracis, cervicis & capitis. From thoracolumbar fascia & lumbar transverse processes to several transverse processes above & mastoid process

Multifidus
(lamina to spinous process 2-3 above, from sacrum to C2)

SUPERFICIAL LAYER

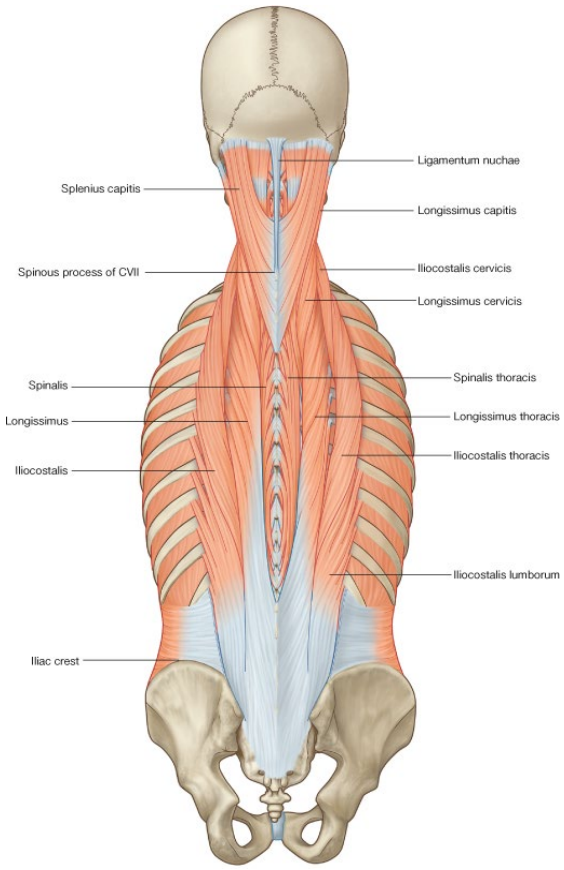
ILIOCOSTALIS (ILC)
LONGISSIMUS (LG)
SPINALIS (SP)

= ERECTOR SPINAE

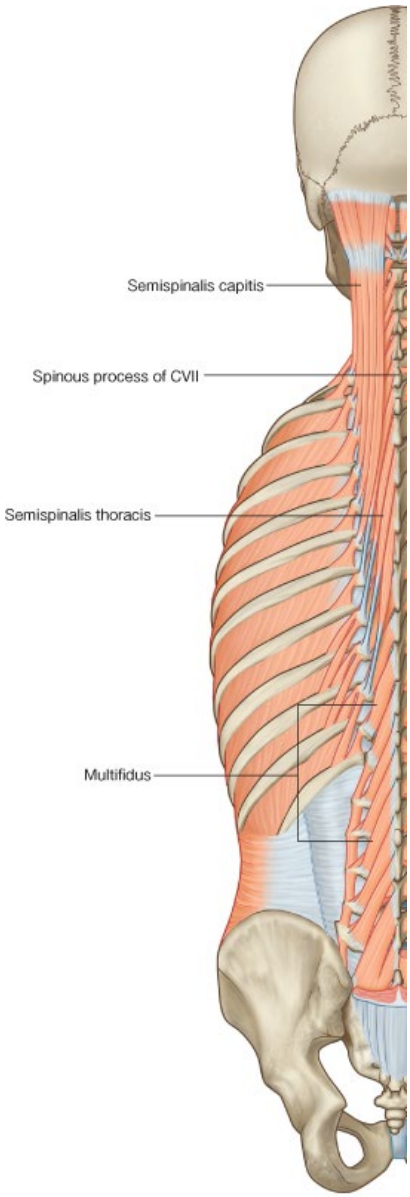
INTERMEDIATE LAYER

LEVATOR COSTARUM (LC)
SEMISPINALIS (SS)
MULTIFIDUS (M)

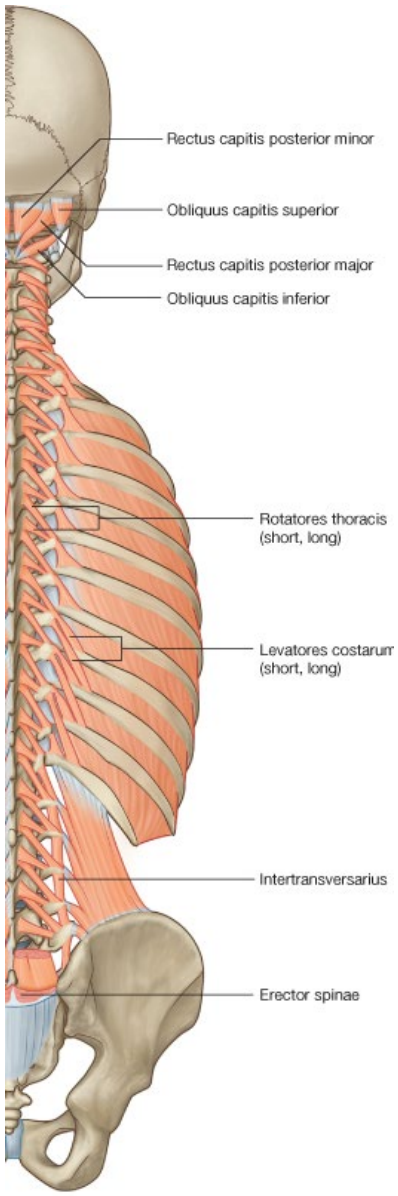
= TRANSVERSOSPINALES



Sacrospinalis



Transverse spinalis



Rotatores